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Research Thesis

Groundwater Contamination Due to Industrial Waste Water and its Impacts on Human Health: A Case Study of Faisalabad

By

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Pakistan Institute of Development Economic

CERTIFICATE

This is to certify that this thesis entitled: **"Groundwater Contamination Due to Industrial Waste water and its Impacts on Human Health – A Case Study of Faisalabad".** submitted by Muhammad Shoaib Siddiqui is accepted in its present form by the PIDE School of Public Policy, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in **Master of Philosophy in Environmental Economics**.

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Dedicated to my Family

Friends and Teachers

Especially to my Elder Brother

(May Allah Bless Them).

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ABSTRACT

Water is the basic requirement of life necessary for drinking, household food preparation, agriculture, animals, and other different purposes. Groundwater is the primary source of water, which is a key driver of domestic, agriculture, industrial sectors. Water pollution is a major problem in Pakistan. Industrial wastewater is a potential source of water pollution and a common threat to the aquatic life of people. Small Estate Area Faisalabad is an industrial zone and industries wastewater discharge which may secrete many hazardous elements in the environment like contaminated water polluting the environment. The current study evaluates the health impacts of contaminated groundwater in Small Estate Area Faisalabad.

We took four water samples from the study area which revealed that the water was unfit for human use. Water samples were tested from Ayyub Research Laboratory Faisalabad. The pH was 6.9, TSS (ppm) 1936.8, Sodium (Mel^{-1}) 22.65, Sulphate ($^{Mel-1}$) 2.40, and Total Hardness (ppm) 241.07 were found to be inconsistent with the required World Health Organization standards. The information about socioeconomic variables and diseases due to the use of groundwater (skin problem, diarrhea, and typhoid fever) was directly collected from 200 families through a well-structured questionnaire. To explore the determinants of frequency of disease, age, education, household size, water source, and quality were considered as explanatory variables.

This study concludes that as the water usage in that particular area increases the probability of diseases like diarrhea, skin disease and typhoid also increase which increases the health cost. The study recommends that the government should play an important role to take this issue seriously and build a cemented wastewater channel for the industrial sector of Small Estate Area Faisalabad.

Chapter I: INTRODUCTION

1.1 Background

Water is the primary component of the fluid of living things and is the reason for all known forms of life. Other than Earth, no other planet in the universe is a comfortable place for human beings and other living belongings because of the non-existence of water. Water is a crucial substance that plays a momentous role in the daily life of living organisms. Groundwater is one of the primary water source which is a key driver of domestic, industrial, and agriculture sectors. The availability of water per capita in Pakistan has decreased from 5600 cm^3 per annum in 1947 to 1000 cm^3 per annum presently. Over the past few decades, water demand increase day by day due to an increase in the population. People use water for many purposes, like drinking, taking a shower, washing, cooking, and cleaning, etc. Polluted water is harmful to human health but still after knowing all these reasons most people are using polluted water and suffering from dangerous diseases.

The quality of pure drinking water is essential for every living being because drinking polluted water can be fatal. Some people are deprived of it, especially people living in rural areas. Also, flood-affected people are the main victims of polluted water. Although Pakistan has been gifted with plentiful water resources like rivers flowing down the Himalayas and Karakoram heights from the world's largest glaciers. However, it has become difficult to get pure drinking water. Although water pollution is rapidly increasing, at the same time many practices are present through which we can purify water. Therefore, people from many countries are suffering from dreadful diseases, especially those living in rural areas. These diseases can be both short and long-term. They include cholera, dysentery, diarrhea, gastrointestinal diseases, and jaundice, etc. Infants are mainly affected by microorganisms because of their low immune system.

1.2 Textile Industries of Pakistan

Globally, the textile is one of the leading industries after agriculture (Sangeetha, et al., 2013). In Pakistan, the textile industry holds the leading role among the manufacturing sectors. This sector contributes almost 8.5 percent to the GDP, provides employment to more than 46 percent of the labor force and contributes a major share to the foreign exchange earnings of the country. Among the Asian countries, Pakistan stands at 8^{th} position in terms of textile exports, 4^{th} position in cotton production and has 3^{rd} largest spinning capacity in Asia after China and India and contributes 5 percent to the global spinning capacity (Government of Pakistan, 2015). Faisalabad is a contributor of more than 20 percent to Punjab's GDP averaging around $20.5 billion. Alongside this, the textile zone is one of the most polluting sectors in the world (Banuri, 1999). The textile industry is associated with many environmental problems such as water pollution, soil pollution, noise pollution, and air/dust pollution. In Pakistan, industrial waste and wastewater are directly released into nearby water storages like rivers, drains, ponds and streams along with open fields where the farmers are cultivating crops without any treatment of those lands (Khalid et al., 2018).

The total number of textile industries in Pakistan is approximately 670. The waste from textile industries comprises of different harmful elements like Ni, Cr, Zn, Cd, Cu, As, Pb, Fe, and Mn. In Faisalabad, the industrial wastewater is disposed into the rivers Ravi and Chenab. This industrial wastewater pollutes freshwater sources such as river water, groundwater and freshwater streams (Akhtar, et al., 2005).

Total discharge of wastewater in 14 major cities of Pakistan is 962,335 million gallons from which 674,009 million gallons are produced from municipal use and 288,326 million gallons from industrial use. Total wastewater discharge into major rivers is 392,511 million gallons which consist of 316,740 million gallons of municipal and 75,771 million gallons of industrial effluents. About 2000 million gallons of sewage is discharged to local surface bodies every day (PAK-SCEA, 2006)

Faisalabad, the city of textile, is the 3rd most populous city of Pakistan. According to an estimate 1100, MCM/year effluents were generated in Faisalabad dispose-off through surface drains; Paharang and Madhuana. Awagat Branch joins Madhuana and Samundri Branch and converts into Samundri main drain. It carries wastewater from the residential and industrial areas of Faisalabad and Samundri disposes of into river Ravi at Bullahy Shah Mamoon Kanjan district Faisalabad (Report EPA, 2010).

The groundwater used in the household also causes different diseases like diarrhea, waterborne disease, stomach problem, skin problems are the leading cause of death in infants and children. Diarrhea is defined as the passage of loose, liquid, or watery stools (World Health Organization, 1985). The big resource polluting the water that is industrial wastewater. Long term use of polluted and fluoride contaminated drinking water causes skin pigmentation and skin cancer (Thakur et al., 2013). In Pakistan, every fifth citizen suffers from disease due to polluted water usage. In Faisalabad also, groundwater quality is extremely poor.

1.3 Problem Statement

Water pollution is a major problem in Pakistan as drinking water quality is improperly managed and monitored. In the drinking water quality index, Pakistan ranks at 80 among 122 countries (Azizullah,. et al (2010). Industrial wastewater not only causes water pollution but is also fatal to aquatic life as well as the people that use this water directly and indirectly. At present, industrial wastewater is posing a threat to the availability of stored water. In developing countries, the condition is worse where over 90 percent of raw sewage and 70 percent of untreated industrial waste are dumped into groundwater and surface water (Anonymous, 2010). It has been estimated that in Pakistan only 1 percent of industrial wastewater gets treated before being discharged (MOE-Pak, 2005). Most of the industries dispose of their wastewater directly into the nearby water sources without regard to environmental degradation (Ullah et al., 2009)

Faisalabad is an industrial hub where industries discharge many hazardous elements in the environment like contaminated water and air pollution that's why many environmental problems exit like dust/air pollution, water pollution, land pollution, etc. Due to the discharge of polluted industrial wastewater groundwater contamination is rising (Mehwish & Mustafa, 2016). It affects the environment and surrounding population near Small Estate Industries Nalka Kohala Sargodha Road Faisalabad. Health problems increase day by day like typhoid fever which is caused by a bacterium, Salmonella typhi. However typhoid fever is rare in industrialized countries but diarrhea, skin problems, hepatitis, etc. are common illnesses. As a result, this study contributes to the literature on water-related diseases and the economic implications associated with them.

