Groundwater Contamination and its Impact on Health: A Case Study of Tehsil Bhalwal District Sargodha

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CERTIFICATE

This is to certify that this thesis entitled: **"Groundwater Contamination and its Impact on Health: A Case Study of Tehsil Bhalwal District Sargodha".** submitted by Muhammad Imtiaz Khan is accepted in its present form as satisfying the partial requirement of the degree in **Master of Philosophy in Environmental Economics**.

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Dedication

I dedicated this thesis to my Parents , for their affection and passion towards my studies

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

EPA	Environmental Protection Agency
HEAL	Health and Environmental Alliance
IEA	International Energy Agency
NGOs	Non-Governmental Organization
OLS	Ordinary Least Squares
PIDE	Pakistan Institute of Development Economics
PNCS	Pakistan National Conservation Strategy
PRC	Pakistan Research Council in Water Resources
TDS	Total Dissolved Solids
WHO	World Health Organization

ABSTRACT

This study examines the effect of contaminated groundwater usage and the health cost faced by households living in Tehsil Bhalwal district Sargodha. The study was done to determine the quality of groundwater and water supply lines. Water samples were taken from the four different areas of tehsil Bhalwal which are side by side to the wastewater channel of the sugar industry. About seven parameters (four were the Physio-chemical, pH, turbidity, hardness, total dissolved solids (TDS), bacteriological, calcium and magnesium were tested in water reports and their results were compared with the permissible level of World Health Organization guidelines for drinking water. The Turbidity ppm silica unit, TDS, total hardness mg/l, total alkalinity mg/l, sulfate mg/l, chloride mg/l, iron mg/l, and fluoride mg/l in reports are objectionable. To study the impact of contaminated water the required information is obtained through primary collection of data and questionnaires have 200 sample sizes of households and which generates 912 observations for our analysis. Results indicate that 2 percent of groundwater was used by the household for drinking and cooking respectively. Only 52 percent and 60.5 percent household uses tap water for drinking and cooking purpose respectively. While 40 percent of households use bottled water for drinking purposes and 30 percent take bottled water for cooking. Applying logit model for the diseases and OLS regression for the health cost estimation, the study finds, that the use of poor water quality for drinking, cooking, bathing, and washing increases the probability of getting a disease like jaundice, skin, and diarrhea which ultimately increases the health cost of the households. From results, it is concluded that households that are using groundwater and tap water suffer more from different illnesses as compared to the households which are using bottled water and their cost of illnesses is increasing as the number of visits to the doctor for medication goes up. Most of the respondents reported

Jaundice, Skin, and Diarrhea as the main diseases. The study recommends establishing a cemented wastewater canal of sugar industry effluents and establish and repair existing water filtration plants to provide safe water.

Chapter 1

INTRODUCTION

1.1 Background of the Study:

Water is an essential requirement for all life forms. Among all other natural resources, water is the most abundant resource on earth, and it is precarious for living organisms including human beings and food production process. Living being existence and nearly all types of economic production mainly depend on water (Albertini, Teodori, & Conti, 2007). Moreover, the earth has the most abundant natural resource that is the groundwater, mostly fresh drinking water is a scarce resource in the world. Moreover, less than 3 percent of the total water on earth is usable. Almost 80 percent of this usable water is in the form of ice sheets and frozen glaciers. About 0.5 percent of the total water on earth is accessible for the living being usage, and this total water is under the surface of the earth's crust in the form of groundwater (Singare, Bhanage, & Lokhande, 2011). About 20 percent of the inhabitants who are living on earth do not have an approach to safe and secure drinking groundwater and 50 percent of the total world population have does not absences of adequate sanitation. The Environmental risk associated with contaminated groundwater and its impact and their health effects in most of the underdeveloped countries is a universal problem and need to be address. (Arokiasamy, Karthick, & Pradhan, 2007).

About one-third of the total world population consumes groundwater for drinking purposes. It is used for agricultural and industrial revolutions in numerous countries. The water quality is pretentious by the interventions which human beings have achieved. The quality of water is deteriorating due to the increase in population growth, industrial growth, change in climate and other factors. Water pollution has a severe hazardous effect on all well-being and life forms on earth (Halder & Islam, 2015).

The groundwater contamination mainly happens due to the absence of adequate sanitation and largely seepage of the contaminated water into drinking groundwater supplies. Another pollution source is the effluent which is released from the industrial sector i.e. textile industry, leather industry, sugar industry, pesticides, and fertilizers from agriculture source leach down to groundwater. Many metal contamination in groundwater is due to industries i.e. Iron, copper, chloride, sodium, etc. Metallic concentration in Groundwater is also due to the landfills. Human impact on the environment which rises the waterborne diseases and almost 80 percent of all diseases and is responsible for 33 percent of deaths of the people (Soomro et al., 2011).

1.2 Groundwater usage in Pakistan:

Groundwater is the major domestic water source. In Pakistan, almost 20 percent of the total population has access to safe drinking water and the remaining 80 percent of people use unsafe drinking water due to scare resources of clean drinking water (Daud et al., 2017).

According to the survey which was held from 2004 to 2005, almost 38.5 million inhabitants in Pakistan do not have access to clean drinking water sources which ultimately increase to 52.8 million peoples up to 2015 (F. J. Khan & Javed, 2007).

In Pakistan major reasons for groundwater contamination due to the sewage and drainage system are set parallel in the ground, which causes seepages and intermixing of contaminated water with the supply lines and the groundwater. That is all due to the absence of treatment technology, apparatus and quality monitoring (Sayal et al., 2016). It has been observed in the last few decades that the groundwater quality has changed and is getting extremely polluted due to physical, chemical and biological conditions. Ground and surface water can be contaminated by numerous ways, like domestic wastes, municipal wastes, industrial wastes, mining, human and animal faces, ultimate disposal of toxic metals and random usage of fertilizers, pesticides (Bask, Nawaz, & Khurshid, n.d.)

About 79 percent is the current water supply in Pakistan. Water supply for drinking and drainage system are poor and have a lot of health issues for the residents. The high concentrations of sodium chloride, calcium, magnesium, sulfate, total dissolved solids, and turbidity are present in very high concentration. These ingredients have high or low concentration, both have an adverse effect on a human. The secretion of poisonous chemicals of the city population and the industries lacking any treatment causing a lot of problems for the clean water availability departments. In Pakistan, the main source of provision is the groundwater supply, which has numerous pathogens and other chemicals that cause 2.5 million people die due to the dangerous diarrheal disease every year (Soomro et al., 2011).

According to the Pakistan national conservation strategy in (1992), the water-related diseases represent 40 percent of the infectious diseases. In the Pakistan major diseases cause by the contaminated water are diarrhea, typhoid, stomach, kidney stone, jaundice, and skin diseases. Availability of surface and groundwater resources to the refrain of 128300 million m^3 and 50579 million m^3 per year respectively. Per person, water availability has been declined from 5600 m^3 to 1000 m^3 per annum (water quality status 2003).

Major cities like Karachi, Lahore, Multan, Rawalpindi, Sialkot, Faisalabad, Peshawar and Gujarat are using contaminated water due to different anthropogenic activities. The sugar industry is also the main factor which contributes a lot to the groundwater contamination. The majority of metallic contamination and chemicals are due to the sugar industry waste effluent. Water impurities have been assessed by different parameters of international standards while the impact on public health has been detected through hospital records as well as by public perception.

Noon Sugar mill in Bhalwal was assimilated in 1964 as a public company and produces white sugar in Punjab province. Industry sources indicate that white sugar production during the year would be recorded close to 7.5 million tons during May 2018, and with little change in domestic demand, lead to a surplus of 2.5 million tons of sugar available for export (Zuberi, 2019).

In the Noon sugar manufacturing company, it consist of five primary procedures cleaning, slicing, evaporation, extraction, and crystallization. Bhalwal sugar industry discharge wastewater consisting of extremely high levels of oil, chloride salts, suspended solids, organic matter, and toxic chemicals. Urbanization, the sugar industry, and landfills are a big polluting source of physiochemical groundwater contamination.

Considering the worst water quality situation, the Pakistan Research council in Water Resources has announced a National Program for determining the water quality status in Pakistan. The main aim of the water quality checking is to develop an everlasting water quality-monitoring network in Pakistan to estimate changes in surface water and groundwater quality. The observed results would lead to develop the essential measures for improving the quality of water and sustainable usage of the water resources in Pakistan (Soomro et al., 2011).

1.3 Significance of the Study:

This study analyzes the effect of groundwater usage on an individual's health in the short term. The current study is not only to measure the groundwater quality of

Tehsil Bhalwal district Sargodha (Pakistan) but also its effect on human health. The area which is surrounded by the wastewater channel of the sugar industry is Bhalwal city, factory area, Moggi Sargodha road and Satellite town. This study concerns the short-term exposure to the contaminated groundwater and their short-term health effect and the health costs that are linked with the use of groundwater and tap water. The groundwater usage for different household practices results in short term health effects that are injurious to health. With these short-term health effects, households mostly experience some health problems such as jaundice, skin diseases, eye irritation, diarrhea and typhoid disease (Azizullah, Nasir, Khattak, Richter, & Häder, 2011).

This study also concerns the inhabitant's awareness regarding groundwater contamination by the sugar industry and sewerage contamination. Three diseases jaundice, skin and diarrhea are taken in this study at the household individual level. Moreover, their health cost working hour lost and opportunity cost are calculated at the individual household level.

1.4 Research Problems

The main research problem is that why most households continue to use ground and tap water in their houses. Numerous studies have shown some examples of the extreme bad effects of contaminated water usage on human health (Pollution & Challenge, 2006). While their hazardous effects are mainly in forms like the deaths of children, severe diseases like jaundice, also a loss of underground water.

In Tehsil Bhalwal District Sargodha groundwater contamination is occurring due to effluents that are released from the sugar industry. It affects our environment and the surrounding population which is living around the wastewater channel of the sugar industry. Many health problems are emerging due to the use of contaminated water. Diarrhea, typhoid, eye infection, skin problems, stomach problem, heart disease, and gastro are the most frequent disease which occurs due to contaminated groundwater usage (Haydar & Qasim, 2013).

The short and medium-term health effects from contaminated ground and tap water use in households are serious illnesses, such as jaundice, skin irritation, skin disease, eye irritation, and diarrhea (Arokiasamy et al., 2007). In tehsil Bhalwal any household used ground and tap water for drinking, cooking, bathing, wash clothes and wash dishes which results in great exposure to the waterborne diseases which results in serious health symptoms i.e. jaundice, skin and diarrheal disease which will increase the health cost of illness of the members of households such as doctor fee, direct and indirect medical cost. These expenditures are measured in the health cost of illness. In tehsil Bhalwal due to the low income and uneducated households are unsafe due to contaminated ground and tap water usage because they have scarce resources to fulfill their need of drinking water and probably the lack of awareness. Many studies have been done on the ground and tap water pollution due to the sugar industry and lack of adequate sanitation and their disease impacts on humans; however, the main research gap is the health cost.

1.5 Research Questions:

a) Does Sugar industry effluents affect the existing groundwater quality of Tehsil Bhalwal, District Sargodha?

b) Does ground and tap water contamination affect the health of people living in Tehsil Bhalwal, District Sargodha?

c) What amount of health cost is born by people through the use of contaminated water?

To address these research questions, the following objectives have been formulated.

