

EFFECTS OF SOLID WASTE DUMPING ON
GROUND AND SURFACE WATER,
SECTOR H-12, ISLAMABAD



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DEDICATED TO

OUR FAMILY, DEAR ONES AND FRIENDS FOR THEIR
CONSISTENT LOVE AND SUPPORT

ACKNOWLEDGEMENT

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At last, but not least, it is with gratefulness that we hereby mention our family, our dear ones and close friends whose giant shadows have been behind our success in the education.

ABSTRACT

Islamabad generates about 550-600 metric tons of solid waste on a daily basis, which was previously disposed off in the right of way of Kashmir highway near sector H-12. This was a temporary disposal site for solid waste. One of the key pathways when evaluating the risk of solid waste on human health and the environment is leaching of the pollutants to groundwater. The overall objective of this study is to evaluate the effects of dumping on water quality. A standard method for sample collection was followed. Best analytical techniques were used for the analysis of target parameters with the available facilities in the laboratory. The result for each sample was then compared with WHO, EU, US EPA, PSQCA guidelines. The parameters for most of the samples were within the permissible limits except for sample number 04, 05, 06. Lead concentration was above the permissible limit in sample number 04, 05 and 06. Cadmium was high in sample number 04 and 05. Whereas iron was above the permissible limits in sample number 05 and 06. In remaining samples the Heavy metals concentration is below the permissible limits. The spatial correlation of latitude and longitude with drinking water samples showed that all the parameters were increasing towards south east direction, whereas the elevation of ground surface is showing decreasing trend in elevation towards south east. So it is observed that open dumping of solid waste does contaminate the ground water.

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CHAPTER 1: INTRODUCTION

1.1 Background of the Study:

Islamabad generates about 550-600 metric tons of solid waste on a daily basis, which was previously disposed off on the right side of Kashmir highway near sector H-12. This was a temporary disposal site for solid waste managed by CDA along Kashmir highway at sector H-12, Islamabad. The reason being that at present, there is no designate landfill site in Islamabad.

Previously, the waste was being buried in trenches and was covered with a soil on daily basis. Although covering with a soil was an effective measure against bad smell and control of rodents etc but the open dumping is an unhygienic and undesirable practice especially when it is done near the residential sectors and institutions. (CDA, 1998)

One of the key pathways when evaluating the risk of solid waste on human health and the environment is leaching of the pollutants to groundwater. The determination and application of leaching risk, however, is one of the more poorly understood components of the risk assessment process. The evaluation of the risk from drinking contaminated groundwater is somewhat more complicated. Since the material is not consumed directly, the amount of the pollutant that leaches or washes off the material must be

predicted. The leaching risk may be evaluated by theoretical calculations from the total concentration of a pollutant of a concern. The leaching concentration (mg/L) is compared to risk-based water quality standard or guideline, with no appropriate consideration of dilution that may occur in groundwater.

1.2 Objectives of the Study:

The overall objective of this study is to evaluate the effects of dumping on water quality. In addition this study will investigate, whether the water is safe to use for drinking purpose in sector H-12, Islamabad. The following are to be addressed in order to achieve the overall objective of this study:

- To evaluate the amount of contamination in ground water and surface water due to the temporary solid waste dumping site.
- To determine the concentration of heavy metals in ground and surface water.
- Correlation between various analyzed parameters.
- Spatial correlation for various parameters in surface and groundwater.

1.3 Scope of the Study:

This study will provide a clear picture of the amount of contamination in water in sector H-11, H-12, H-13, I-11, I-12, due to solid waste that was dumped previously at sector H-12, Islamabad.

1.4 Previous Work:

This type of work has also been done in the past by many other people

Zenone et al, September 1974

The study conducted in three solid-waste disposal sites in the Anchorage, Alaska and proved that the leachate was detected in two solid waste dumping sites where the water table was very near to land surface and no leachate was detected in the third site where waste disposal is well above the local water table.

Fasunwon O.O et al, 1998

The investigation has been done on ground water pollution, and the direction of the flow of the contaminants in a dumpsite in Nigeria, the rate of contaminants from the dumping site with in the sub surface was investigated by using Electrical Conductivity Method. The results were interpreted by using computer software (WINK LINK). The high and low resistivity of zones, delineated from the cross section map of the site revealed that the concentration of the contaminants was restricted to a particular zone and leachate flow towards the eastern direction of the dumpsite area.