1.4 Issues and Gap

- Groundwater use is not health-friendly in Faisalabad.
- Contaminated water put an adverse impact on people's health, furthermore, monetary cost incurred economically distress the people as they lack resources to go to the hospital and aware of medical facilities.
- According to the best of my knowledge, there is no study exists that monetizing the damages of water contamination in Pakistan. The present study is attempting to fill this gap.

1.5 Objectives of the study

a. Assessing the impact of polluting contaminants on groundwater quality in Faisalabad.

b. Assessing the impact of contaminated groundwater on humans in Faisalabad.

c. To evaluate the Health cost borne by people due to the use of contaminated water, living in Faisalabad.

1.6 Research Question

a. What are the impacts of polluting contaminants on groundwater quality in Faisalabad?

b. What are the diseases incurred by using contaminated water?

c. What amount of health cost is borne by people who use contaminated water?

Chapter II: LITERATURE REVIEW

2.1 Review of Literature

Tariq, et al., (2006) studied the characteristics of industrial waste and their possible impacts on groundwater quality. The study was conducted Hayatabad industrial estate (HIE). The total 12 samples and including 7 from industrial effluents at the discharge point of each industry and 1 from drain receiving effluents 4 from the tube or dug wells. The main chemical that finds in the water (cd, cr, cu, fe, mn, ni, pb, zn). The permitted limit comparing with the National Environmental Quality Standard (NEQS). The BOD was above the acceptable limit in almost all of the effluent. The other recommendation of this study is that the social awareness and water treatment plant etc.

Ahmed A., et al., (2007) examined irrigated land supplies which contribute to more than 90 percent of agricultural production and serve most of the country's food demand. The agriculture sector is considered as the foundation of Pakistan's economy. It indorses 25 percent of the GDP and nearly 50 percent labor force is engaged in the agricultural sector. The agriculture sector uses more water and its consumption continues to govern water requirements. Similarly, for industrial development, the main reason for energy is hydropower, which is generated by the impression of water stored in huge dams and reservoirs. Therefore water is detrimental to the survival of our economy.

Halder J. N., Islam., (2015) analyzed water dynamics among all natural resources, and its importance for the existence of society, food production, and economic development. On a global level, numerous cities face serious water deficiency while nearly 40 percent of the world's food supply is grown under irrigation and an extensive variety of industrial processes depend on freshwater. The environment, economic growth, and progress are all vastly inclined by water-its regional and seasonal availability and the quality of surface and groundwater. The quality of water is pretentious by human actions and is deteriorating due to the increase of urbanization, population growth, industrial production, climate change, and other factors. The subsequent water pollution is a severe danger to the well-being of both the Earth and its population.

Pawari & Gawande (2015) explained that most of the complications that affect the mortality rate of humans are related to water quality. (Schwarzenbach, Egli, Hofstetter, Gunten, & Wehrli, Global Water Pollution and Human Health, (November 2010), In recent years, due to anthropological actions, the groundwater quality has decreased day by day which is caused by adulteration or overexploitation or by a combination of both. The different activities in domestic and industrial create multifaceted problems.

In numerous countries, groundwater is the prime source of water for household, agricultural and industrial usage. India acquires 2.2 percent of the global inclusive land and 4 percent of the global water possessions along with 16 percent of the total world population. It is projected that nearly a third of the world's population consume groundwater for drinking purposes. Therefore, water quality concerns and administration options require more attention in developing countries. Increased demand for groundwater resources in India is also majorly due to harsh agricultural activities. Water quality is subjective to natural and man-made effects along with local climate, physical or land features and irrigation practices.

Sayal, et al., (2016) studied the cause of human illnesses and concluded that a large number of the health diseases are aquatic with their course of action as to move directly through the intestinal tract or contact with contaminated food and water. Nearby communities of the industrial wastewater passages are relatively more unprotected to the hazardous health effects caused by these pollutants. The quantification of health effects endorses the economic viability resulting in their condensed utility. The presence of heavy metal pollutants and disease-causing particles is verified by chemists, environmentalists, and epidemiologists. An affiliation between heavy metal pollution and health has been the concern of natural science experts for a long time. However, for the quantification of these health impacts, illness and anticipation costs are required to be presented in quantitative terms. Multiple economic strategies have been devised for health injury caused by environmental pollution quantification. These all methods contain revealed partialities, stated partialities, contingent valuation, willingness to pay, etc. The important citizen for such an assessment of health impacts is the health production function or dose-response model. The health production function used to study the relations among pollution, illness, willingness to pay and averting expenses. The total cost of illness can be computed by calculating the loss of efficiency, working days lost, opportunity cost, and expenditures on medicinal treatment. Whereas the averting cost valuation is based on all the preventative measures to avoid the fatal effects of heavy-metal pollution.

Solicitations and assets of averting expenditure techniques are most useful to lessen the level of distress rising from externalities for assessment of the willingness to pay of the peoples and to estimate the real costs or benefits of drinking water quality. However, averting expenditures are explained in contradiction to various types of pollution. Illness and averting costs approaches have also been used to estimate the welfare improvements of air pollution reduction, arsenic elimination from drinking water, and cement air pollution using health production function.

Krishna, et al., (2009) examined in this study the statistical methods for data interpretation which have been obtained during a monitoring program of ground and surface water in Patancheru industrial city near Hyderabad, India. Thirteen parameters including trace origins (B, Cr, Mn, Fe, Co, Ni, and Zn, As, Sr, Ba and Pb) have been monitored on fifty-three sampling points from a hydrogeochemical survey collected from surface and groundwater. Water covering of about 120 km^2 had been established during the mid-1970s on Hyderabad. Fifty-three samples of water (surface and groundwater) were collected which cover entire Patancheru, Nakkavagu, Peddavagu, Pamalavagu basin. The case study of surface and groundwater pollution due to uncontrolled industrial waste discharges and the results of factor analysis performed on eleven heavy metals recognized four factors for surface water and two factors for groundwater controlling their variability in waters of Patancheru.

Wu & Sun, (2016) studied the assessment of groundwater quality for a better understanding of the status of groundwater pollution and impending dangers to residents in alluvial plains of China which are the hub of agricultural and industrial activities. The objective of the study was to analyze water contaminated due to industrial wastewater and also its impact on people’s health. The data uses in the study in secondary form. Ninety samples were collected from shallow pumping wells during October 2013. It was found that shallow groundwater is extremely polluted with TH, NO_3, NO_2, TDS, SO_4^2, and F. The distribution of pollutants specifies that the industrial and agricultural happenings are important factors that impact groundwater quality. Water pH ranges from 7.72 to 8.31 with an average of 8.13, which states that the groundwater in the study area is somewhat basic. The dominance of minerals in groundwater is Ca_2 Na Mg_2 K by their average values. Groundwater quality in muddy plains is impacted intensively by agricultural and industrial activities, as 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.

Suthar, et al., (2010) analyzed water quality and assessment of the river Hindon at Ghaziabad, India along with the impact of industrial and urban sewerage wastewater. The data uses in the paper is primary data. The Hindon water sample was collected from different sites. The annual rainfall mean in this area is 702 mm varying spatially in different sub-regions of the district. The Econometric technique ANOVA was used. PH indicator was used to check the water quality for drinking purposes and irrigation. BIS suggests the 6.5 to 8.5 PH value range 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.

Khan, et al., (2013) Examined in the study is Health hazards associated with heavy metals in the Swat drinking water, Northern Pakistan. The objective of the study is to check the health risk due to heavy metals from industrial waste in the drinking water. The primary data was used in the study. The data were collected from Madyan, Fatehour, 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 for health. The metal creates problems in the drinking water and also immoral impact on health. The study concludes that heavy metals like (Mn, Ni, Zn, Cd, Cu, and Pb) in the drinking water collected both surface and groundwater resource that metal has big problems creates 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.

Abdalla, et al., (1992) Analysis in this study the Valuing Environmental Quality Changes Using Averting Expenditures. The objective of the study to determine of the consequences of the provision of new technologies and averting expenditure for safe drinking. Primary data was taken for this work. In this study the

Researcher checks the averting expenditure for safe drinking water. And many problems exist in the water body and check for the averting expenditure. The secondary data was used. The results of the study is that averting expenditure has let to provision of clean water, on the contrary, the groundwater still remains highly contaminated unfit for household uses. The study concludes that Data on the averting expenditure increases of households in a Pennsylvian community was collected to estimate the costs of a groundwater contaminated incident. Averting Expenditures were estimated to range from $61,313.29 to $131,334.06 during an 88-week TCE contamination period. Averting expenditure is compulsory for drinking water.