1.6 Objectives of the research:

The overall objective of this study is to assess the health status of household individual's which are affected by the Physio-chemical groundwater contamination due to sugar industry effluents in Tehsil Bhalwal, District Sargodha. Specific objectives of the research are as follow:

a) To analyze the existing ground and tap water condition/contamination in Tehsil Bhalwal.
b) To analyze the health effect of people living around the sugar industry and wastewater channel.
c) To estimate the health cost of household individual's living near the wastewater channel in Tehsil Bhalwal, District Sargodha.

1.7 Hypothesis of the Study

To achieve the objectives of the study, the following hypotheses have been developed.

a. H_0: There is no significant effect of ground and tap water contamination on the health of the respondents.

H_1: There is a significant effect of ground and tap water contamination on the health of the respondents.

b. H_0: Ground and tap water contamination does not increase the health cost of the respondents.

H_2: Ground and tap water increases the health cost of the respondents.

Chapter 2:

LITERATURE REVIEW

This chapter is divided into two sections which covers the thematic literature review on the previous work done on physiochemical groundwater contamination. Due to which many issues like water contamination are discussed.

2.1 Ground and Tap Water Contamination

Haydar & Qasim, (2013), This research was conducted to estimate the quality of water of Sargodha city and water supply system. Different Water samples were collected from 4 different water sources (one sample was taken from a tube well and three from surface water sources) and 8 household connections (two from each water source). Total of twelve samples was collected from the area. They take two types of samples, one sample is collected before monsoon and other samples after the monsoon was taken from every sample area point. About six parameters of groundwater analysis report were analyzed, four was the physiochemical, turbidity of the samples, pH value of sample reports, hardness, total dissolved solids (TDS) and two bacteriological analysis report consist of total coliforms and fiscal coliforms were analyzed for each sample which is reported and compared with the World Health Organization framework for drinking water usage. The study results confirmed that physical quality and the chemical quality of all drinking water sources was acceptable except the New Satellite Town. However, bacterial contamination was present in all the water source samples, only the sample taken from the tube well source showed water contamination before the monsoon season and after the monsoon rainfall season. The study concludes that insufficient management and no decontamination were responsible for bacterial contamination at surface water sources. Many possible reasons for water contamination at household level connections was decontamination, poor, old and drippy water lines along with unusual and poorly conserved sewage and drainage system. It was suggested in this study that appropriate water treatment practices especially current chlorination with residual chlorine are frequently be used in all sources to obtained safe water quality supply to the consumer door.

Majolagbe et al., (2017), Study reveals that groundwater pollution has 6 hydrogeological factors like depth to water generating source, aquifer media, a distance of water source to the pollution source, net renew and mud particles. Pollution vulnerability range from 161 to 175 which causes groundwater pollution. One groundwater pollution is landfill which creates environmental pollution like a dumpsite. Improper method and practice generate solid waste of different origins like industrial, trace metal, organic, domestic, agriculture and street sweep. 100 percent in developing countries generate dumpsite due to low and medium income. 90 percent of the municipal solid waste from India and other countries was disposed of unscientifically. About one hundred and thirty-eight million tons of municipal solid waste out of two hundred and fifty-one million tons of Municipal Solid Waste was generated by the united states of America in landfilled as well as 82.9 percent of the pollution wastes were dumpsite located in Ireland. These effect has decrease the standards of life and generates serious public health and environment problems. The dumping site was divided into two groups. One group consist open dumping site, and that is also called the controlled dumping site and the second group was sanitary dumping site. Sanitary dumping sites were extremely planned repression system, and wastes are Sequestered from the environment. This environmental-friendly landfill system consists of moderately or involves full hydrogeological segregation. Health risk affect due to acidic water was linked to several diseases condition like cancer, ulcer and intestinal proliferation.

Brazil's third-largest producer of sugarcane, covering the area of about 10 million. Sugarcane agriculture in Brazil began 500 years ago. This research study assesses the conservational impact of sugarcane due to industrial contamination. The author focused on the impact of sugar cane effluents, air and solid, consisting the biological and mineral fertilizer. The conclusion of this study was the manufacture of ethanol. Struggles were done to reduce groundwater use in sugar mills. Groundwater contains the concentration of potassium and reinstates riparian cushions and forest wreckages in sugarcane farmhouses. Major developments was desirable with regard to the preclusion of soil erosion and deprivation, safety of water assets contrary to pollution from pesticides and toxic chemicals which are generating due to the sugar industry, and the development of sugarcane in agriculture to rise ranges of natural vegetation, particularly within endangered biomes (Filosoa, et al., 2015).

Jangam & Pujari, (2017) Studied the groundwater sanitation due to urban areas has an increasing population. In in this paper author study, two sites one was the onsite sanitation and off-site sanitation system, where the hydrogeological conditions and anthropogenic activities (INDUSTRIAL and AGRICULTURE) has appeared. Groundwater sources were bore well installed by the private campiness that impacts on-site sanitation systems like $Na2^{+,}$ $C1^{-}$, and nitrate ions fiscal and e-coliform and the total dissolved solids(TDS), these can increase the permissible limit of the concentration mentioned by the Department of Indian Standard. The source of groundwater which is located near to the onsite sanitation has high chances of the groundwater contamination. The result indicate chemistry of coastal aquifer were mixing groundwater. The under groundwater pollution in the area assisted by onsite sanitation is reliant on hydrogeological characteristics. It's observed that the water quality has a direct influence on the onsite sanitation system and influence of evaporation effects on groundwater chemistry through drinking water.

Pawar, et al., (1998), Show that sugar mill is the important mode of the economy of Maharashtra, India. Development economic activities like accommodating dairies, paper mills, and poultry farms is a benefit for the economy but its effect on groundwater contamination. The huge amounts of waste (solid waste, liquid waste, and gas pollution) generated the village industry lead to air problem, aquatic pollution, and solid contamination. However, water quality and water pollution have become a serious problem for society. Studied review the type of groundwater pollution due industry which resolved waste in groundwater. Water consumption almost fifteen hundred liters/ton of sugarcane crumpled per day (L/ton/ day). Due to interior procedures, almost 60 percent of that water has recalculated and the remaining 40 percent consent as sewage from the baking house, mill house, and strainer cloth wash. The main objective of this to evaluate the influence of manufacturing activity on the chemical composition of groundwater and second is to conclude the class of groundwater in the regular state. Empirical funding of this paper underground water samples was got to the laboratory for examination of sodium, calcium, magnesium, chloride, sulfate, potassium (K), phosphate (PO4), nitrate. Most efforts of this study environs to please consumption water and class of water aspect has almost neglected. The water source was unfit for social feeding and rural pollution that bear so many years.

Abbas, et al., (2018), Investigate the solid waste impact on groundwater quality in Jhang, Pakistan. Groundwater has major sources for drinking purpose in this area, but many people were affected due to groundwater. People were thrown solid waste dumpsite on groundwater that causes the health problem and also deteriorate the environment. He collected a sample of surrounding areas municipal solid waste dumping site and testing the water quality. Its prove water was not clear in this area, whose people use drinking water from groundwater. Because of much industrial waste dump into groundwater that reverses into the pipeline, which people using water for any purpose. TDS found high (75%), CE (90%) Chloride (35%), Hardness (60%), Alkalinity (25%) and calcium (30%) with a high concentration of physiochemical into groundwater was present in dumpsite that indicates the poor water quality did not use for drinking water. Poorly managed solid waste sites contaminate groundwater which directly impacts human health.

Suthar, et al., (2010), Analysis in this paper water quality and assessment river of Hindon at Ghaziabad, India impact of industrial and urban wastewater. The data uses in the paper is primary data. Samples of Hindon water were collected from six different sites. The mean annual rainfall in this region is 702 mm varying spatially in different sub-regions of the district. The technique was used ANOVA. PH indicator was used to check the water quality for drinking purposes and irrigation. BIS suggests the 6.5 to 8.5 range of PH for any purposes in that respect. The mean of PH was 7.40 to 7.89 at a different site. The study concludes that the average PH level of this water is very low for drinking and any other purposes. The ANOVA test result of PH level and variable were negative. The policy recommendation is that there was the establishment of an institution that manages and controls the quality of water according to this ordinance.

2.2 Health Issues And Diseases Due To Contaminated Water Usage

Fito et al., (2019), Studied that the developing countries do not have the safe supply of the water. In Haramaya Woreda people take drinking water for daily consumption. Water samples of groundwater were collected from five different areas as their names are Meda Belina, Addale Waltaha, Tinike, Haro Adi and Derartu Mechetu. Some Physio chemical like (Pb, Cr, Cd) Pb(0.217 ± 0.040 mg/L), Cd(0.069 ± 0.004 mg/L), Cr(0.133 ± 0.002 mg/L), and the total hardness of water, which ranged from (271.67 ± 0.57 to 410.67 ± 0.58 mg/L) beyond the limit of WHO ($P<0.05$) that cause health problem in local communities. The problem of water pollution has serious by Ethiopia's backward socio-economic development, which has low living standards, low social services, and poor environmental conditions that cause health status in Ethiopia due to poor water quality. In this study analysis, the physical and chemical properties and metal content of clean water are necessary for public health protection and environmental improvements in the areas. On the other hand, this research assesses physicochemical and heavy metal ingredients of clean water and evaluate the clean water quality of Haramaya Woreda. however, appropriate measures are taken to protection of water sources and treatment of water from anthropogenic activities are the main steps towards the protection of the public health of the local area residents.

Naveen, et al., (2017), Studied the physiochemical and biological analysis in India state of Karnataka is situated north of Bangalore. Where landfill leachate contamination directory has established for urban which is used as a parameter to check water quality and underground water contamination. Presently in these landfill leachate qualities has becoming a grave problem in the developing republics and harmful for environmental. The author investigates of this study landfill dumping, manure ingress and local wastes including in all the animals waste disposed to the site that causes disease to relate to heart, skin, jaundice and kidney problem. The high concentration of Physio chemical effect on the quality of groundwater in Mavallipura pollution has deteriorated day by day, and mostly poor affected by solid waste management. Numerous analysis achieved in the research study that connections among the landfill leachate and water supply was detected. Water excellence in water forms was found extremely poor and nutrients assembling it unsuitable for any of the use.

Gawande & Engineering, (2015), many of the foremost complications that humanity is fronting in the twenty-first century are related to water quantity. In recent years, the increased risk to groundwater quality due to anthropological actions has become a matter of great concern. A vast mainstream of groundwater quality problems present today are caused by adulteration and by overexploitation, or by a combination of both. Groundwater is the prime source of water for domestic, agricultural and industrial revolutions in numerous countries. India accounts for 2.2% of the inclusive land and 4% of the world's water possessions and 16% of the world population. It is projected that one-third of the world's population use groundwater for drinking. Therefore, water quality concerns and its administration options need to be given greater attention in the developing countries. Due to lack of adequate sanitation and over-exploitation of industrial activities, numerous diseases like water-borne diseases, heart disease, kidney stones, jaundice, and skin diseases prevail in the society Harsh agricultural activities have increased the demand on groundwater resources in India. Water quality is subjective by natural and anthropogenic effects counting local climate, geology and irrigation practices.