Esmail et al, 2009

The study conducted in Yemen and proved that improper land filing is one of the sources of water pollution. The leachate was sampled at three different locations of the landfill. The groundwater samples were

collected from 5 boreholes. The results showed that 4 out of 5 boreholes were contaminated. Therefore it was conclude that improper landfill is dangerous for environment.

OJO O, 1995

The study examines the surface ground water pollution which results from waste generated by industrial, commercial, household activities and several urban centers of Nigeria. The study emphasizes the need fro improved water quality standards and criteria.

UNNISA, 2008

The study conducted in Hyderabad metropolitan area, where the solid waste generated is deposited off as landfill area, two landfill sites were selected and groundwater samples were analyzed. Results showed that ground water samples were highly contaminated. The overall analysis indicates increasing risk for sustainability of groundwater resources.

CHAPTER 2: STUDY AREA DETAILS

2.1 Location:

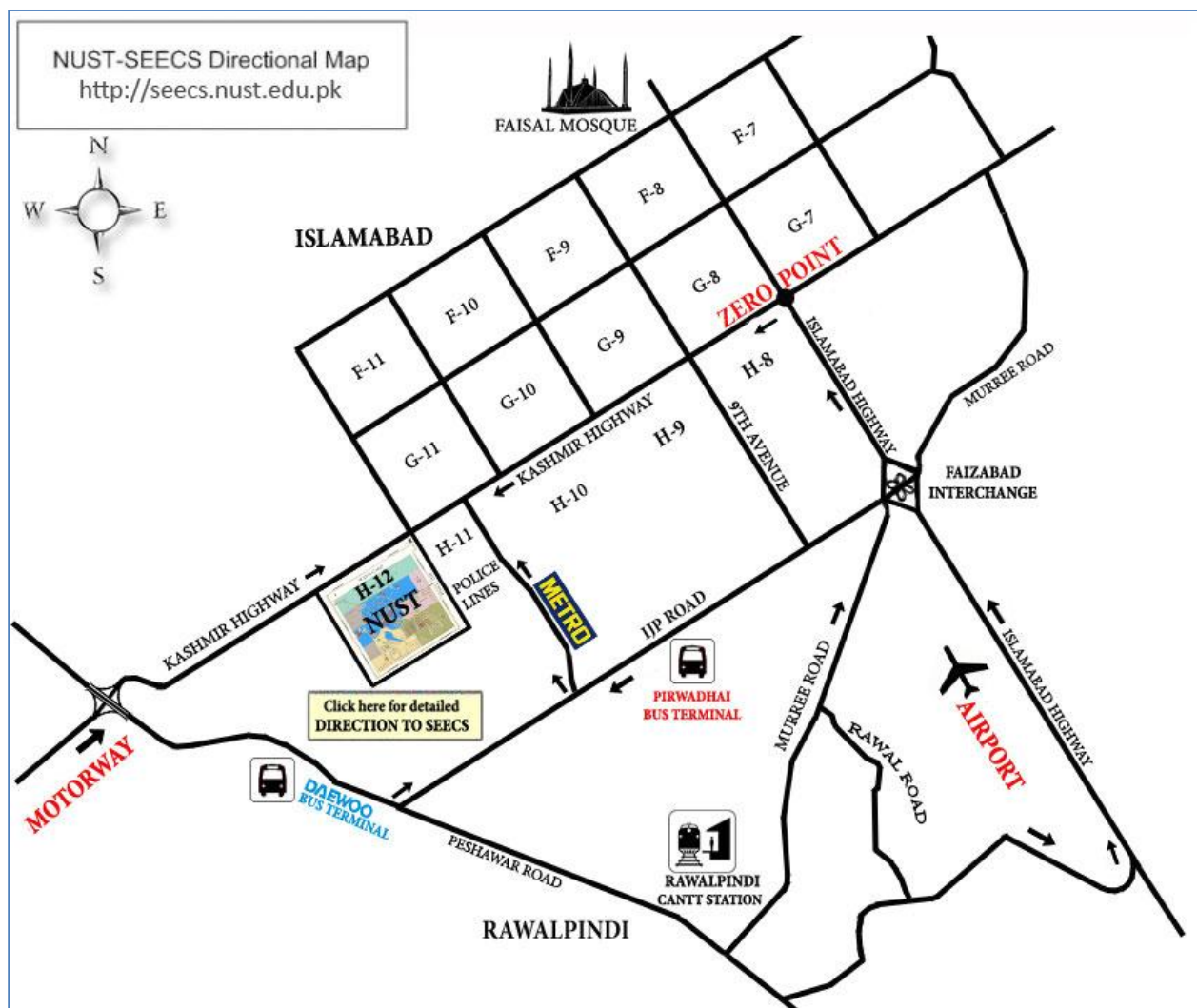


Figure 2.1 showing map of Islamabad

The metropolitan area of Islamabad lies between longitudes 72°45' and 73°30' E and latitudes 33°30' and 33°50' N. Islamabad is the national capital and the hub for all governmental activities. Islamabad is a planned city in a beautiful setting at the foot of the mountains immediately north of Rawalpindi, constructed to serve as capital of the newly independent country of Pakistan. Construction began in the early 1960's, following extensive surveys and planning. Since then, rapid growth in Islamabad population has made ever-increasing demands on natural resources and caused adverse effects on the environment (Survey of Pakistan, 1982).

Potential environmental problems are (1) providing additional resources of ground water, (2) extensive pollution of surface water and of ground water by improperly disposed solid waste, (3) continued availability of geologic construction materials, (4) effects of mining of limestone, sand, gravel, and clay, (5) potential subsidence of building foundations caused by instability of loess, (6) control of gully erosion, (7) danger of debris flows from the mountain canyons and floods along the streams, and (8) earthquake hazards (Sheikh and others, 1999).