Baba & Tayfur, (2011) studied the polluted ground and surface water and its health effects in Turkey. The main objective of the study is to check groundwater pollution that falls into two main categories: natural and anthropogenic sources. Important sources of natural groundwater pollution in Turkey include geological formations, seawater intrusion, and geothermal fluid(s). The data type used in secondary form. To check the impact on the groundwater contamination through natural and anthropogenic sources. The anthropogenic sources have an impact on public health. And natural sources like mining have bad impact on health. The source is mining, industrial waste, agriculture sector, and many other emissions.

Singh & Singh, (2011) examined the impact and range of groundwater pollution in a rural area in Punjab State, India. The objective of the study checks the impact of groundwater quality for 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 indicate a positive and significant relationship between government policies (investment in public research, extension, and highways and commodity programs) and productivity and growth. If the government intervenes with direct payments like commodity programs, it could affect the dimensions of the water and healthcare structure.

Wu & Sun, (2016) studied the economic and health perspective of groundwater contamination due to industrial wastewater. The objective of the study to check the willingness to pay of the people for safe drinking water. In this paper primary data was used. The focus of the study was to check the impact of lead (Pb) contamination on drinking water from industrial waste sources on population health and utility in Dingi village, near to an industrial estate in Haripur Pakistan. GIS approach was used for water sampling and household's survey. The quantification of health impact was based on the scientific tools of environment, economic theory, econometrics, and statistics. Marginal willingness to pay was based on chances of sickness, medical costs, and avertive costs and was yearly estimated at $53 per household. The opportunity cost of leisure ($22) and aversive measures ($54) were also calculated to find the total economic cost borne by the households ($300).

Nasir et al, 2016 studied the impact of contamination on the underground water. The study was taken in 2014-2015 to assess the status of water quality of the study area of district Faisalabad. Randomly sample was taken from industrial wastewater channel that carries wastewater of industrial Estate of Faisalabad, as well as the local sever to measure the pollution contribution of these source to the river Ravi and also its consequence on groundwater. The quality of groundwater pumped near drains for drinking was found the worst as on 90 percent of the sample was found unfit concerning TDS, Na, K, Ci, and So^4. The biggest problem is the area is industrialization and also groundwater contamination due to the wastewater of the industry.

2.2 Conclusion

Water is one of the basic requirements of life. Water is essential for drinking, agriculture, household food preparation, livestock, and other many other purposes. Nowadays it is difficult to get pure drinking water, pure drinking water decrease day by day due to different practice like industry practice, pesticide use in the agriculture sector, etc. The waste of industry comprises of the different harmful element that is, Ni, Cr, Zn, Cd, Cu, As, Pb, Fe, and Mn, that all harmful chemical pollutes the groundwater quality that water not useful for the human use (Tariq & Ali, 2006). In the Faisalabad, the industry wastewater disposed into river Ravi and Chenab. The use of polluted water creates different type of disease like diarrhea, waterborne disease, stomach problem, skin problem is leading cause of death in the infants and children. 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 Faisalabad 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 III: DATA DESCRIPTION AND RESEARCH METHODOLOGY

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

3.1 Study Area

Faisalabad has the largest number of industrial zones in Pakistan. Faisalabad is also called the "City of Textiles" because the number of industries clustered in the district Faisalabad is on a broad scale. The textile industry is the backbone of the economy of Faisalabad. These all industries play a key role in the development of the city and contributing five billion dollars of annual textile exports from the Faisalabad textile industries. However, these industries are a big polluting source, apart from leather and sugar industries. Small Estate Industry Area located in district Faisalabad is the most industrial area in Punjab province. At present, there is no treatment facility exit in Small Estate Area, and waste effluents are discharged to the nearby drains, without any treatment. The waste of these industries comprises of different hazardous elements such as Nickel, Chromium, Zinc, Cadmium, Copper, Arsenic, Lead, Iron, and Manganese. The industrial wastewater is disposed into the Ravi and Chenab rivers. Thus the major contaminated sources are industrial wastewater and household wastage (Mehwish & Mustafa, 2016). The industrial wastewater, as well as household wastage, are two big channels that pollute the groundwater quality. Aleem, et al,. (2018). This is my research area where the quality of groundwater is polluted day by day and also causes hazardous impacts on people’s health due to different type of disease like diarrhea, typhoid fever and waterborne diseases which are reported as the leading cause of death in infants and children.

3.2 Data Collection Procedure & Sampling Technique:

3.2.1 Data Collection Procedure

To achieve the first objective of my study, various water tests were performed for assessing water quality. They include pH, turbidity, TDs, TA, TH, DO and Sulphate test. Water quality testing for hazardous chemicals that contribute to water pollution and health problems were also performed. All diagnostic work was performed in the Biochemistry Laboratory, soil, and environmental section, Ayyub Agriculture Research Institute, Faisalabad.

To achieve the 2nd objective of my study questionnaire-based primary data was collected from households about the types of diseases borne by people, type of water resource use of people, and expenditure on health, loss of working hour, averting measures for drinking water of the people of Small Estate Industrial area Faisalabad.

3.2.2 Sampling Technique

A total sample of 200 respondents was taken from the residents of the small estate in Faisalabad. Random sampling was employed based on their residential setting and demographic characteristics. Simple random sampling is a sample if individuals that exist in a population are selected at random, without any set rule or formula. The first part of the questionnaire tested the groundwater quality for drinking purposes, PH level, and industrial waste chemical in the groundwater, information about which was obtained through quantity. The second part of the questionnaire asked the respondents about the types of diseases they suffer from and the third part inquired about the health cost borne by them.

3.2.3 Discussion of data

Questionnaire has been divided into three parts. First part covered the socio-economic and demographic variables. Section two mainly focused on health issues, types of disease and also types of water resources used for drinking, shower and other use, and other purposes. Third section of the questionnaire covered the health cost spending, either direct or indirect cost of treatment of illness. Indirect cost, doctor fee (per visit), travel cost (return) medicinal expenditure, lab test, and other costs that are directly related to disease and respondent were considered. In indirect cost, loss of working hours, the opportunity cost of illness, cost of an attendant with diseased persons were taken.

3.3 Research Methodology

Parameters of water quality provide essential information about the water quality and the health of 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 solid (TDS), Potassium (k), chloride, magnesium and calcium. While 4 samples are collected from 4 different area of Small Estate Area Faisalabad as per international standards. All the water samples are analyzing in Ayub Agriculture Research Institute. Water quality of study area Small Estate Area Faisalabad was compared with World Health Organization maximum permissible level.

3.4 Econometric Models

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

3.4.1 Model 1

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

Equation I

$$(logit)D_1 = \beta_0 + \beta_1 Age_i + \beta_2 Edu_i + \beta_3 Gen + \beta_4 Chl_i + \beta_5 Inc_i + \beta_6 WS_1 + \varepsilon$$

$$(Logit)D_2 = \beta_0 + \beta_1 Age_i + \beta_2 Edu_i + \beta_3 Gen + \beta_5 HHS_i + \beta_6 WS_{2i} + \beta_7 DL_i + \varepsilon$$

$$(logit)D_3 = \beta_0 + \beta_1 Age_i + \beta_2 Edu_i + \beta_3 Gen + \beta_4 Inc_i + \beta_6 WS_{2i} + \varepsilon$$

Variable Specification:

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

D_2: Skin Disease (Yes =1, No = 0)

D_3: Typhoid Fever (Yes=1, No=0)

Age: Age (in Years)

Edu: Education (Years of Education)

Gender: (male =1 female=0)

Total Income: Total Income of household (In rupees)

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

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

DL: Duration of living in the area (in Years)

Child: Number of children's in household

The expected signs of the coefficients of the dependent as well as independent variables have been gathered in Table II. These signs have been seen in the literature on groundwater-related diseases like the work of (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 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 Diarrhea		
D_2	Individual estimation of Skin disease		
D_3	Individual estimation of Typhoid Fever		
Edu.	Education of Respondent (Years of Education)	Positive (-)	
Age	Age of respondent (in Years)	Positive (+)	
Gen.	(male =1 , female=0)	Pos/Neg (+/-)	
Inc.	Total Income of family (In rupees)	Pos/Neg (+/-)	Sayal et al., (2016)
Children	Number of children in household	Positive (+)	
WS_1	Groundwater+ Tap water=0, bottled water=1	Neg (-)	
WS_2	Ground water=0, tap water/other=1	Neg (-)	
HHS	Household size	Pos/Neg (+/-)	
DL	Duration of living	Pos(+)Neg(-)	

3.4.2 Model II

In Pakistan average spending on health care is 33 percent by public and most spending in Pakistan is private spending (Muhammad, et al., 2015). Health cost (in rupees) is our dependent variable and the data related to health costs collected through primary survey. As my dependent variable is continuous in nature so I used ordinary least square (OLS) depending on the distribution of data. If it is normally distributed with mean and variance equal to zero, OLS estimation is used (Team, 2017).