Wu & Sun's study the evaluation of groundwater quality was carried out for a better understanding of the status of groundwater pollution and impending risks to residents in an alluvial plain (China) where agricultural and industrial activities are concentrated. The objective of the study to analysis water contaminated due to industrial wastewater and also impact health. The data uses in the study in secondary form. The ninety samples were collected from shallow pumping wells during October 2013. Shallow groundwater is seriously contaminated by TH, NO_3, NO_2, TDS, SO_4^{2}, and F. The distribution of contaminants indicates that the industrial and agricultural happenings are significant factors impacting the groundwater quality. Minimum, maximum, median, mean, and standard derivation of the main physicochemical parameters. The pH ranges from 7.72 to 8.31 with an average of 8.13, which indicates that the groundwater in the study area is somewhat basic. The dominance of captions in groundwater is Ca_2 Na Mg_2 K according to their average values. Groundwater quality in a muddy plain impacted intensively by agricultural and industrial activities was assessed for drinking and irrigation purposes. The comment of the study is examined the industrial wastewater impact on health. Some solid waste in industrial wastewater and bad effect on health (Wu & Sun, 2020).

Momodu & Anyakora, (2010), Studied on groundwater contamination in Nigeria, A case study of Suruleres city Lagos. Use of heavy metal contamination of groundwater in the middle class of Lagos was determined. 49 percent well and borehole water sample was collected in the study area where people use water for drinking purpose. In this water were appeared heavy chemicals like Aluminum, Cadmium and lead content to beyond the limit of WHO. According to WHO, the maximum contamination limit (MCL) for aluminum (0.2), cadmium (0.003) and lead (0.01) mg/l that use of these metal deteriorate the water supply in this environment. Because water has an essential part of our life which use for everything purpose and its support all forms of plant and animals. Author funding in this study as two aspects of natural sources, one is surface water that gives freshwater lake, river water, and stream: second is groundwater which contains all the mixed of anthropogenic activities. Pure water has not available for drinking as it acquires contaminants from its surroundings and those arising from humans and animals as well as other biological activities. Heavy metal deteriorate the environment through groundwater contamination that humans were exposed to aluminum, arsenic, cadmium, lead, and mercury. Aluminum has causes senility and presenile dementia. Arsenic exposure can cause illness or symptoms of cancer, abdominal pain, and skin lesions. Cadmium exposure produces kidney damage and hypertension. Lead as poison that affects human carcinogen, while for mercury, toxicity results in mental disturbance and impairment of speech, hearing, vision, and movement.

Patoli, et al., (2010), Examined multi-drug Escherichia coli in drinking water samples from Hyderabad, Karachi. Antibiotic resistance in pathogenic bacteria was a serious problem in health issues for humans. Escherichia coli is a member of fecal coliforms that contaminate the drinking water from human and animal fecal waste. Untreated drinking water coming from these sources contains coliforms including Escherichia coli. Escherichia coli symptoms were rear, some time can cause illness, diarrhea, abdominal pain, fever and sometimes vomiting. In developing countries such as Pakistan, drinking water supply lines and open sewage system damage frequent contamination of water. E.coli 64.29 percent isolated from drinking water and coliforms 35.71 percent in drinking water.

Industrial wastewater contamination poses a serious threat to human and environmental health, especially in developing countries. The availability of safe drinking water has been a serious menace in Pakistan either because of shortages or due to contamination by untreated industrial waste. The rural and urban population was safe drinking water 23.5% and 30 %. Majority industrial in Pakistan were not established environmental regulation. Industrial waste contamination serious health problem that involved some chemical Pb and arsenic highly toxic component that causes acute and chronic disease like blood pressure, renal disorders, joint pain and malfunctioning of the nervous system. The presence of heavy metal contamination and disease association is a fact proven by chemists, environmentalists, and epidemiologists. The economic perspective focuses on the quantification of these health effects which reduce people's utility. Econometric estimation based on the probability of sickness was estimated by using the Probit model. The study revealed that there should be aware regarding pollution and the lack of resources in developing countries for the installation of the treatment plant (Sayal et al., 2016).

Singh & Singh, (2011), studied the Impact and extent of groundwater pollution: A case study of rural areas in Punjab State (India). The objective of the study checks the impact of groundwater quality for the safe drinking water. The data type for the study was secondary data. The econometric model used the economic model used to identify the health of the people. The results of the study there is a positive and significant of government polices (investment in public research, extension, and highways and commodity programs) on productivity growth. If the Government intervenes (like direct payments for commodity programs): it affects the dimensions of the structure.

They Examined in this study the health risks associated with heavy metals in the drinking water of Swat, Northern Pakistan. The objective of the study is the to The objective of the study is to check the health risk due to heavy metals from industrial waste in the drinking water. The data were used for primary data. The data were collected from Madyan, Fatehpur, khwazakhela and Mingora and other different places like Pump, Tube well, etc. The econometrics technique was used that is ANOVA. The results of the study are heavy metal is very harmful to health. The metal creates problems in the drinking water and also immoral impact on the health. The study concludes that heavy metals like (Mn, Ni, Zn, Cd, Cu, and Pb) in the drinking water collected both surface and groundwater resources that metal has big problems create in human health. $P<0.05$ that are full significant means that impact on the health. To control the industrial waste in the water we also clean the water and that water use for drinking purposes and others (K. Khan et al., 2013).

2.3 Conclusion of the Literature review:

Groundwater is the major domestic water source. Due to the rapid increase in population and industrialization groundwater quality is fading day by day all over the world. These literature reviews add up the results of numerous research studies which was held for the drinking water quality by taking into account the physical and chemical properties of drinking water as well as the effluent of the industrial sector. The Physical parameter of water quality such as pH value, high turbidity, total coliforms are due to lack of sanitation and the water discharge through sugar mill have a high level of oil, chlorides, alkalinity, suspended solids, organic matters, and chemicals.

Water is one of the basic requirements of life. Water is essential for drinking, agriculture, household food preparation, livestock, and other many other purposes. The waste of industry comprises of a different harmful element that is, Ni, Cr, Zn, Cd, Cu, As, Pb, Fe, and Mn, that all harmful chemical pollute the groundwater quality that water not useful for the human use (Tariq & Ali, 2006). The use of polluted water creates different types of diseases like diarrhea, waterborne disease, hepatitis, stomach problem, skin problem, gastro, heart diseases are increasing the cause of death in the adults and children’s. The health costs borne by people can be classified into different branches: avertive costs, expenditure on hospital treatment, social costs in terms of number of working hours lost and stress on income, therefore in our study we are measuring the health cost of small estate area of tehsil Bhalwal district Sargodha that have never been measured in the studies that have already been conducted in the study area, and this is the Research Gap that I have going to be address.

Chapter 3

DATA DESCRIPTION AND RESEARCH METHODOLOGY

This section of the study covers the study area, data collection procedure, sampling techniques, and empirical framework of the models which will be used in further estimations and calculations.

3.1 Study Area:

Sargodha is the 11th largest city in Pakistan. Groundwater quality is poor and is generally saline. The study area of my research is the Tehsil Bhalwal, District Sargodha. Bhalwal is a highly populated city. According to the population census 2017, the total population of Bhalwal is approximately 2,50000. Due to the rapid increase in urbanization industrialization has deteriorated the groundwater condition. However, Bhalwal sugar industry discharging wastewater containing high levels of oil, magnesium, sulfate, iron, suspended solids, organic matter, and chemicals. Urbanization, the sugar industry, and landfills are a big polluting source of physiochemical groundwater contamination (Abbas, et al., 2018). The waste of industry comprises of different hazardous elements and chemicals like zinc, nickel, lead, manganese. sugar mill effluents contain acidic and alkaline compounds, a significant concentration of suspended solids and a high BOD, COD, and sugar concentration (Akbar & Khwaja, 2006). Industrial effluents and household wastage are the main sources of water pollution. I carried a survey of drinking water supply in Bhalwal and reported the 4 samples which were collected from the surrounding area of the sugar industry in Bhalwal. Bhalwal city, factory area, Moggi Sargodha road, and satellite town are the selected area which is frequently affected by wastewater channel of the sugar industry and sewerage contamination. All these 4 samples are unfit for drinking purposes and have a high concentration of calcium, calcium carbonate, total alkalinity, iron, total dissolved solids, chlorides, turbidity ppm silica unit and bacteriological contamination. Water contamination is homogeneously distributed here; rather it is not present in heterogeneous distribution. Sugar industry effluents are the biggest environmental disaster and public health issue in recent times in Tehsil Bhalwal. The purpose of this study is to explore the impact of sugar industry effluent's in drinking water on the frequency of health symptoms and health costs in Tehsil Bhalwal of district Sargodha. People use contaminated groundwater for cooking, bathing and washing their mouths after eating and cleaning utensils that cause skin disease which is most frequent in the female. The existing literature pointing out that majority of the diseases are mainly due to drinking contaminated water affected by the sugar industry wastewater channel.

3.2 Data Collection Procedure & Sampling Technique:

3.2.1 Data Collection

Questionnaire-based primary data is collected from those who are living in Tehsil Bhalwal District Sargodha. Total four areas of district Bhalwal is chosen for the household survey data collection, which includes Bhalwal city, factory area, Moggi Sargodha road and satellite town Bhalwal because this selected area is around the wastewater channel of the sugar industry. Quality of water is also determined through a water testing laboratory. A simple random sampling technique is used to collect information from the residents who are using bottled and contaminated water i.e. ground, tap water. Households that are using bottled water is our control group. While the households using ground and tap water is our experimental group.

3.2.2 Sampling Technique

In this study, we use the Simple Random Sampling technique. According to the population census 2017, the total population of Bhalwal is approximately 2,50000. We use Cohen's sample size formula and we found that at a 95 percent confidence level, and a 7 percent margin of error. A sample size of 200 (n=200) households is taken from the study area which is using bottled water and contaminated water i.e. Ground and tap water.

3.2.3 Empirical Framework

Questionnaire have three Parts. Part 1 covers the socio-demographic variables. Part 2 mainly focus on awareness and availability of water source, either they are using bottled water or using groundwater i.e. Ground or tap water or types of diseases related to physicochemical groundwater contamination and the existing water situation due to Sugar industry effluent's and seepage. Third and last part covers the health cost spending either it is direct or indirect of the questionnaire will cover the direct and indirect cost of treatment of illness. In Direct cost; doctor fee (per visit), Travel cost (return), medicinal expense, Lab test or any other expenses which is directly related to disease and respondents, will be considered. While Indirect cost consists of loss of working hours, the opportunity cost of illness, the opportunity cost of an attendant with a diseased person.

3.4 Research Methodology

Parameters of water quality provide essential information about the water quality and the health of the consumer. The number of physical and chemical parameters are selected to check the ground and tap water quality which depends on the given available resources. The parameters are potential hydrogen (pH), Electric conductivity (EC), Total dissolved solids (TDS), Potassium (k), chloride, magnesium, and calcium. While 4 samples are collected from four different areas of Bhalwal as per international standards. All the water samples are analyzing in district level water testing laboratory public health engineering department Sargodha. Water quality of study area Bhalwal was compared with the World Health Organization maximum permissible level.