2.2 Climate:

Records for the Islamabad station of the Pakistan Department of Meteorology (written commun, 1988) indicate a monsoonal climate of rainy hot summers and cool dry winters figure 2.2; precipitation is characteristic of the semiarid zone of Pakistan. The monsoon rains usually start in June, peak in

August, and end by September figure 2.3. A much smaller winter monsoon peaks in March. The four monsoon summer months always have some precipitation, but any of the other months can be completely dry. Annual rainfall of only 249.1 millimeters (mm) was recorded in 1982. The high of 1,732 mm was recorded in 1983. The average for 1931–87 was 1,055 mm. The maximum recorded temperature was 45.9 degrees Celsius ($^{\circ}\text{C}$) in June 1972, and the minimum was -3.9°C in one January before 1961. Freezing temperatures are rare and have been recorded only in November, December, and January. There is no record of snow (written commun., 1988).

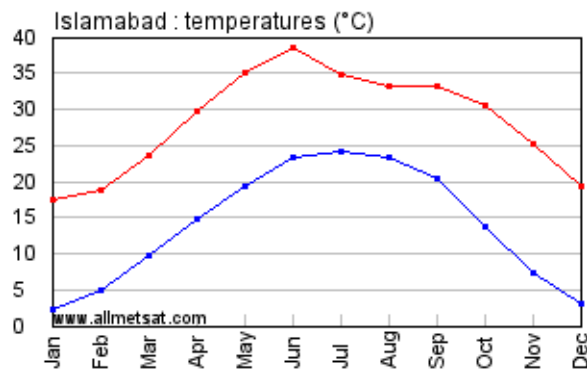


Figure 2.32 Temperature variations in Islamabad

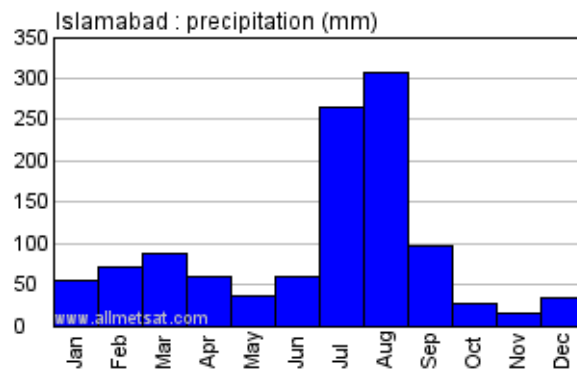


Figure 2.33 Precipitation variations in Islamabad

2.3 Topography:

Islamabad is located on the northern most edge of the tract known as Potohar plateau. The site is an uneven table and land is gradually rising in elevation from 500 to 600 meters above mean sea level. In the extreme north the hills rise more steeply. The highest point of hill series belonging to Eocene division of the tertiary period is about 60 million years old. The rock formation consists of gray or dark color lime stone with layers of shale containing fossils. The land gradually slopes towards the south. The land is composed either of alluvium (clay or silt) or of gravel caps. The plains are formed of alluvial deposits laid by the past and the present river systems in varying thickness. A large part of the area is undulating and at various places it is badly dissected by gullies and ravines. The Korang stream has been dammed at a place named Rawal, to form the Rawal Lake. Another dam has been built on the Soan River to form the Simly Lake.