Equation II

$$HC = \beta_0 + \beta_1 Age_i + \beta_2 Edu_i + \beta_3 Gen_i + \beta_4 Inc_i + \beta_5 HHS + \beta_6 WS_1 + \beta_7 WS_2 +$$

$$\beta_8 Novst + \beta_9 TTL_i + \beta_{10} D_1 + \beta_{11} D_2 + \beta_{12} D_3 + \beta_{13} AVRT_i + U_i$$

HC: Health cost (In rupees)

Age: Age of respondent (in Years)

Edu: Education of Respondent (Years of Education)

Gen: (If male =1 female =0)

Income: Income of respondent (In rupees)

HHS: Household Size (total family members)

WS_1: groundwater water

WS_2: Filter Water

WS_3: Bottle water

D_1: Diarrhea

D_2: Skin Dieses

D_3: Typhoid Fever

AVRT: Averting measures

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

No vist: Number of visits to doctor in a month

Health Cost	Doctor Fee, Medicinal expenditures, Lab test expenditures, Travelling expenses, Loss of working hours multiplied with an hourly wage.

Table 3.2 Variable Specification

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 (-)
Gen	If Female=0, Male=1	Pos (+) Neg(-)
WS_1	If uses Groundwater +Tap water=0, Bottled water=1	Pos (+) if (0)
WS_2	If uses Ground Water=0 Tap Water=1	Neg (-) if (1)
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 doctor in a month	Positive (+)

3.5 Variable Description

Gender

Gender is taken as 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 problem is more predominant in females as compared to males.

Education

Education refers to the years of schooling received by the respondents. It is associated with awareness about the surroundings and more importantly, the contaminated water problem in the research area.

Age

Age is taken in the form of continuous, explanatory variable. It is assumed that 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.

Children

I took child as an explanatory variable. Here the child is considered any individual less than ten years old. In the regression results, the child has the positive effect for diseases.

Water Source and Quality

Water source is taken as a dummy variable i.e. (groundwater=1 and otherwise 0 as it is for other sources). There are three type of water sources; groundwater, filter water, bottled water.

Income

Income is taken in Rs per month. It relates to the drinking water quality because affordability for better water is associated with income. 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 income impact on different diseases. Among them includes Thakur et al. (2015); Roy, (2008) and Khan, (2007).

Health Cost

It is taken in two groups i.e. direct and indirect cost. 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. This variable has been included after literature revealed its direct role in economic well-being of households (Chowdhury et al. 2015).

3.5 Data Analysis

Descriptive Analysis of the Data

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

Table 3.3 Descriptive Statistics of Variable

Variables	Obs	Mean	Std. dev	Min	Mix
Age	200	27.4058	8.252076	14.25	57.5
Education	200	8.252076	2.622229	2.6	15
Income	200	47847.5	24007.81	14500	149000
Gender	200	1.456583	1.331886	0	1
HHS	200	4.54	1.314167	2	8
N0 of Visits	200	4.01	1.974689	0	10
Working Hour Loss	200	46.925	46.40524	0	315
Water Source	200	0.06	.23808828	0	1
Averting Measure Cost	200	798.85	455.5842	0	2550

3.6 Socio-Economic Variables or Characteristics of the Respondents

Living Year Duration

The total number of observations was 200. The year range is set from 1 to 10. The minimum year was 1 and the maximum is 70 in my data. The maximum household 58 lies in 11 to 20 years range. The total members of 200 households were 906.

Table 3.4 Living Duration

Year Range	Frequency
1-10	36
11-20	58
21-30	46
31-40	23
41-50	21
51-60	12
61-70	4

Groundwater Contamination Awareness

Table 3.5 shows that people's awareness about groundwater odour, contamination due to industries wastewater and contamination due to sewerage. Binary form data is used as 0 for No and 1 for Yes

1.50 percent of respondents say there is no odour in the water, 98.5 percent of peoples say Yes. Groundwater contamination due to industry results in 5 percent respondents answering No and 95 percent as Yes. 3rd one is groundwater contamination due to sewerage in which 64.50 percent respondent answer No, there is no contamination due to sewerage and 35.50 percent people answer Yes, groundwater contamination is present due to poor sewerage system.

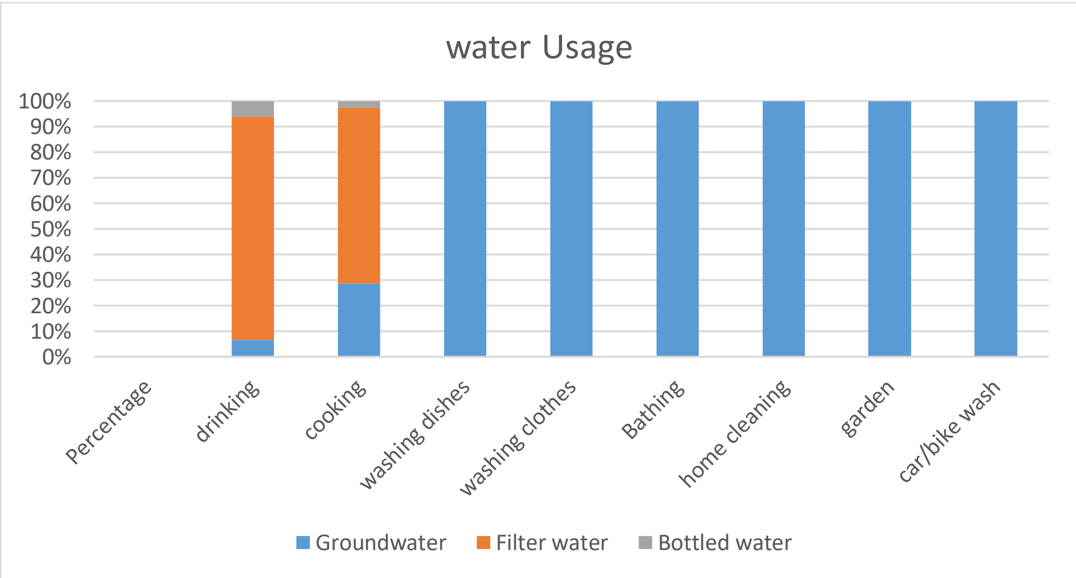
Table 3.5 Groundwater Contamination Awareness

1.Water Odour	**Frequency**	**Percentage**
0	3	1.50
1	197	98.5
2.Groundwater Contamination due to Industry	Frequency	Percentage
0	10	5.00
1	190	95.00
3.Groundwater Contamination due to Sewerage	Frequency	Percentage
0	129	64.50
1	71	35.50

Water Use in Household

The graph shows usage of water in the household for different purposes, drinking, cooking, washing dishes and clothes etc. 6.5 percent people use groundwater for drinking, 87.5 percent respondent use filter and 6 percent people use bottled water for drinking. For cooking 28.5 percent peoples use groundwater, 69 percent use filter water and 2.5 percent use bottle water. For washing dishes, washing clothes, home cleaning, garden, car/bike wash 100 percent people use groundwater.