3.5 Water Quality Analysis

The parameter potential hydrogen (pH) which is used in drinking water has indirect effects on health by bringing change in other water quality variables. According to the World Health Organization permissible limit of the pH values must not increase 8.5. the pH value in this study area is different in each locality. In Moggi Sargodha road pH Value is 8.32, the satellite town has 7.87, the factory area has 8.02 and Bhalwal city has 7.98 pH value. The total dissolved solid mg/l is also called ions concentration that determines the water quality. According to the World Health Organization standard of the total dissolved solids in drinking water must not increase from 500 to 1000 mg/l. In this study, the Moggi Sargodha road area has a total dissolved solid value was 4900, while the satellite town has 1020, the factory area has 970 and Bhalwal city has 290 TDS value. Magnesium is the main natural constituent of groundwater and found in minerals. According to the World Health Organization, acceptable limits of magnesium in drinking water is 150mg/l. While the Bhalwal city has 7.5mg/l, the factory area has 17.5mg/l value, satellite town have 32.5mg/l value and Moggi have the highest 92.5mg/l magnesium value. Calcium is an essential mineral nutrient to human health and almost 95% of total Calcium of the human body present in teeth. According to the World Health Organization, the limit of Calcium must be 200 mg /l. In this study area values of calcium varied from 40mg/l in Bhalwal city, 104mg/l in Moggi, 56mg/l in the factory area and 44mg/l in the satellite town. All results of calcium are below the standard values determined by the world health organization. The limit of iron mg/l is 1.0mg/l set by the WHO. While in satellite town iron varied from 1.02mg/l, 1.21mg/l in Moggi, 1.001mg/l in Bhalwal city and factory area have 1.85mg/l concentration of iron in water samples. Bacteriological contamination was found in the water sample government supply line in Bhalwal city (**see appendix 1**).

3.6 Econometric Models

In this section, we will discuss the two econometric models. First model is the disease model and the second is the health cost model.

3.6.1 Model I

To check the effect of diseases due to contaminated water on the respondent. I use a logit model because it is a suitable model to describe the relationship between a non-negative binary dependent variable and independent variables. By using the logit model, we have to check the dependent variable diseases "D". I have used binary variable '1' for the (D_1) Jaundice and '0' for otherwise, (D_2) Skin Disease (Yes =1, otherwise = 0) , (D_3) Diarrhea (Yes =1, otherwise = 0). I have applied this model separately to the diseases discussed in this study.

Equation

$$(logit)D_1 = \beta_0 + \beta_1 Age_i + \beta_2 Edu_i + \beta_3 Gen + \beta_4 Inc_i + \beta 5 WS1 + \beta 6 HHS + \varepsilon$$

$$(Logit)D_2 = \beta_0 + \beta_1 Age_i + \beta_2 Edu_i + \beta_3 Gen + \beta 4 WS2 + \beta 5 DL + \beta_6 HHS + \varepsilon$$

$$(logit)D_3 = \beta_0 + \beta_1 Age_i + \beta_2 Edu_i + \beta_3 Child + \beta_4 Inc_i \ \beta 5 WS1 + \beta 6 Adult + \varepsilon$$

Variable Specification:

D_1: Jaundice (Yes =1, No = 0)

D_2: Skin Disease (Yes =1, No = 0) **D_3:** Diarrhea (Yes =1, No = 0) **Age:** Age of respondent (in Years)

Edu: Education of Respondent (Years of Education)

Gender: (male =1 female=0)

Total Monthly Income: Total Monthly Income of household (In rupees)

WS_1: Water source for drinking and cooking (Groundwater + Tap water=0, Bottled water =1)

WS_2: Water source for bathing, washing, etc. (Groundwater + tap water=0, other=1)

DL: Duration of living in area (in Years)

Child: Number of children's in household

The expected signs of the coefficients of the independent variables has been gathered in Table II. These signs have been seen in the literature (Patoli, et al., 2010) and (Sayal, et al., 2016). These will be a good indicator of the results of this study which will prove whether this study provides the same results as previous studies done on similar problems in other areas.

Table 3.1: Variable Specification

Variables	Variable explanation	Expected sign	References
D_1	Individual estimation of Jaundice disease		Sayal et al., (2016)
D_2	Individual estimation of Skin disease		
D_3	Individual estimation of Diarrhea		
EDU.	Education of Respondent (Years of Education)	Positive (-)	
AGE	Age of respondent (in Years)	Positive (+)	
GEN.	Gender (male =1 , female=0)	Pos/Neg (+/)	
INC.	Total Monthly Income of family (In rupees)	Pos/Neg (+/)	
CHILDREN	Number of children in the household	Positive (+)	
WS_1	Groundwater+ Tap water=0, bottled water=1	Neg (-)	
WS_2	Ground water=0, tap water=1	Neg (-)	
HHS	House hold size	Pos/Neg (+/)	
DL	Duration of living	Pos(+)Neg(-)	

3.6.2 Model II

Measuring health costs isn't an easy task. There are so many factors which are directly or indirectly affecting the level of health. In Pakistan average spending on health care is 33% by the public and most of the spending in Pakistan is private spending (Muhammad, Gul, Saleem, & Abrejo, 2015). I cannot measure all the factors which are affecting health cost but some of the factors have more share in measuring health cost. To measure health costs, we use the Ordinary Least Square (OLS) method, in which health cost (in rupees) is our dependent variable and the data related to health cost is also collected through a primary survey.

Equation 2

$$HC(D) = \beta_0 + \beta_1 Age_i + \beta_2 Edu_i + \beta_3 Inc_i + \beta_4 WS + \beta_5 AVRT + \beta_6 HHS + \beta_7 Time_i + \beta_8 Novist_i + \varepsilon$$

Variable Specification:

HC: Health cost of Respondents of households in last six month (In rupees)

Age: Age of respondent (in Years)

Edu: Education of Respondent (Years of Education)

Inc: Total Income of Households (In rupees)

WS: Water source (Groundwater + Tap water=0, bottled water + other =1)

HHS: Household Size (total Number of family members)

AVRT: Cost Incurred on Adopting Averting measures

Time: Total Time spent to visit for treatment from beginning to return (in hours)

Novist: Number of visits to the doctor in a last six month

The expected signs for the variables used in the health cost estimation of contaminated groundwater have been presented in Table 4.2 Ch (Muhammad, Gul, Saleem, & Abrejo, 2015), so these signs have been taken as a road sign. These signs will provide a basis for the results of this study to carefully analyze the similarities or differences in the relationship between health cost and its affiliated variables.

Table 3.2 Variable Specification for Health Cost

Variables	Description	Expected Sign
HC	Health cost (In rupees)	
Age	Age of respondent (in Years)	Positive (+)
Edu.	Education of Respondent (Years of Education)	Negative (-)
Inc.	Total income of respondent (In rupees)	Negative (-)
WS_1	If uses Groundwater +Tap water=0, Bottled water+ other source=1	Pos (+) if (0)
HHS	Household Size (total Number of family members)	Positive (+)
AVRT	Cost Incurred on Adopting Averting Measures	Negative (-)
Time	Total Time spent to visit for treatment from beginning to return (in hours)	Positive (+)
NOVIST	Number of visits to the doctor in a month	Positive (+)

3.7 Variable Description Age

Age is an important variable. With the increase in age, the resistance against different diseases decreases, therefore, it is important to investigate the impact of age on the prevalence of disease due to drinking contaminated water contaminated with sugar industry effluents. Hence, it empirically needs to investigate whether contaminated water has a more severe effect in old age. The positive and significant impact indicates that old age people are vulnerable to contamination in the drinking water. It is observed during the interview process that old people are commonly facing diseases like jaundice and skin problems in the study area, implying that age could be a potential explanatory variable in our model. Literature also reveals that different kind of disease increase in old age because of the decline in body resistance (Farooqi et al; 2016).

3.7.1 Education

Education refers to the years of schooling received by the respondents. It is associated with awareness about the surroundings and more importantly, the water contamination in the study area. Therefore, education may have a negative impact on the prevalence of diseases.

3.7.2 Gender

Gender is taken in the form of a dummy variable i.e. (1=male,0=female). It is considered as an important explanatory variable because the questionnaire-based survey has revealed that skin disease is more prevalent in females as compared to males.

3.7.3 Household size

The number of total family members has been considered as an explanatory variable because it is expected to affect the dependent variable. As family size increases it can affect two ways to the probability of prevalence of diseases. If numbers of children are higher in the family that can help to bring drinking water from other sources then family size is expected to affect the probability of diseases negatively. However, if the number of elders is dominant in the family and they are not economically active then no one will go out bring water and also they don't sufficient resources to shift towards cleaner sources of water, implying that large family size may lead to a higher probability of diseases.

3.7.4 Water Source

Water source (WS) for drinking and cooking is taken as a dummy variable i.e. (0=Groundwater+ Tap water, 1=Bottled water + other sources/averting measures). Most households use groundwater and tap water for home cleanliness, washing, and bathing.

3.7.5 Income

Income is taken in Rs per month. It relates to the quality of medication because it indicates affordability or excess to better medical facilities and a body of literature attempt to investigate the income impact of different diseases (Khan, 2007).

3.7.6 Duration of living

Living duration is an important variable used in a skin disease model. This means that for how long people are living in the area of study. The households living from many years, they are much more adaptive to the environment and have less probability of getting infected from the use of contaminated water for bathing and washing and other usages.

3.7.7 Health Cost

It is taken into two groups i.e. direct and indirect costs. Direct cost includes doctor fee, travel cost, medicinal expenses and lab tests whereas indirect costs include economic loss of working days and opportunity cost of the attendant with the patient. It is taken in Rupees

3.8 Descriptive analysis:

The descriptive statistics are considering an important part of quantitative research. The descriptive statistics tell us about the mean value for the observation along with with its standard deviation, minimum and maximum values.

Table 3.3: Descriptive statistics of variables

Variable	Units	Observation	Mean	St. Dev.	Minimum	Maximum
Age	(Years)	200	30.85	8.24	1	90
Living duration	(Years)	200	38.595	17.666	1	90
Household size	(Number)	200	4.595	1.173	2	9
Education	(Years)	200	10.56	3.22	0	20
Income	(PKR)	200	73307.5	32428.26	23000	195000
Health cost	(PKR)	200	6813.068	5242.272	0	31266.67
Averting cost	(PKR)	200	815.925	802.9744	0	2370
Working hour lost	(Hours)	200	7.595	11.6796	0	120

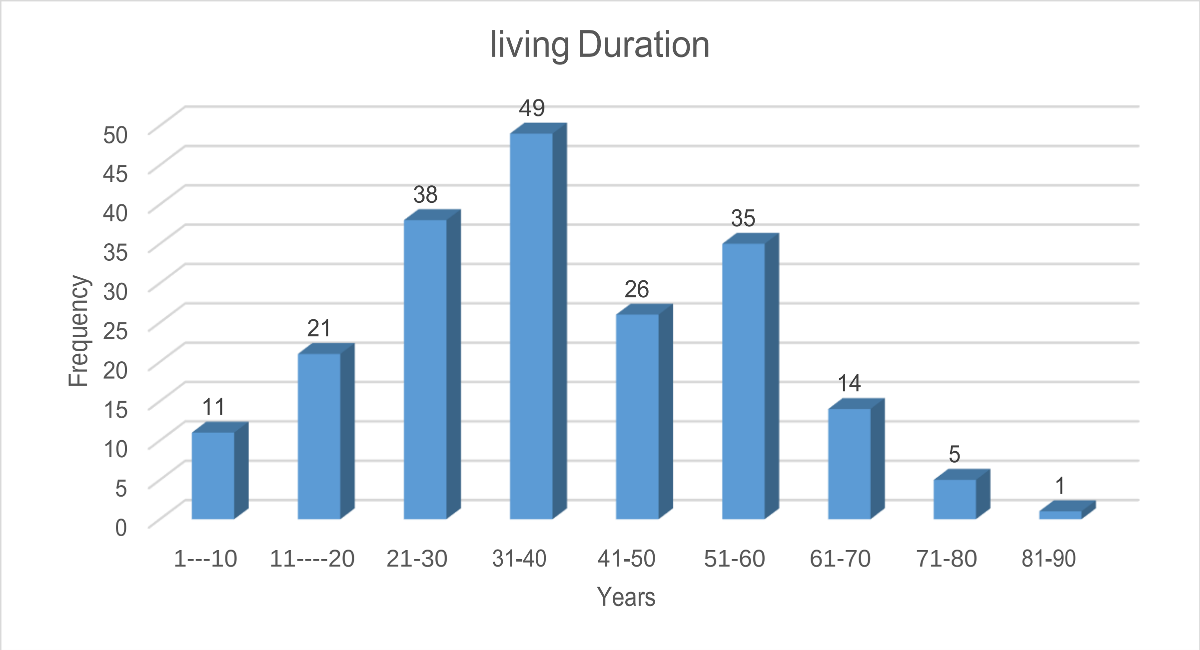
3.9. Socio-Economic Characteristics of the respondents Age

In the sample of 200 households having 912 family members, the minimum age was 1 year and the maximum age was the 90 years.