The Potohar plateau is a well-defined physiographic unit of Pakistan between the Indus basin plain and the foot hills of Himalayas. It covers about 11,200 km² area bound by Kala Chitta and Margalla hills in the north and the salt range in the south, Indus River in the west and Jhelum River in the east.

The plateau slopes from NE to SW, in the direction of flow of the river Soan, which is the main river of the area and joins river Indus in North of Kalabagh. In the eastern Potohar, Kanshi, Kahan and Bunha rivers drain unto the Jhelum River. Only the Soan and Kanshi rivers are perennial while rest of the

drainage consists of seasonal stream. The plateau has level to undulating topography with scattered gullies and gorges created through active water erosion (Haye 2005).

2.4 Geology and Soil:

The Potohar region has a complex geological history of mountain formation, alluvial-loessic deposition, and erosion cycles. Limestone is the characteristic rock of Margalla range. In age it ranges from the Jurassic to Triassic. It is usually reddish or bluish white in color mixed or altering with it beds of red or bluish clay or shade or sandstones. Adiala, Dhamial, Loibher forests are situated over alluvial deposits. The deposits contain small sized rounded pebbles of sandstone, quartzite or granite and sand mixed or alternating with clayey deposits. They have been described as alluvial deposits, but it is equally probable that they have a glacial origin (Haye 2005).

The soil in Potohar region is shallow, clayey and of low productivity. Mostly, on the Southern and Western aspects of the Potohar plateau, the soil is thin and infertile. Streams and ravines cut the loose plain, affected by gully erosions and steep slopes. Such land is unsuitable for cultivation. However, large patches of deep fertile soil are found in the depressions and sheltered localities supporting quality small forests (Rakh) and rain fed agriculture. Limestone is the characteristics of Margalla range. It is the usually gray and

bluish white in color. The soil formed by the disintegration of shells, clay and sandstone occurs in scattered places (Haye 2005).

The soil is formed by disintegration of shells, clay and sandstone which collects in scattered situation. Due to nutritive properties of the calcium carbonate, it gives rise to a dark colored minerals soil capable of supporting good tree growth and rain fed crops despite its shallowness (Haye 2005).

2.5 Hydrology:

The Soan and Kurang Rivers are the main streams draining the area. Their primary tributaries are the Ling River, draining northwestward into the Soan; Gumreh Kas, draining westward into the Kurang from the area between the Kurang and Soan; and Lei Nala, draining southward into the Soan from the mountain front and urban areas. The Kurang and Soan Rivers are dammed at Rawal and Simly Lakes, respectively, to supply water for the urban area. Extensive forest reserves in the headwaters of the Kurang and Soan Rivers benefit the quality and quantity of supply (Sheikh and others, 1999).

2.6 Hydrogeology:

A supplemental network of municipal and private wells as deep as 200 meters (m) produces ground water primarily from Quaternary alluvial gravels. The altitude of the water table decreases from about 600 m at the foot of the Margala Hills to less than 450 m near the Soan River, so that the saturated zone generally lies 2–20 m below the natural ground surface (Ashraf and Hanif,

1980). Lei Nala carries most of the liquid waste from Rawalpindi and contributes greatly to the pollution of the Soan River below their confluence. Solid-waste disposal practices threaten the quality of ground-water reserves (Sheikh and others, 1999).