Figure 3.1: Water Use in Household



Precautionary Measures for the Groundwater

The *table 3.6* shows precautionary measures of the water for drinking and cooking, 57 respondents out of 200 used boiled water for cooking and also 0 for drinking. 175 peoples use filter water for drinking and 138 out of 200 used filter water for cooking. 3rd is bottled water in which 12 household used bottled water for drinking and 5 out of 200 used bottled water for cooking.

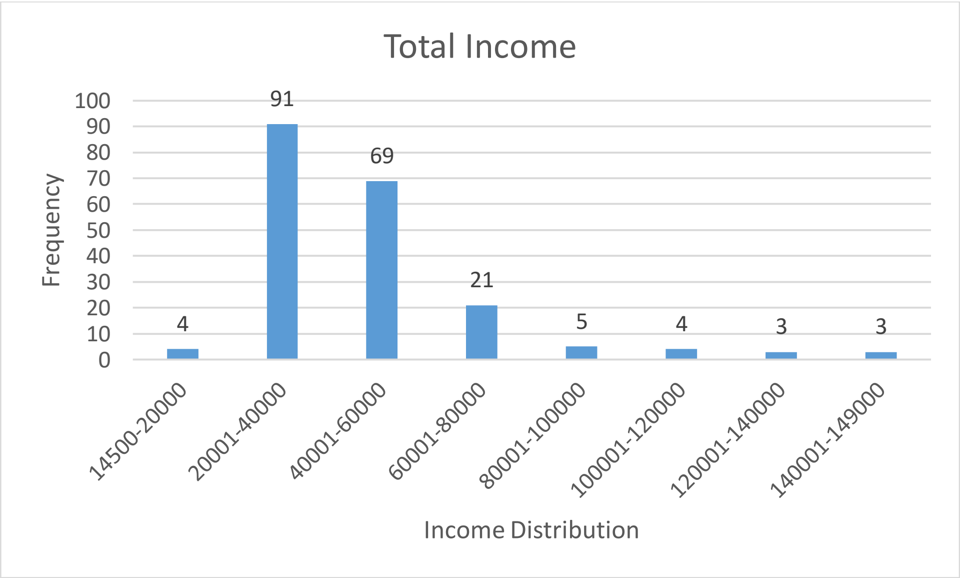
Table 3.6 **Precautionary Measures for the Groundwater**

Water sources	Drinking	Cooking
Boiled Water	0	57
Filter Water	175	138
Use of Chlorine	0	0
Bottled Water	12	5

Total Income of the Household

The total income of households ranges from Rs 20,000 to Rs 160,000. Maximum households lie in between Rs 21,000 to Rs 40,000 range i.e. 91 households. And minimum respondents (3) lie in the range of 160,000.

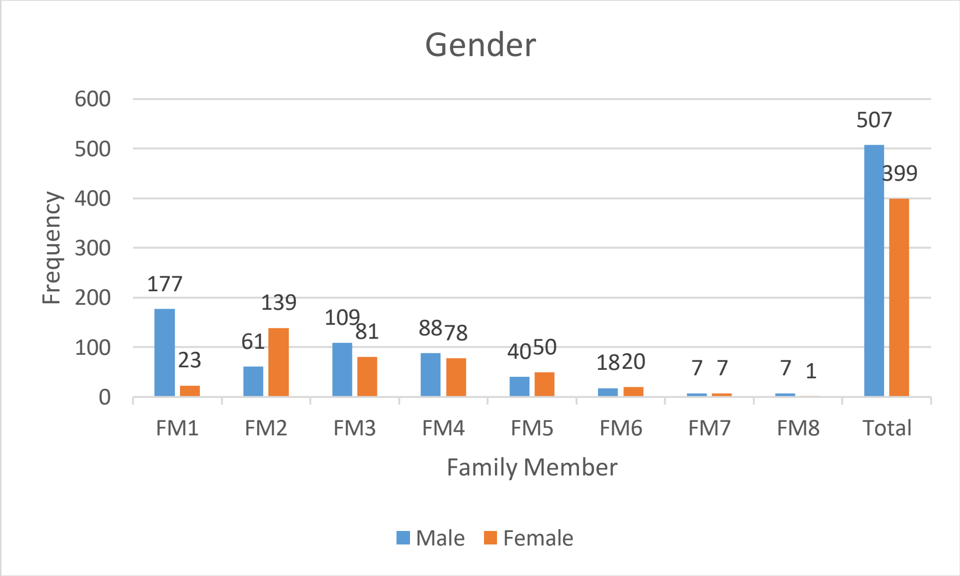
Figure 3.2 Income



Gender

This graph shows the numbers of males and females in the data. There are total 906 members in 200 households.

Figure 3.3 Gender



Household Size and Frequency

In the following table, 507 males and 399 females are from 200 households. The total household members are 906 in 200 household. 10 households have 2 members.

Table 3.7 Household Size

Household Size	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Household Size Frequency	10	24	76	51	24	7	8	200
Male	13	45	157	149	73	24	46	507
Female	7	27	147	106	70	24	18	399

Education

In the following table minimum education is 0 and the maximum is 16 years completed education. The range of completed years of education is from 0 to 16 by a difference of 4 years of education. The abbreviation FM means Family members

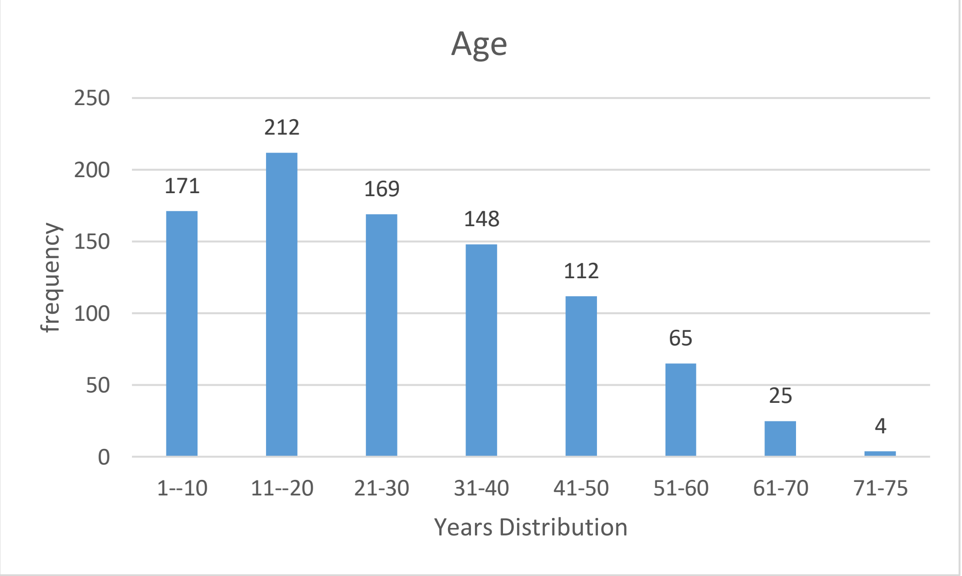
Table 3.8 Education

Years of Schooling	**FM1**	**FM2**	**FM3**	**FM4**	**FM5**	**FM6**	**FM7**	**FM8**	**Total**
0	1	9	22	22	8	6	2	0	70
1-4	1	2	20	36	21	10	1	2	93
5-8	63	78	66	49	38	12	7	3	316
9-12	98	76	59	45	17	8	4	3	310
13-16	37	35	23	14	6	2	0	0	117
									906

Age

Range of age is from 1 to 80 years, by the difference of 10 years. Minimum age is 1 and maximum 80. 212. Maximum family members lie in 11 to 20 years range.

Figure 3.4: Age



Disease Distribution

In this table diseases and their occurrence to different family members are shown. From this table we conclude that skin disease is most frequent in women and diarrhea is common in children.