3.10 Duration of Living

Duration of living is the number of years through which households are living in the area which is around the wastewater channel of the sugar industry. The minimum year of the living duration of household was 1 year and the maximum year of living was 90 years in the study area. 1 to 10 years of eleven households exist.11 to 20 years twenty-one household lies in bin range of year. While the maximum household lies in the range of 31 to 40 years which were forty-nine household which are living around the wastewater channel of the sugar industry.

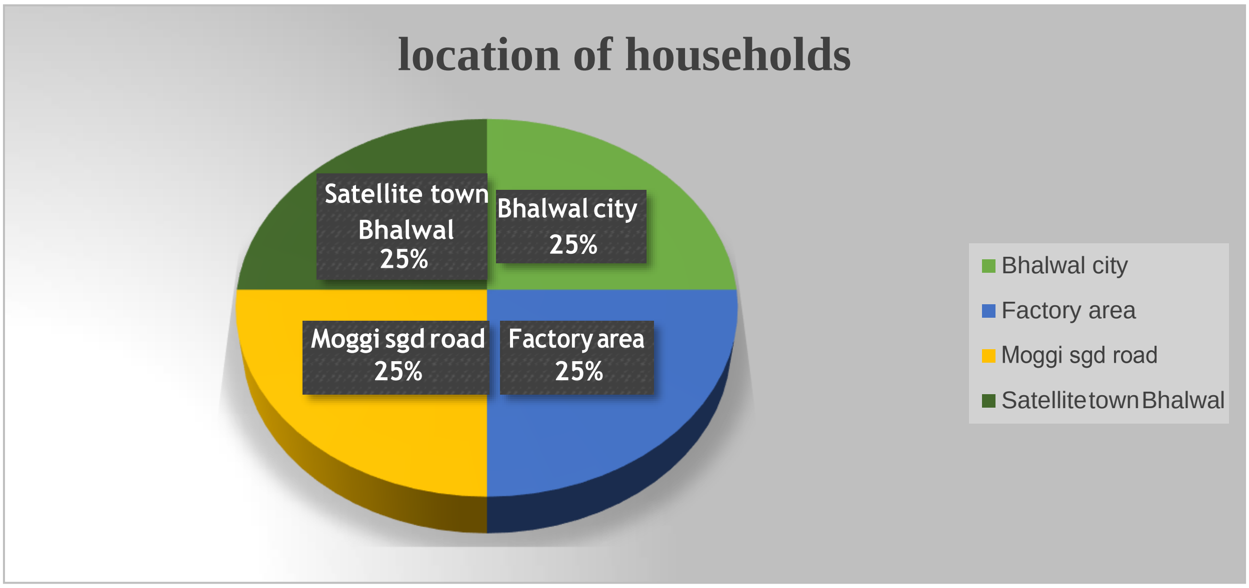
Figure. 3.1: Living Duration



3.11 Location of households

Bhalwal city was divided into four subunits as shown in figure 3.2. Fifty samples were collected from each subunit. These areas are around the wastewater channel of sugar industry effluents. Groundwater contamination was homogenous in the study area. Although the tap water which is supplied to the factory area, satellite town, Moggi, Bhalwal city households is also found contaminated. So mostly household uses bottled water for drinking and cooking.

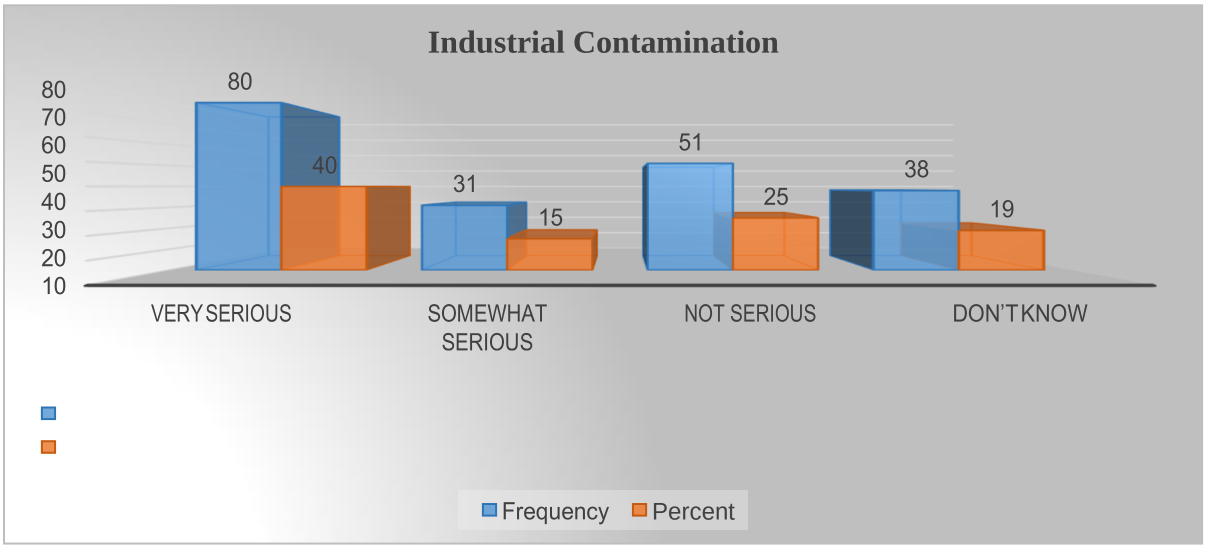
Figure. 3.2: Location of households



3.12 Industrial Contamination

According to figure 3.3. Household resident's perspective about sugar industry contamination in groundwater. About 40 percent of people were aware of the industrial wastewater contamination. About 15 percent say that is a somewhat serious problem and 25 percent of households say there is no serious problem with groundwater contamination due to the sugar industry effluents. While 19 percent of households don't have any idea about industrial contamination.

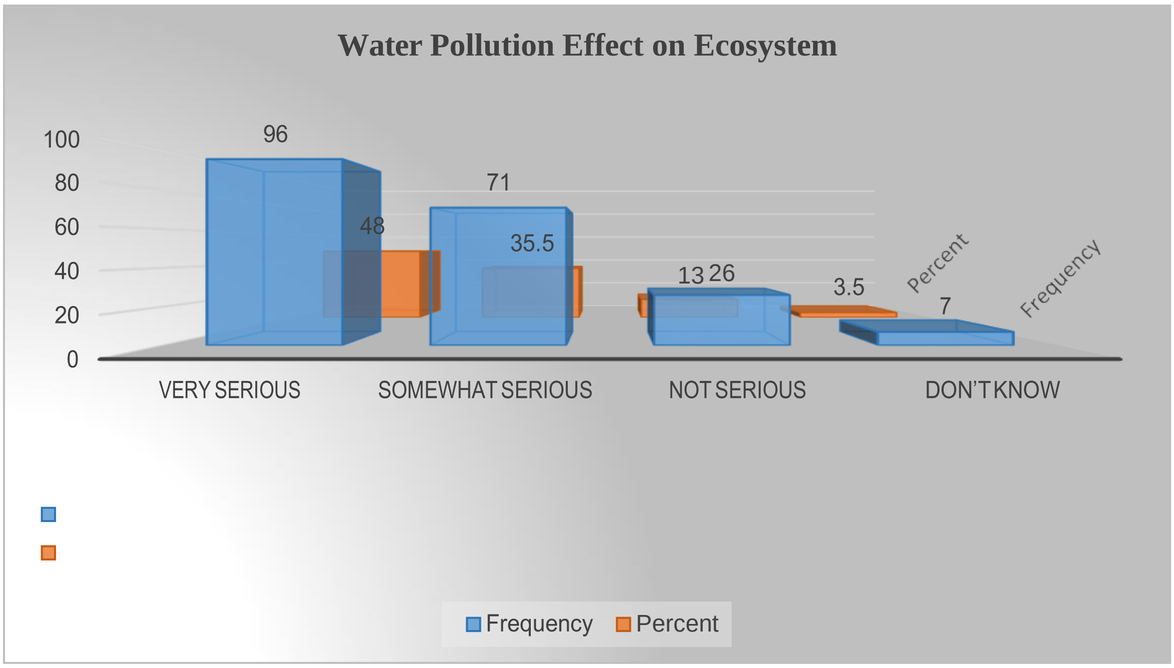
Figure. 3.3: Industrial Contamination



3.13 Water Pollution Effect on Ecosystem

While the sugar industry effluents affect the ecosystem. About 48 percent of households states that the problem of water contamination due to the sugar industry affects the ecosystem seriously. While 35.5 percent view that is somewhat serious to the ecosystem and 13 percent says not seriously affecting the ecosystem.3.5 percent says they don't have any idea regarding this problem.

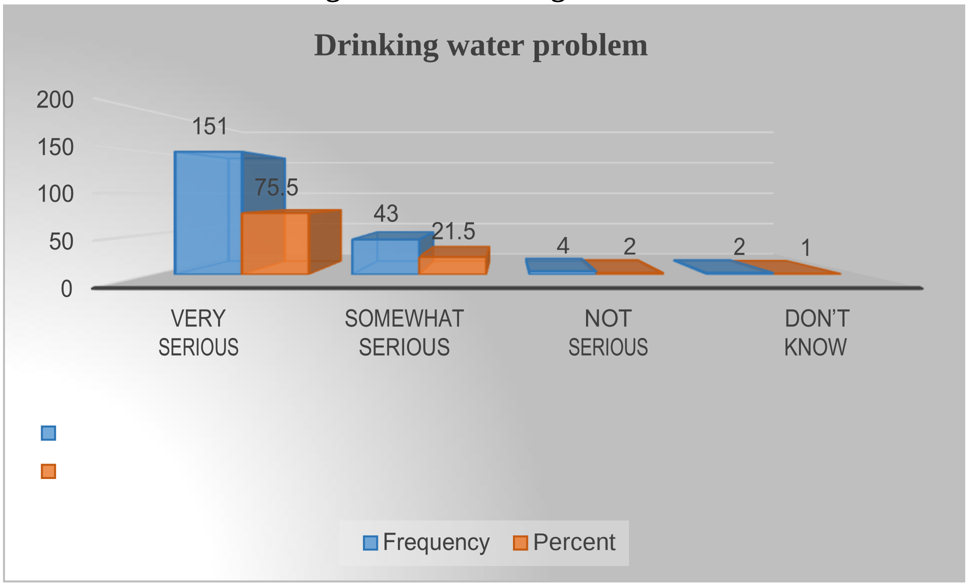
Figure. 3.4: Water Pollution Effect on Ecosystem



3.13 Problem of Safe Drinking Water in Bhalwal

Household's point of view about the problem of safe drinking water was about 75.5 percent say there is a very serious issue. About 21.5 percent say a somewhat serious issue of drinking groundwater. Only 2 percent of households say there is no serious issue of safe drinking water. while 1 percent don't know about the awareness.