CHAPTER 3: STUDY METHODOLOGY

This section describes the methodology that was adopted to meet the study objectives. The task under taken includes:

1. Study area selection
2. Sample collection
3. Laboratory Analysis
4. Results and Discussion
5. Interpretation
6. Conclusion

3.1 Identification of the Sampling Site:

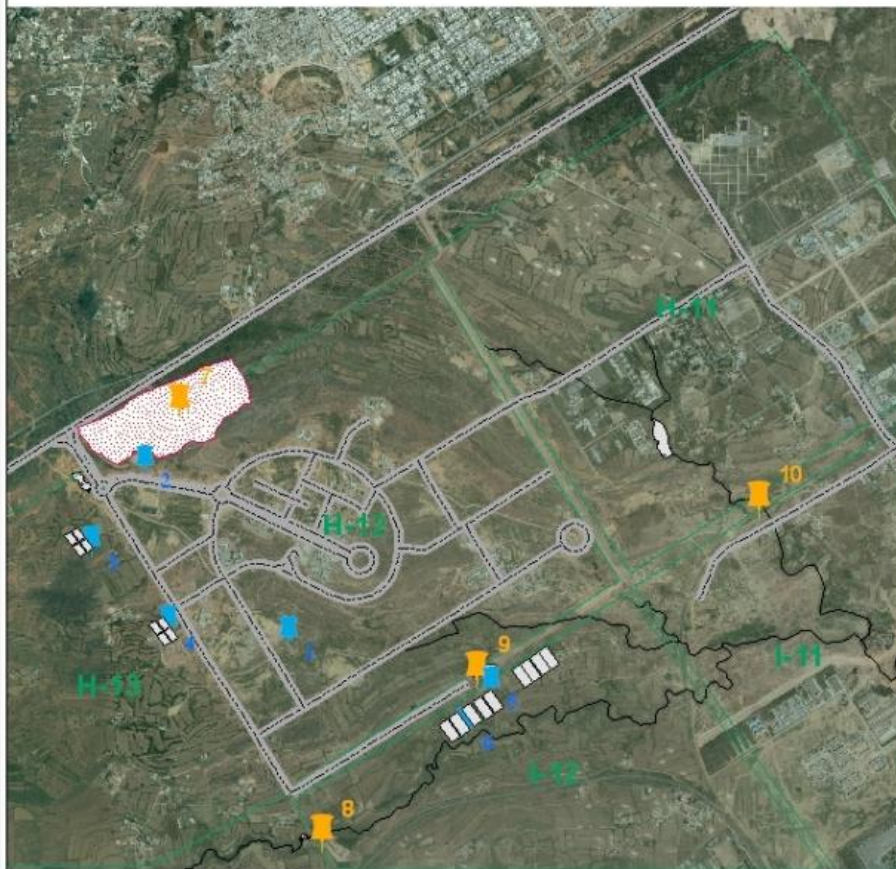
A preliminary survey of the sampling sites was carried out around sector H-12. Figure 3.1 is showing the satellite image of study area whereas figure 3.2 is the GIS generated map of the study area.

SAMPLING LOCATIONS



Legend

- Dumping site
- drinking water sample
- waste water sample
- roads
- water bodies
- Nallas



33°41'11.90"

33°36'26.87"

72°58'34.47"

73° 00' 49.97"