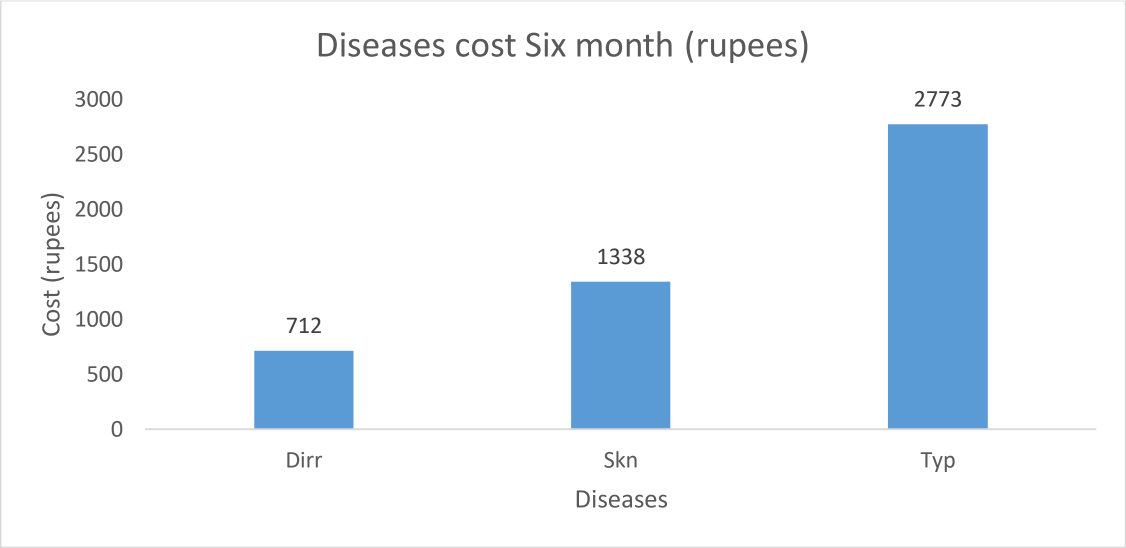
Table 3.9 Disease

	Respondent	**Spouse**	**Father/Mother**	**Brother**	**Sister**	**Son**	**Daughter**
Diarrhea	45	20	10	3	8	52	40
Skin Disease	37	115	26	7	10	12	17
Typhoid	21	6	5	0		5	6

Disease Average Cost

The average cost of the disease means that total cost, doc fee, lab test fee, med cost, and travel cost are all added and divided thorough average formula. The average cost for diarrhea, skin ailments and typhoid are given.

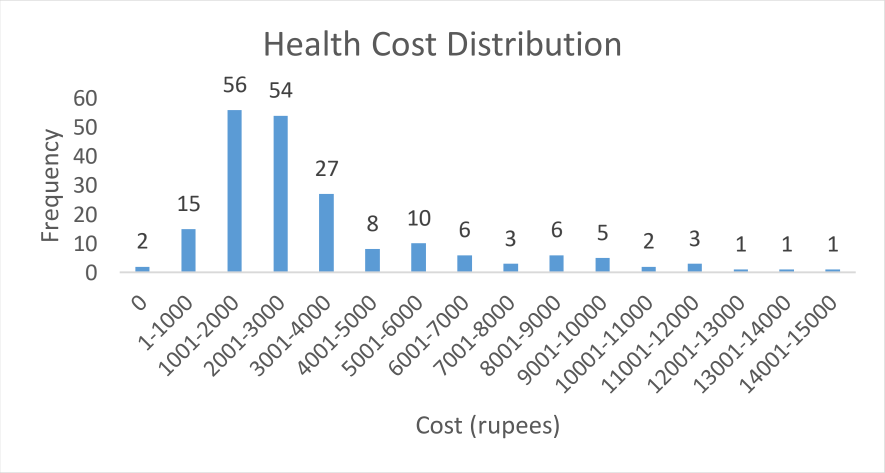
Figure 3.5 Average Cost



Household Health Cost

The graph shows the health cost borne by people, from selected 200 households. Maximum no of 52 members bore 1001 to 2000 rupees. The range is set from 0 to 15000 rupees. The graph shows the cost borne by peoples in the study area.

Figure 3.6 Household Health Cost



Chapter 4: Econometric Results

4.1: Section 1: Econometric Analysis of Disease model

4.1.1 First Model

In this chapter we have discussed two sections, first one is consisting of logit regression of the diseases and 2nd is health cost of all diseases due to the use of contaminated water. In first section logit regression is used and shows the effect of the independent variable on diseases that have occurred due to use of contaminated water. Logit regression was used for estimation because the dependent variable is binary, (Sick=1 Not sick=0). In my study, three types of disease, Diarrhea, Skin problem, and Typhoid Fever are under consideration.

Regression Results of Diarrhea

Table 4.1 Results of the Logistic Model for Diarrhea

Variables	Dy/dx	Odds-R	Std. Err.	Z	P>|z|
Age	0.0014	1.0071	0.00595	0.25	0.806
Education	-0.0266	0.8774	0.01808	-1.47	0.140
Income	-1.87e-06	0.9999	0.000001	-0.28	0.781
Child (Dummy)	0.0163	1.0835	0.05698	0.29	0.774
Water Source (Dummy)	-0.3474	0.2287	0.15531	-2.24	0.025

Number of obs = 200, Wald chi2(5) = 13.28, Prob > chi2 = 0.0209, Above table presents the regression results of Diarrhea disease. Age has positive and insignificant impact on the probability of diseases. This implies that 1-year increase in age is expected to contribute in the probability of diseases by 0.004 percent. This relationship shows that disease is common in all age groups. Education shows 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 not 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) show a positive coefficient with insignificance, implying that children's number increase has greater tendencies to get infected by diseases. Empirical results reveal that no of children if increases by 1 member lead to an increase in the probability of disease by 0.016 percent. Income has negative and insignificant relation with the disease. Empirical results show that 1 percent increase in income leads to decrease in the probability of getting disease by 1.87 percent. As the income of households increases, the respondents of household use better food and clean water or purchase water from market. This would decrease the probability of diarrhea disease. Water source is significant at 5 percent confidence interval but have negative coefficient value. It means that as household members are shifted from ground water to bottled water which is the averting measure than the probability of getting diarrhea decreases.

Regression Results 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	-.0018469	.973476	.00394	-0.47	0.639
Education	.007771	1.119856	.01352	0.58	0.565
Living Duration	.0078045	1.120303	.00345	2.26	0.024
Household Size	.0036563	1.054661	.02051	0.18	0.858
Gender	-.0215544	.730713	.2417	-0.89	0.373
Water Source (Dummy)	-.9261168	.0013128	.04577	-20.23	0.000

Number of obs = 200, LR chi2(6) = 116.71, Prob > chi2 = 0.0000

The above table presents the regression results for the skin disease. Age has a negative and insignificant impact on the probability of disease. This implies that 1-year increase in age is expected to contribute in the probability of diseases by 0.001 percent. This relationship shows that disease is common in low age group. Education shows an insignificant positive 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 positive coefficient with significance level of 5 percent, implying that as the living duration of household's increases families have higher tendencies to get infected by diseases. Empirical results reveal that increase in duration by 1 year leads to increase the probability of disease by 0.0078 percent. Family size shows a positive coefficient with insignificance level, implying that larger families have greater tendencies to get infected by diseases. Empirical results reveal that increase in family size by 1 member leads to increase the probability of disease by 0.0036 percent. While in skin disease gender is insignificant but negative relation with the disease. The empirical results show that as the male members increase by 1unit in household then the probability of getting skin disease decreases by 0.0125 percent. Water source is significant at 1 percent confidence interval but has negative coefficient value. It means that as household members are shifted from ground water to other water source which is the averting measure than the probability of getting skin disease decreases.