Figure. 3.5: Drinking Water Problem



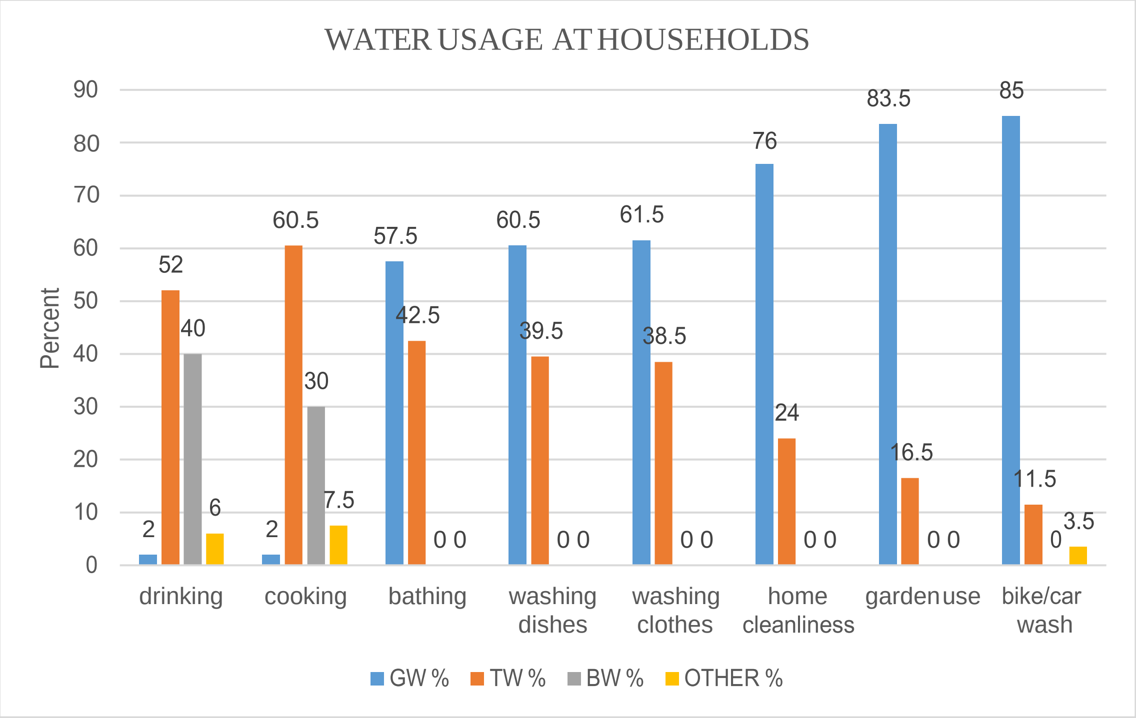
3.14 Usage of water

For drinking purpose water source 1 which is groundwater was used by 2 percent of households. Tap water used by 52 percent of households. Bottled water was used by 40 percent of households for drinking purposes. While 6 percent of households use groundwater for drinking form other sources like tube wells or water plants by different NGOs. For cooking purposes, households use 2 percent groundwater, 60.5 percent tap water, 30 percent of households use bottled water and 7.5 percent other sources in their houses.

Groundwater was used by 57.50 percent household for bathing. While 42.50 percent of households use tap water for the bathing. While for washing dishes 60.50 percent of households use groundwater and 39.50 percent of households use tap water. For washing clothes, 61.50 percent of households use groundwater and 38.50 percent supply lines that is the tap water.

Household use 76 percent groundwater and 24 percent supply line water for home cleaning. Households use 83.5 percent groundwater and 16.5 percent supply tap water for the gardening. While for bike/car wash households uses 85 percent groundwater. 11.5 percent of households use tap water for washing the bike and cars. 3.5 percent of households use another source to wash cars/bike.

Figure. 3.6: Water Usage at Household

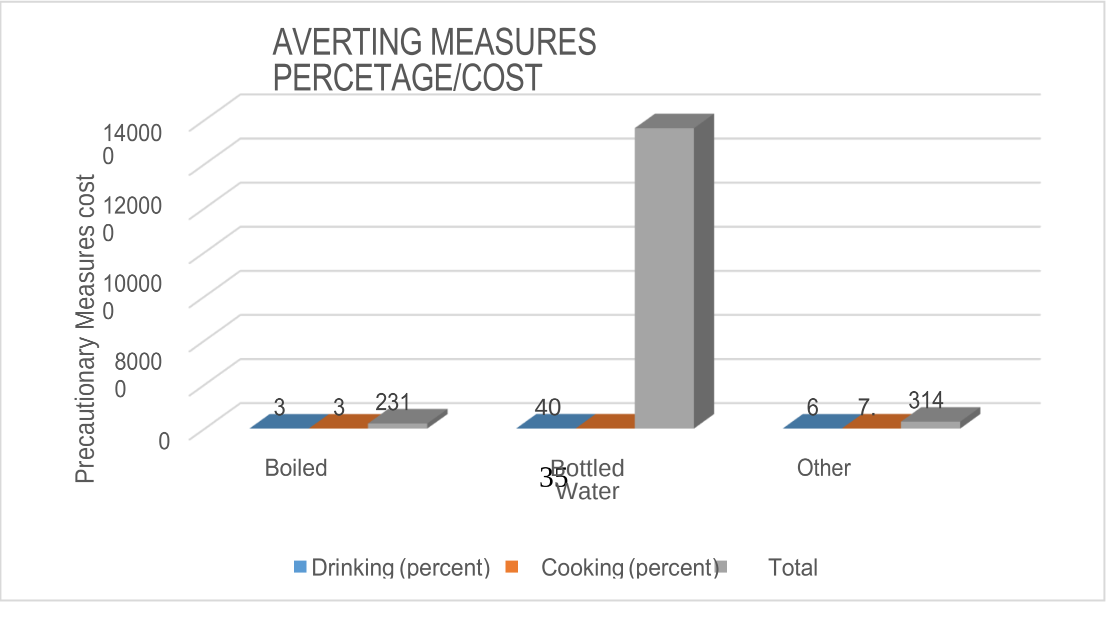


GW=Ground water, TW=Tap water/government supply, BW=Bottled water

3.15 Precautionary measure for water

In precautionary measure boiled water which is 3 percent used in drinking and cooking in total household sample and bears a cost of 2310 rupees/month. Bottled water is used by 40 percent household for drinking and 30 percent for cooking and cost/month is 136229 rupees. Another source for drinking is used by 6 percent households while 7.5 percent is used for cooking and has a cost of 3140 rupees/month.

Figr. 3.7: Averting Measure Percentage/Cost



3.17 Household size, HHS Frequency, and Gender:

Total 507 male and 405 females exist in the sample of 200 households. The minimum family size was two and the maximum was nine. Male and female were distributed under the household size.

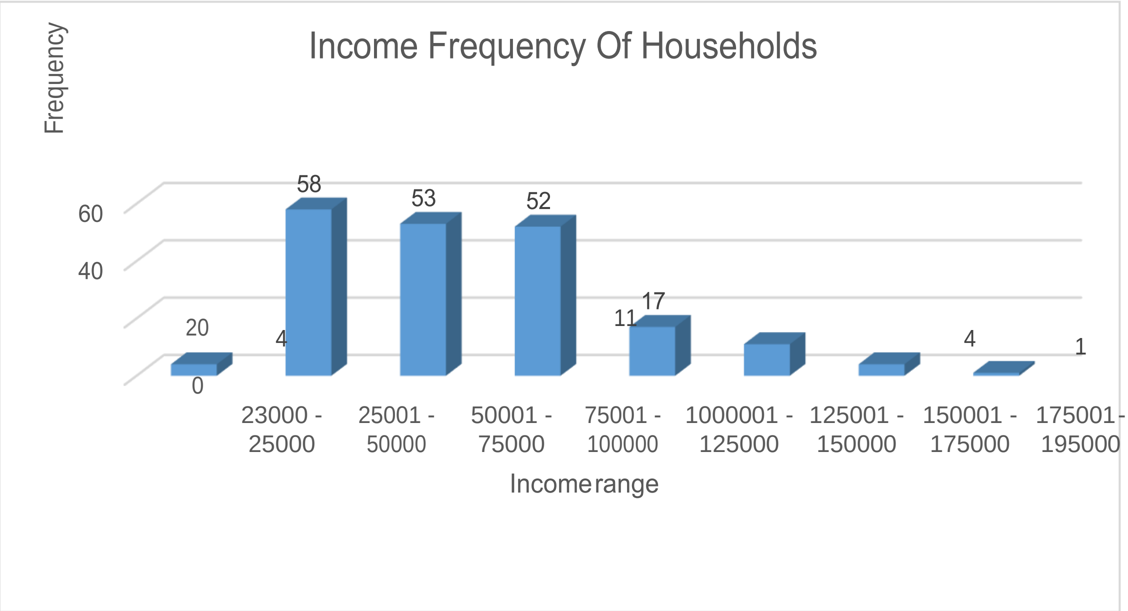
Table 3.4: Table of HHS, HHS Frequency and Gender

Household size	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**
HHS Frequency	4	28	65	66	27	6	3	1	200
Male	3	45	147	181	89	22	15	5	507
Female	5	40	111	145	72	19	9	4	405

3.18 Total Family Income/Month Frequency Of Households

The minimum income of household was 23000 and the maximum income was 195000. The total income of households ranges from 23000 to 195000 rupees. Fifty-eight households lie in the income range of 26000 to 50000 rupees. Fifty-three households lie in the income range of 51000 to75000 rupees. Fifty-two household lies in the income range of 76000 to 100000 rupees.