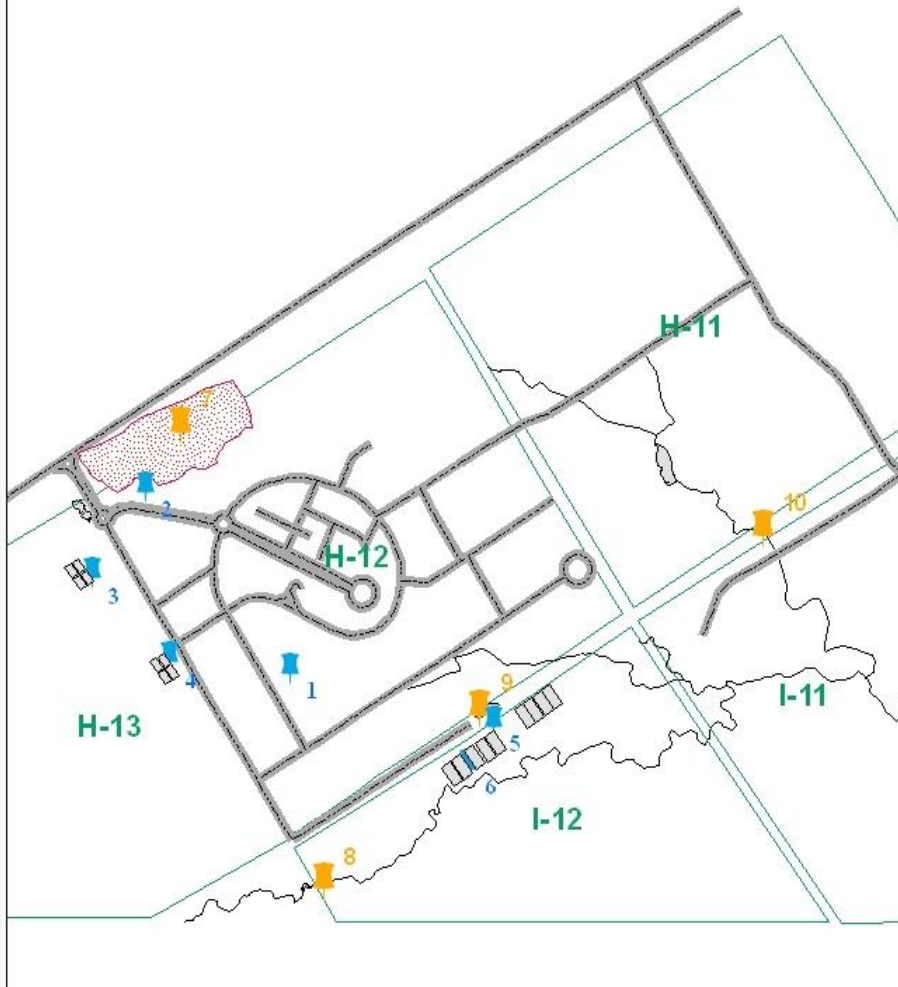
Figure 3.1 H-12 dumping site and sampling locations

SAMPLING LOCATIONS



Legend

- Dumping site
- drinking water sample
- waste water sample
- roads
- water bodies
- Nallas



33°41'11.90"

33°36'26.87"

72°58'34.47"

73° 00' 49.97"

Figure 3.2 H-12 dumping site and sampling locations

3.2 Field Sampling Plan

Prior to conducting sampling, a sampling plan was developed to ensure that:

- Documented and approved procedure must be followed during sampling.
- Samples were collected at pre-selected locations.

Keeping in view the following steps, sampling plan was devised:

- The appropriate sampling equipment was selected.
- Appropriate sampling containers were selected.
- The volume required for each sample was determined.

A checklist of items required for field sampling was prepared to ensure proper preparation.

3.3 Sample Container Cleaning:

Sampling bottles were cleaned using the standard bottle cleaning procedure.

This procedure was also applied to cleaning of other sampling equipment.

- Washed using liquid detergent
- Rinsed thoroughly with hot tap water
- Rinsed thoroughly three times with de-ionized water

3.4 Sample Container Labeling:

Each sample bottle was assigned label. The information, which was entered on the label included.

- Sample number
- Sample date and time
- Sample location
- Source of water

3.5 Sampling Procedure:

The following sampling procedure was followed during water sampling:

3.5.1 Collection of Samples:

Manual sampling procedures were adopted for the collection of water samples.

3.5.1.1 For ground water:

After running the water from boring pipe for at least 5 minutes, the bottles were filled with water. A smooth flow of water makes collecting the samples easier and more accurate.

3.5.1.2 For hand pumps water:

Water samples from hand pumps were collected after purging of hand pump.

3.5.1.3 For stream or wastewater:

While collecting the wastewater the bottles were kept well above the stream to avoid the unwanted bet material going into the sample.

Two sampling bottles were filled simultaneously at each sampling location. The bottles were filled until the water was just about to spill over the tip of the bottle. The cap was carefully replaced and screwed onto the bottle. After collecting sample into the bottle, the samples were labeled. The sample bottle was kept in ice box at 4° C prior to transportation to laboratory. .

3.5.2 Addition of Chemical:

Nitric acid (HNO₃) was added to one of the sampling bottles from each location. HNO₃ was added in a quantity sufficient to lower the pH of the samples to just about 2, to stabilize the concentration of total and dissolved metal.

3.5.3 Transportation:

Sample containers were packed so that contamination from outside is avoided. Samples were taken from sampling location to the laboratory in a private car.

3.6 Laboratory Analyses:

Best analytical techniques were used for the analysis of target parameters with the available facilities in the laboratory. All chemicals and reagents used in this project were of analytical grade. Standards were made by certified standards.