Regression Results of Typhoid Fever

Table 4.3 Results of the Logistic Model for Typhoid Fever

Variables	Dy/dx	Odds-R	Std. Err.	Z	P>|z|
Age	0.0657	1.06555	.003	2.19	0.028
Education	-.01685	.849767	.01008	-1.67	0.094
Income	-2.03e-06	.99960	.00001	-0.36	0.718
Gender	-.04840	.1087	.02299	-2.11	0.035
Water Source drinking (Dummy)	-.17807	.10874	.04112	-4.33	0.000

LR chi2 (5) = 15.66 Number of obs = 200 Pseudo R2= 0.1263

In the above table show the logit regression results of typhoid fever. As the results indicate age has positive coefficient and shows significant relationship with typhoid fever. It means that if age increases by 1 year than probability of typhoid increases by 0.065 percent. Because with the increase of age probability of disease especially typhoid increases according to review of literature. While education has negative but significant relationship, it implies that education increases by 1 year than the probability of disease of the typhoid fever goes down by 0.016 percent. As the education increases the awareness of the disease also increases, which alternatively increase in the use of averting measures and decreases the probability of disease. In this regression analysis income has negative but insignificant relationship with the typhoid fever. It means that when resident income increases by 1000 rupee than the probability of typhoid is 0.00001 percent. As income increases the precautionary measures are used by the respondents of the households in way, they shift their mode of drinking water from ground to bottled water. This ultimately reduces the probability of getting sick. As the result gender have negative but significant relationship with the disease. It implies that as the male increase by 1 member than the probability of disease frequency is 0.048 percent. Males are more affected than females in the typhoid disease model. Water source is negative but significant at 1 percent. It means that as household members are shifted from ground water to bottled water which is the averting measure than the probability of getting typhoid decreases.

Marginal Effect

The marginal effect is used to analyze which explanatory variable is more likely to marginally affect the explained variable. Variables are not in the same unit e.g. age is taken in years, household size is taken in number of members that’s why marginal effect is being used which explains that which variable is more significantly affecting dependent variable. For example, household size has a significant negative marginal effect on the total disease occurrence and water quality, age, dummy variables and contaminates have positive marginal significant effect on waterborne diseases. All independent variables have dissimilar measurement units and coefficient, which cannot be linked in terms of magnitude. That’s why the study used standardized Regression Model for understanding the impact of independent variables.

Regression Results of Health Cost

4.2 Section 2: Econometric Analysis of Health cost model

In order to estimate the health cost due to ground water contamination related symptoms, Ordinary Least Square model is applied on 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 travel cost, doctor fee, medicinal expenditure, lab tests and working hour loss and time lost during visit to doctor due to illness. All these variables are taken in 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.

Table 4.4 Regression Result of Health Cost

HEALTH COST	COEF.	STD. ERR.	T	P>T
DIARRHEA	504.7372	582.9453	0.87	0.388
SKIN DISEASE	1926.304	599.5639	3.21	0.002
TYPHOID FEVER	1299.821	723.7905	1.80	0.074
AGE	114.0775	48.78833	2.34	0.020
EDUCATION	-72.63171	160.6676	-0.45	0.652
INCOME	.5751539	.0769588	7.47	0.000
HOUSEHOLD SIZE	1829.561	275.244	6.65	0.000
GENDER	875.9396	260.1587	3.37	0.001
NOVIST	774.3028	246.6152	3.14	0.002
WATER SOURCE (DUMMY D,C)	-2369.119	1836.783	-1.29	0.199
WATER SOURCE (DUMMY B,W)	-942.7328	646.4107	-1.46	0.146
AVERTING MEASURE	-1.980186	.956396	2.07	0.040
WORKING HOUR LOSS	165.9081	9.415245	17.62	0.000
_CONS	-21304.63	2042.474	-10.43	0.000

Number of obs = 200, Prob > F = 0.0000, R-squared = 0.8513, Adj R-squared= 0.8409

The regression results of the health cost function are shown in above table. These results show that Diarrhea has insignificant relation with the health cost. This shows that if 1 unit increase in disease occurs, the health cost by Rs 504.73 for six months or Rs 84.12 per month. Skin disease shows highly significant and positive relation with health cost regression model. It implies that if 1 unit increase in disease increases the health cost by Rs 1926.30 for six months or Rs 321.05. Typhoid is significant at 5 percent and displays positive relation with the health cost. This implies that if there is 1 unit increase in disease increases the health cost by Rs 1299.82 for six month or Rs 216.63. While age in the health cost model has positive relation. Although the result is statistically significant at 5 percent, it may be due to the fact that 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 doctor. This may explain the reason that why age has positive and significant impact on the probability of prevalence of disease but the contribution in cost is insignificant. Education indicates negative but insignificant effect on health cost, implying that 1-year increase in education leads to nearly Rs 72.63 for six months increase in health cost. The education is considered as proxy for awareness and increase in awareness makes people more conscious about their health, motivating them to spend more on health. But in reality, people have limited income due to which they do not shift their mode of drinking water and mostly people are educated but do not have any source of income. Number of doctor visits and loss of working hours have highly significant positive relationship with health cost. By increasing 1 more visit to the doctor in six months, the health cost increases by Rs 774.30, while loss of 1 working hour leads to a financial strain of Rs 165.90, which could otherwise have been a part of the patient's real 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 1.908. Water source for drinking and water source for bathing had been taken as dummy variable explained above, the results depict negative and insignificant relation with total health cost, implying that respondents using water from other sources rather than ground water are facing less health cost. This also implies that those who are adopting averting measures are facing less health cost. If the respondents use their groundwater, the chances of getting disease increase, which lead 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. Income of the respondent shows positive and significant relation with total health cost. Increase in income is proportional to availability of better health care facilities. Thus, increase in income leads to increase in health cost.

Chapter 5: CONCLUSIONS AND RECOMMENDATIONS

Water is the basic requirement of life. Water is necessary for drinking, household food preparation, agriculture, and other different purposes. The most abundant natural resource on earth is the groundwater. The study was designed to measure the effect of water pollution of Small Estate Area Faisalabad. The water quality of Faisalabad is very poor and harmful for human beings. Firstly, water quality is very bad, after sample testing of water, it was found that the quality of drinking water and washing, bathing water was worst and cannot be used for both drinking and washing, bathing purposes.

In order to quantify objectives' primary survey was conducted and explored for the empirical findings of the research study, two econometric models were used. Groundwater is unfit for drinking purposes. The peoples living in my study area have different problems, some of them are unaware about the groundwater and some also have financial problems. After applying different physical and chemical tests on water samples total calcium 3.35 (meL^{-1}), PH level 6.9, total hardness (ppm) is 241.07, Magnesium (meL^{-1}) 1.45, Potassium (meL^{-1}) 1.18 and Sulphate (meL^{-1}) 2.40 does not meet the standards of World Health Organization. The study revealed that health cost of the people of the Small Estate Area Faisalabad. Research finding illustrated that the demographic condition are very serious. Literacy and education level of the families play a significant role in a better understanding of the problems due to use of contaminated water. There are three type of diseases diarrhea, skin disease and typhoid fever that have significant effect on health cost. This study concludes that as the water source usage of that area increases than the probability of getting diseases like diarrhea, skin disease and typhoid fever increases. Due to increase of diseases ultimately the health cost of the respondents increases.

5.1 Policy Recommendations

1. The population of small Estate Area Faisalabad is severely affected by the contaminated groundwater. Therefore, it is necessary to improve sewerage system and also install filtration plants.
2. Water quality is very low therefore government should be installing public supply water or tap water.
3. It is known that industrial wastewater discharged into canals is used for agriculture purposes. It is recommended that water treatment plants must be installed to clean this polluted water before it is used for any purposes.
4. The polluter pay principal must be applied in order to generate sense of responsibility. There is a need to formulate new rules and regulations.
5. Media should play a vital role to start the extension programs regarding the groundwater pollution awareness; therefore, government must also assist the media to illuminate this serious problem of groundwater contamination.

All those above-mentioned policy recommendations call for the ending the pollution in Small Estate Area Faisalabad, and thus help to keep water safe and clean. This will help the people to control the health issues caused by the polluted water.

REFERENCE

Abdalla, C. w., Roach, B. A., Epp, D. J., (May, 1992). Valuing Environmental Quality

AHMED, A., IFTIKHAR, H., CHAUDHRY, G., (2007). Water Resources and Conservation Strategy of Pakistan. ©*The Pakistan Development Review*, 997–1009.

AKHTAR, N., JAMIL, M., NOUREEN, H., MUHAMMAD, I., IQBAL, I., & ALAM, A. (2005). Impact of Water Pollution on Human Health in Faisalabad City (Pakistan). *JOURNAL OF AGRICULTURE & SOCIAL SCIENCES*.