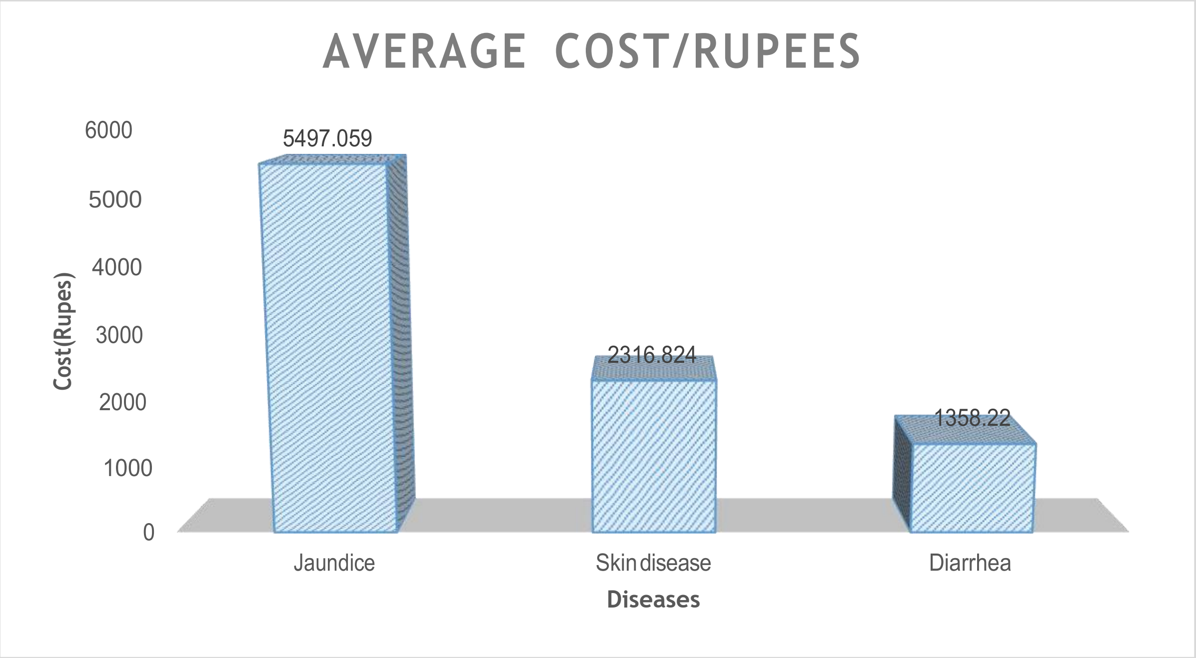
Figure. 3.8: Income Frequency of Households



3.19 Average Cost of Treatment

The average cost of jaundice disease was 5497.059 rupees for six months, while the skin disease have 2316.824 rupees and diarrhea disease have 1358.22 rupees. The average cost of the disease is calculated from the patients which are suffering from one disease only. Direct and indirect medical cost is also included in this cost of treat of jaundice, skin and diarrhea disease.

Figure. 3.9: Average cost of diseases treatment



3.20 Diseases Distribution

In table 3.4, diseases and their occurrence to different family members are shown. From this table, we conclude that mainly jaundice disease affected the old age relations of the households. While skin disease is most frequent in women's and diarrhea is held to children of households.

Table 3.5: Disease Table

Disease	Jaundice	Skin	Diarrhea
Respondent	22	15	7
Spouse	10	52	3
Mother	6	20	0
Father	5	2	0
Son	10	6	33
Daughter	6	21	29
Brother	1	5	6
Sister	2	5	8
Grand/child	2	7	10
Total	64	133	96

Chapter 4

ECONOMETRIC RESULTS

4.1. Introduction

This chapter contains observed results of the econometric model which are given in chapter three. Equations are estimated in Stata software. Results and discussions are divided into the following two sections. Section one is about the disease model which includes the regression results of Jaundice, Skin disease and Diarrhea disease discussing the probability of getting sick. However, Section two is about the health cost model and factors involved in it. Both the section are explained in detail.

4.2: Section 1: Econometric Analysis of Disease model

4.2.1: Regression analysis:

In this section, the first model which is used to calculate the disease to the respondent of the household is logit function. In these regression analysis, the technique which is used to estimate the occurrence of the disease is logit Model, because this technique is used for the dependent variable in the form of dummy having the Jaundice(yes=1, No=0), Skin(yes=1, No=0) and Diarrhea disease(yes=1, No=0). The independent variables which are used in this model are age, monthly income, education, household size, water $source_1$ dummy for drinking and cooking (0=ground + tap water, 1= bottled water), Water $source_2$ dummy for bathing and washing (0= ground+ tap water, 1= other), duration of living in that area and gender. The comparison across each disease model has been made by adding a dummy variable in the model as explained earlier in the methodology. The results of the model have been presented in Table 4.1, 4.2, and 4.3 as shown below:

4.3 Regression results of Jaundice Disease

Table 4.1 Results of the Logistic Model for Jaundice

Variables	Dy/dx	Odds-R	Std. Err.	Z	P>|z|
Age	0.0125	1.06371	.00501	2.50	0.012
Education	-.0199	.906207	.01461	-1.37	0.171
Income	-2.84e-06	.99998	.0000	-1.94	0.052
Household Size	0.0831	1.50621	.03415	2.43	0.015
Gender	-.07184	.70185	.04272	-1.68	0.093
Water Source₁ (Dummy)	-.12135	.545332	.06657	-1.82	0.068

LR chi2 (6) = 24.71 Number of obs = 200 Pseudo R2= 0.0998

Table 4.1 presents the regression results of jaundice disease. Age has a positive and significant impact on the probability of diseases and coefficient is significant at a 5 percent level relationship with the jaundice disease. This implies that a 1-year increase in age is expected to contribute to the probability of diseases by 0.0125 percent. This relationship shows that disease is common in a high age group. Education show an insignificant negative relationship with the probability of diseases. Since the residents of these groups have limited resources at their disposal, the increase in education does significantly increase their health care. Education of the family members does significantly affect the disease likelihood because education brings awareness. Although, education contributes to improving exposure and it has an insignificant and negative relationship with the probability of diseases. Family size shows a positive coefficient with a significance level of 5 percent, implying that larger families have greater tendencies to get infected by diseases. Empirical results reveal that the increase in family size by 1 member leads to an increase in the probability of disease by 0.08 percent. Income has a negative and significant relationship with the disease with a significance level of 5 percent. Empirical results shows that if a 1 unit increase in income leads to a decrease in the probability of getting the disease by 2.84 unit. As the income of households increases, the respondents of households use better food and clean water or purchase water from the market. This would decrease the probability of disease. While in jaundice disease gender is a significant but negative relation with the disease with a significance level of 10 percent. The empirical results show that as the men increase by 1 number in the household then the probability of getting jaundice decreased by 0.71 percent. Water source is significant at 10 percent confidence interval but has negative coefficient value. It means that as household members are shifted from groundwater to bottled water which is the averting measure than the probability of getting jaundice decreased.

4.4 Regression result of skin disease

Table 4.2 Results of the Logistic Model for skin disease

Variables	Dy/dx	Odds-R	Std. Err.	Z	P>|z|
Age	0.0197	1.0865	.00664	2.97	0.003
Education	-.05295	.80011	.01575	-3.36	0.001
Living Duration	-0.0062	.97391	.00264	-2.37	0.018
Household Size	0.0763	1.3791	.03415	2.24	0.025
Gender	-.00492	.97948	.04337	-0.11	0.910
Water $Source_2$ (Dummy)	-.15880	.51287	.07459	-2.13	0.033

LR chi2 (6) = 29.58 Number of obs = 200 Pseudo R2= 0.1103

Table 4.2 presents the regression results of skin disease. Age has a positive and significant impact on the probability of diseases and the coefficient is significant at a 1percent level relationship with the skin disease. This implies that a 1-year increase in age is expected to contribute to the probability of diseases by 0.0197 percent. This relationship shows that disease is common in the high age group. Education shows a significant negative relationship with the probability of diseases. Since the residents of these groups have limited water resources at their household for daily usage for bathing, washing, etc. the increase in education does significantly increase their health care. Education of the family members does significantly affect the disease likelihood because education brings awareness. Although, education contributes to improving exposure and it has an insignificant and negative relationship with the probability of diseases. Living duration of households in the study area shows a negative coefficient with a significance level of 5 percent, implying that as the living duration of households increases families have fewer tendencies to get infected by diseases. Empirical results reveal that the increase in duration by 1 year leads to a decrease in the probability of disease by 0.006 percent. Family size shows a positive coefficient with a significance level of 5 percent, implying that larger families have greater tendencies to get infected by diseases. Empirical results reveal that the increase in family size by 1 member leads to an increase in the probability of disease by 0.076 percent. While in skin disease gender is insignificant but negative relation with the disease. The empirical results show that as the men increase by 1 number in the household then the probability of getting skin disease by 0.004 percent. Water source is significant at 5 percent confidence interval but has negative coefficient value. It means that as household members are shifted from groundwater to other water sources which is the averting measure than the probability of getting skin decreased.

4.5 Regression result for diarrhea

Table 4.3 Results of the Logistic Model for Diarrhea Disease

Variables	Dy/dx	Odds-R	Std. Err.	Z	P>|z|
Age	-.02033	.92048	.00788	-2.58	0.010
Education	.03209	1.1397	.01976	1.62	0.104
Income	-5.69e-06	.99997	.0000	-3.05	0.002
Child (Dummy)	0.1838	2.1155	.08406	2.19	0.029
Adults (Dummy)	0.0516	1.2344	.04272	1.23	0.220
Water Source$_1$ (Dummy)	-.25729	.34000	.07943	-3.24	0.001

LR chi2 (6) = 53.09 Number of obs = 200 Pseudo R2= 0.2024

Table 4.3 presents the regression results of Diarrhea disease. Age has a negative and significant impact on the probability of diseases and coefficient is significant at a 5 percent level relationship with the jaundice disease. This implies that a 1-year increase in age is expected to contribute to the probability of diseases by 0.020 percent. This relationship shows that disease is common in a small age group. Education shows a significant positive relationship with the probability of diseases. Since the residents of these groups have limited resources at their disposal, the increase in education does significantly increase their health care. Education of the family members does significantly affect the disease likelihood because education brings awareness. Although, education contributes to improving exposure and it has an insignificant and negative relationship with the probability of diseases. Children (dummy) shows a positive coefficient with a significance level of 5 percent, implying that children number increase have greater tendencies to get infected by diseases. Empirical results reveal that children if increase size by 1 member leads to an increase in the probability of disease by 0.18 percent. Income has a negative and significant relationship with the disease with a significance level of 1 percent. Empirical results shows that if a 1 unit increase in income leads to a decrease in the probability of getting the disease by 5.69 percent. As the income of households increases, the respondents of households use better food and clean water or purchase water from the market. This would decrease the probability of diarrhea disease. Water source is significant at 1 percent confidence interval but has negative coefficient value. It means that as household members are shifted from groundwater to bottled water which is the averting measure than the probability of getting diarrhea decreased.

4.6 Section 2: Econometric Analysis of Health cost model

To estimate the health cost due to groundwater contamination related symptoms, the Ordinary Least Square model is applied to the data. The dependent variable (health cost) is continuous in numerical form, OLS is the appropriate model for this type of data. The dependent variable in this model is health cost (Rs) while the explanatory variables are the travel cost, doctor fee, medicinal expenditure, lab tests and working hour loss and time lost during the visit due to illness. All these variables are taken in the Rs unit. Other explanatory variables include age (years), education (years of schooling), water source (dummy variable, 0=ground + tap water,1= bottled water), income (Rs/month), probability of (skin disease, Jaundice, and diarrhea disease) and household size). All explanatory variables have been selected after careful analysis of literature and have been discussed in Chapter III in detail. The results for the OLS model have been presented in Table 4.4:

Table 4.4 Regression Results of Health cost model

Total Health Cost	Coef.	Std. Err.	t	P>t
Jaundice	4720.074	556.6075	8.48	0.00
Skin	1906.821	399.1393	4.78	0.00
Diarrhea	1770.807	424.3902	4.17	0.00
Age	44.59203	30.9263	1.44	0.151
Education	-157.3349	94.81905	-1.66	0.099
Novist	1831.357	163.9043	11.17	0.000
HHS	186.8829	220.7582	0.85	0.398
Total time lost	232.0089	18.77448	12.36	0.000
Averting cost	.4263291	.4866255	0.88	0.382
WS(DUMMY)	-1382.254	732.4084	-1.89	0.061
Income per month	.0391335	.008851	4.42	0.000
_cons	-1511.711	1375.31	-1.10	0.273

Number of obs = 200   R-Squared = 0.7139   Prob > F = 0.00

Section 2 contains the health cost function. This regression table shows that Jaundice have significant relation with the health cost. Jaundice is highly significant in this regression. Jaundice disease is the disease which takes the patients to the hospital and in-hospital the treatment can be costly. This implies that a 1 unit increase in disease increases the health cost by Rs 4720 for six months or Rs 786.6 per month. Skin disease is a highly significant and positive relationship with health costs. It implies that 1 unit increase in disease increases the health cost by Rs 1906 for six months or Rs 317.66. Diarrhea has a strongly significant and positive relationship with a health cost. This implies that a 1 unit increase in disease increases the health cost by Rs 1770 for six months or Rs 295. While age in the health cost model has positive relation. Although the result is not statistically significant, it may be because people in old age suffer more from symptoms due to low immunity, lack of physical mobility and improper nourishment but they are also reluctant to visit a doctor. Moreover, due to financial constraints and negligible contribution to family income, the young generation is reluctant to spent on their parents. This may explain the reason that why age has a positive and significant impact on the probability of prevalence of disease but the contribution in cost is insignificant. Education indicates a negative but significant effect on health cost, implying that a 1-year increase in education leads to nearly Rs 157.33 for six months decrease in health cost. The education is considered a proxy for awareness and an increase in awareness makes people more conscious about their health, motivating them to spend more on health. This awareness also leads to adopting averting measures to control disease in advance before it appears. One example could be, buy water from other sources to avoid drinking contaminated ground and tap water. The number of doctor visits and loss of working hours has a highly significant positive relationship with a health cost. By increasing 1 more visit to the doctor in six months, the health cost increases by Rs 1831.357, while the loss of 1 working hour leads to a financial strain of Rs 232.0089, which could otherwise have been a part of the patient's disposable income. Since health cost is a function of averting measures adopted by the residents, Rs 1 increase in the cost of averting expenditures decreases the heath cost by Rs 0.426. Water source had been taken as dummy variable explained above and results depict negative but and significant on total health cost, implying that respondents using water from other sources rather than groundwater are facing less health cost. This also implies that those who are adopting averting measures are facing fewer health costs. If the respondents use their groundwater and tap water, the chances of getting disease increase, which leads to increased health cost. However, if they adopt certain averting measures, such as getting water from filtration plants or buying bottled water, the health cost affiliated with disease decreases. Since it is unknown that for how long they are using averting measures and in the presence of this information the interaction of dummy and from the period they are using may help to measure the impact more appropriately. The income of the respondent shows a positive and significant relationship with a total health cost. An increase in income is proportional to the availability of better health care facilities. Thus an increase in income leads to an increase in health cost.

Chapter:5

CONCLUSION AND POLICY RECOMMENDATION

5.1 Conclusion

Groundwater is the important and main source of drinking water in district Bhalwal. Groundwater is unfit for drinking and household usage. People living in Bhalwal are using poor groundwater due to wastewater effluents of the sugar industry i.e. sometimes people are unaware of the groundwater contamination. Some people have financial limitations due to which they use the contaminated groundwater. The water reports have a high concentration of total dissolved solids, calcium, conductivity, and total alkalinity as compared to the permissible level of a world health organization as discussed in the methodology. While then magnesium and chloride are low as compared to the world health organization. Bacteriological contamination is also shown in water sample reports. Thus, unfit ground and tap water intake of inhabitants results in causing the disease like jaundice, skin and diarrhea disease. About 93.5 percent of people's perspective is that groundwater contamination is due to sugar industry effluents and 54 percent uses ground and tap water. It is essential to note that most of the residents are commonly unaware of the health risk due to the contaminated groundwater. Some household inhabitants consider that the groundwater is free from all types of contamination. About 32 percent of the household report jaundice. While diarrhea is most frequent in children and skin disease was frequently reported in the female. The majority of the respondents are facing disease frequency either 1 or zero, implying that one respondent is not facing more than one disease. Therefore, rather than poison regression, the Logit model is applied to the data due to the binary nature of the dependent variable i.e. in the form of 0 and 1. The explanatory variables for disease model regression were age, gender, education, household size, water source, living duration, and income. The results showed that age and household size had a significant positive effect at 5 percent significance on the Jaundice disease frequency while gender and water source have a negative effect at 5 percent significance. While for skin disease has a water source, education and living duration have a negative effect at 5 percent for water source, living duration and 1 percent significance for age and education. The results in the diarrhea disease model, age, income and water source have a negative effect at 5 percent significance. While income and water source have a negative effect at 1 percent significance. This study concludes that the existence of diseases like jaundice, skin and diarrheal disease due to the contaminated groundwater.

For estimating total health costs, a simple OLS model has been employed. For this purpose, total health cost has been taken as the dependent variable while the explanatory variables include age, education, water source and, income, expenditure on averting measures, diseases and direct and indirect costs (number of visits to the doctor, the financial loss of working hours due to illness). Results show that frequency of diseases, averting expenditure, no of doctor visits, total time lost and income have a significant positive relation with total health cost while water source and education has a significant negative relationship with a health cost.

In conclusion, this study proves the existence of effluents of the sugar industry in groundwater of the selected areas of tehsil Bhalwal along the wastewater channel of the sugar industry. High level of groundwater contamination in water has led to several diseases like Diarrhea disease, Jaundice disease, and skin problem females and diarrhea in children of all age groups. The results revealed that water contamination due to sugar industry effluents and decreasing water quality is the leading cause of symptoms inthe study areas. The increased frequency of diseases also leads to elevated health costs that are borne by the residents. The lack of education coupled with scarce resources forces the residents to live in these impoverished circumstances. People continue the use of contaminated ground and tap water for their daily life activities while only some of them can afford to spend on adopting averting measures.

5.2 Policy Recommendation:

- The respondents of the study area are facing the problem of safe drinking water and the concerned authorities must take immediate steps towards the upgrading the existing and installation of new filter plants in district Bhalwal.
- The polluter pay principle to the sugar industry and the residents which are polluting the environment is applied to generate the sense of responsibility in residents and the concern authorities of the sugar industry.
- The responsibility of the educated people of the study area as well as the local authorities to address this grave issue and to save people from the health risk.
- Bacteriological contamination was due to the inadequate treatment and sanitation, poor sewage and drainage system in the area. Another reason of the bacteriological contamination was the intermitted water supply, improper maintenance and the scattered layout of sewer lines and government drinking water supply lines. The government must layout the future water supply and sewer pipes opposite sides to each other of the street to eliminate the chances of cross-connection between them.
- The government should play a vital role to start the extension programs regarding the awareness and importance of public health issues related to groundwater contamination.

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Appendix: I

Water analysis reports

	W.H.O Max Permissible Levels	Results			
Parameters		**1**	**2**	**3**	**4**
Temperature	NGVS	---			
Depth (Feet)		130	90	110	110
Ph	6.5-8.5	7.98	8.02	8.32	7.87
Odour	Unobjectionable	Ok	Ok	Ok	Ok
Colour	<15TCU	Ok	Ok	Ok	Ok
Taste	Unobjectionable	Ok	Ok	Salty	Ok
Turbidity ppm silica units or N.T.U	<5NTU	0.08	1.02	0.06	0.02
TDS mg/l	1000	290	970	4900	1020
Calcium mg/l	200	40	56	104	44
Magnesium mg/l	150	7.5	17.5	92.5	32.5
Total Hardness mg/l	500	130	210	630	240
Total Alkalinity mg/l	NGVS	170	270	410	200
Sulphate mg/l	250	170	600	659	432
Chloride mg/l	250	57.6	102.3	197.2	75.4
Iron mg/l	1	1.02	1.6	1.85	1.5
Conductivity mg/l	NGVS	414	1385	7000	1457
Fluoride mg/l	1.5	0.9	1.85	1.68	1.7
Arsenic ppb	50	---	Nil	Nil	Nil
Bacteriological analysis results	There should be no colony of coli from bacteria per 100/ml sample	contaminate	---	Nil	Nil

Appendix II

Survey Questionnaire

Group________________ Serial No.____ Date: / /2019

I am M Phil Research student department of Environmental Economics at Pakistan Institute of

Development Economics (PIDE) Islamabad. Mainly my focus is to **"Groundwater contamination and its impact on health: A Case Study of Tehsil Bhalwal District Sargodha".** This is the part of my M.Phil. Thesis and this information will be very helpful to me. I request you to kindly respond to the questionnaire.

I would like to assure you that the information given by you will be kept strictly confidential and will be used for research purpose only.
I am hopeful to receive your co-operation

Muhammad Imtiaz Khan

SECTION I
Personal Information

1. Name_____________.
2. For how many years you are living in this area:
   .
3. Address:
   .

SECTION II

Sr. No.	Ground water contamination Awareness	Yes/No
1	Do you feel any change in odour of the water?	
2	Do you think ground water contamination is due to sugar industry effluents?	
3	Do you think ground water contamination is due to sewerage or other factors?	

Sr. No.	Groundwater Contamination Awareness	1	2	3	4
1	In your opinion, how serious is the problem of industrial contamination polluting the ground water?				
2	How seriously effecting is the problem of water pollution to the ecosystem?				
3	In your opinion, how serious is the problem of safe drinking water in your area?				

Very Serious=1, Somewhat Serious=2, Not Serious=3, Don't now=4

SECTION III

Usage of water:

	Groundwater	Tap Water \Government Supply	Bottled Water	Others
Drinking				
Cooking Meal				
Bathing				
Washing Dishes				
Washing Clothes				
Home Cleaning				
Garden Use				
Bike/Cars wash				

Precautionary Measure for Water

	Drinking	Cooking Meal	Cost
Boiled			
Filter			
Use of chlorine for purification			
Bottled water			
Others			

Information About Family Members

Sr. No	Name	Gender Male=1 female=0	Education (Years)	Age (In Years)	Relation of responded with family member	Working=1 Not working=0	Income Resource Govt=1 Private=0 Others=2	Occupation	Monthly Income (Rs)	Monthly Expenditure (Rs)
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

SECTION IV Health Cost Incurred

Sr. No	Last Six(6) Month											Health Cost (Rupees)						
	Name	Jaundice disease Yes=1, No=0	Disease Frequency	Duration of Sickness	Skin Disease Yes=1 No=0	Disease Frequency	Duration of Sickness	Diarrhea Yes=1 No=0	DiseaseFrequency	Duration of sickness	Doctor fee	Lab Test fee	Medicinal Exp.	No of Visits to Doctors	Traveling Cost	Working Hour Loss	Time Lost For Visits	E
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		

Appendix: III

Age Table

Age	Frequency
1-10	113
11-20	171
21-30	233
31-40	124
41-50	117
51-60	121
61-70	26
71-80	6
81-90	1

Minimum age is 1 year while maximum age is 90. Maximum members that is 233 have age range from 21 to 30 years.

Education in years

Minimum years of education is zero while maximum year of education is eighteen years. Maximum frequency 291 respondents which have year of education range from 13-16 years.

Table 1 Education in years

Years of Education	Frequency
0	76
1-4	64
5-8	204
9-12	272
13-16	291
17-18	5