Aleem, M., Cao, J. S., Li, C., Aslam, A. M., (2018). Evaluation of Groundwater Quality in the Vicinity of Khurrianwala Industrial Zone, Pakistan. MDPI.

Azizullah, A., Khathak, N. K., richter, p., hader, D. p., (2010). Water pollution in Pakistan and its impact on public health — A review. Environment International, 479-497.

Baba, A., & Tayfur, G. (2011). Groundwater contamination and its effect on health in Turkey. *Springer Science+Business Media*.

Banuri., T. (1999). Pakistan: Environmental Impact of Cotton Production and Trade. *International Institute for Sustainable Development*.

Bask, R., Nawaz, H., & Khurshid, M. (1999). Chemical Analysis of Underground Water of Faisalabad City Sector 11 (Areas Along Narwala and Sargodha Road). Pakistan Journal of Biological Sciences, 715-719.

Changes Using Averting Expenditures: An Application to Groundwater Contamination. *University of Wisconsin Press*, 163-169.

Deshapnde, S. M., Aher , K. R., & Gaikwad, G. D. (n.d.). Assessment of Groundwater Quality and its, Suitability for Drinking Uses in Warora tehsil, District Chandrapur, India.

Ghaziabad, India: impact of industrial and urban wastewater. *Environ Monit Assess*, 103-112.

Halder, J. N., Islam, M. N., (2015). Water Pollution and its Impact on the Human Health. *JOURNAL OF ENVIRONMENT AND HUMAN*, 2373-8332.

Impact and extent of ground water pollution: a case study of rural area in Punjab State (India) . (December 2011). *International Journal of Environment and Health*.

International Journal of Engineering Research and General Science, 2091-2730.

Japan International Cooperation Agency, 2010. Preparatory Study on Lahore Water Supply, Sewerage and Drainage Improvement Project in Islamic Republic Of Pakistan.

Khakbaz1, P. P.-N., Mahdeloei, S., & heidari, A. (2012). Soil Pollution Control Management Techniques and Methods.

Khalid, S., Shahid, M., Bibi, I., Sarwar, T., Shah, A. H., & Niazi, N. K. (2018). A review of environmental contamination and health risk assessment of wastewater use for crop irrigation with a focus on low and high-income countries. International journal of environmental research and public health, 15(5), 895.

Khan, K., Lu, Y., Khan, H., Zakir, S., Ihsanullah, Khan, S., Wang, T. (2013). Health risks associated with heavymetals in the drinking water of Swat, northern Pakistan. *Journal of Environmental Sciences*, 2003–2013.

Krishna, A. k., Satyanarayanan, M., Govil, P. k. (2009). Assessment of heavy metal pollution in water using multivariate statistical. *Journal of Hazardous Materials*, 366–373.

Mehwish, N., & Mustafa, U. (2016). Impact of Dust Pollution on Worker's Health in Textile Industry: A Case Study of Faisalabad, Pakistan. *Pakistan Institute of Development Economics*.

Pakistan, Government of (Various Issues) Agricultural Statistics of Pakistan. Ministry of Food, Agriculture and Livestock. (2005-06).

Pak-SCEA, 2006. Pakistan; Strategic Country Environmental Assessment Report: Rising to the Challenges, May 2006.

PAWARI, M. J., & GAWANDE, P. S. (2015). Ground Water Pollution & Its Consequences.

Sangeetha, B., Rajeswari, M., Atharsha, S., Saranyaa, K., (2013). Cotton Dust Level in Textile Industries and Its Impact on Human. *International Journal of Scientific and Research Publications*, 2250-3153.

Sayal, A., Amjad, S., Bilal, M., Pervez, A., Mahmood, Q., ., & Afridi, M. A. (2016). Industrial Water Contamination and Health Impacts: An Economic Perspective. *J. Environ*, 765-775.

Schwarzenbach, R. P., Egli, T., Hofstetter, T. B., Gunten, U. v., & Wehrli, B. (November 2010, November). Global Water Pollution and Human Health. *Annual Review of Environment and Resources*.

Singh, S., Singh, H. (2011). Impact and extent of ground water pollution: A case study of rural area in. *International Journal of Environment and Health*.

Suthar, S., Sharma, J., Chabukdhar, M., (2010). Water quality assessment of river Hindon at

Tariq, M., Ali, M., & Shah , Z. (2006). Characteristics of industrial effluents and their possible impacts on quality of underground water. *Soil & Environ*, 64-69.

Team, T. A. (JANUARY 16, 2017). *The Ultimate Properties of OLS Estimators Guide.*

Thakur, V. K., Thakur, M. K., & Gupta, R. K. (2013). Rapid synthesis of graft copolymers from natural cellulose fibers. Carbohydrate Polymers, 820-828.

Ullah, R., Malik, R. N., & Qadir, A. (2009). Assessment of groundwater contamination in an industrial city, Sialkot, Pakistan. Environmental Science and Technology, 429-446.

World Health Organization. (1985). *A manual for physicians and other senior health workers.* WHO Library Cataloguing-in-Publication Data.

Wu, J., & Sun, Z. (2016). Evaluation of Shallow Groundwater Contamination and Associated Human Health Risk in an Alluvial Plain Impacted by Agricultural and Industrial Activities, Mid-west China. *Expo Health*, 311–329.

APPENDIX.1

Water Analysis Report

	Results			
Parameters	**A**	**B**	**C**	**D**
Location				
Depth (Feet)	100	105	100	110
pH	6.9	6.6	6.2	5.8
EC ($dScm^{-1}$)	2.690	2.900	1.653	2.270
TSS (ppm)	1936.8	2088.0	1190.2	1634.4
Sodium (mel^{-1})	20.88	22.65	12.42	17.20
Potassium (meL^{-1})	1.18	1.31	0.79	1.05
Calcium (meL^{-1})	3.39	3.53	2.32	3.12
Magnesium (meL^{-1})	1.45	1.51	1.00	1.34
Carbonate (meL^{-1})				
Bicarbonate (meL^{-1})	12.00	12.80	7.60	9.60
Chloride (meL^{-1})	12.80	13.80	6.60	10.80
Sulphate (meL^{-1})	2.10	2.40	2.33	2.30
Total Hardness (ppm)	241.07	250.88	165.20	221.44
SAR	13.41	14.27	9.64	11.53
RSC (meL^{-1})	7.16	7.76	4.28	5.15

APPENDIX 2

Serial No. ______.

Date: ______.

Survey Questionnaire

I am MPhil Research student department of Environmental Economics at Pakistan Institute of Development Economics (PIDE) Islamabad. Mainly my focus is to **"Groundwater contamination due to Industrial Waste Water and its Impact on Human Health: A Case Study of Faisalabad".** 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 Shoaib Siddique

Section I

Personal Information

1. Name: ___________________________________.
2. Phone/Email: ______________________________.
3. Education: ________________________________.
4. Gender: a. Male b. Female
5. Address: ____.
6. For how many years you are living in this area: ________________________________.

Section II

Ground Water Contamination Awareness

Sr. No.		Yes/No
1	Do you feel any change in odour of the water?	
3	Do you think ground water contamination is due to industrial wastewater?	
4	Do you think ground water contamination is due to sewerage or other factors?	

Usage of Water

	Groundwater	Tap Water \Government Supply	Bottled Water	Others
Drinking				
Cooking Meal				
Washing Dishes				
Washing Clothe				
Home Cleaning				
Garden Use				
Car/Bike Wash				

Precautionary Measure for Water

	Drinking	Cooking Meal	Washing\ Taking shower
Boiled			
Filter			
Use of chlorine for purification			
Others			

Section III

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	Occupation	Monthly Income (Rs)	Monthly Exp. on health (Rs)
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Health Costs Incurred

In Last Six Months.										Health Cost (Rupees)						
Sr. No	Diarrhea Yes=1, No=0	Disease Frequency	Duration of Sickness	Skin Disease Yes=1 No=0	Disease Frequency	Duration of Sickness	Typhoid Yes=1 No=0	Disease Frequency	Duration of sickness	Doctor Fee	Lab Test fee	Medicinal Exp.	T.Travaling Cost	Working Hour Loss	Total Time lost	Total Expenditure
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																