Below are the procedures that were adopted during water analysis in laboratory. These procedures are taken from the report, Standard Operational Procedures for Environmental Water Quality Monitoring in Pakistan, Draft 1, February 2010.

3.6.1 Temperature:

The air temperature measurement is carried out with a dry thermometer. Approximately one meter above the sampling point. The thermometer must be shaded from the sun. The water temperature is measured by dipping the thermometer to the reading off depth and waiting until the reading is constant. Where the direct measurement is not possible i.e. in spring's large quantity of water is collected and the temperature is taken as soon as possible.

3.6.2 pH:

Calibrate the meter and electrode system.

- 1- Place the sample and buffer solution in a clean glass beaker using a sufficient volume to cover the sensing of the electrodes.

- 2- If field measurements are being made the electrode may be immersed directly in the sample stream to an adequate depth.
- 3- After rinsing and gently wiping the electrodes, if necessary immerse them in to the sample beaker or sample stream and stirrer at a constant rate to provide homogeneity and suspension of solid. Note and record sample pH and temperature. Repeat measurement on successive volume of sample until values differ by less than 0.1 pH units 2 to 3 volumes change are sufficient (Pak EPA, February 2010).

3.6.3 Total Dissolved Solids:

Choose the sample volume that yield residue between 5 to 200 mg. Transfer a measured volume of well mixed sample to pre weight dish and evaporate to dryness in a drying oven if necessary at successive sample portion to the same dish after evaporation. When evaporating in a dry oven, lower temperature to approximately 2 degree below boiling to prevent splitting. Dry evaporated sample at least one hour in an oven at 103-105 degree. Cool in desiccators to balance temperature and weigh. Repeat cycle of drying cooling desecrating and weighing until a constant weight is obtained or until weight loss less than 4% of previous weight or 0.5 mg ever is less (Pak EPA, February 2010).

Formula for calculating TDS,

$$\text{Total dissolve salts (mg/L)} = \frac{(A-B)*1000}{\text{Sample volume in ML}}$$

Sample volume in ML

Where;

A= weight of dried residue + dish

B= weight of empty dish.

3.6.4 Total Suspended Solid:

Preparation of glass filter disc; place the glass fiber filter (AP-10 Millipore) on the membrane filter approximately. While vacuum is applied, wash the dish with 3 successive 20ml volume of distilled water remove filter from membrane filter apparatus and dry in an oven at 103-105 degree for an hour. Remove to desiccators, repeat the drying cycle until the constant weight is obtained (Pak EPA, February 2010).

Assemble the filtering apparatus; wet filter with a small volume of distilled water to seat it again the fritted support.

Shake the sample vigorously and quantitatively transfer 100mL sample in to filter funnel using a graduated cylinder. Remove all traces of water by applying vacuum after sample has passed through. (Pak EPA, February 2010).

With suction on, wash the graduated cylinder, filter non-filterable residue and filter funnel wall with three portion of distilled water.

Carefully remove the filter paper from the filter support. Dry at least one hour at 103-105 degree. Cool in desiccators and weigh.

Formula for calculating TSS,

$$\text{TSS} = \frac{(A-B) \times 1000}{\text{ML of sample}}$$

ML of sample

Where;

A= Weigh of filter + residue in mg

B= Weigh of filter in mg

3.6.5 Sulfate:

Analytical technique: Gravimetric (Pak EPA, February 2010)

Procedure:

- 1- Take 100ml filtered sample in a flask
- 2- Add 1.5 ml of HCL (1+1) N
- 3- Boil it at hot plat.
- 4- Also boil Barium Chloride 10%
- 5- Add 30ml Barium Chloride into sample at boiling state

- 6- Place the sample for over night.
- 7- Take a Whatman filter paper No.42 and it initially after drying in oven at 103 degree for one hour and cooling in dedicator.
- 8- Get precipitate of Barium Sulfate after filtration of sample.
- 9- Put filter paper in an oven for drying at 103 degree C , Temperature.
- 10- After drying filter paper, put it into desiccators for cooling.
- 11- After cooling, weigh it finally.

CALCULATION:

$$\text{Mg/l Sulfate} = (\text{Final weigh} - \text{initial weight}) / \text{ml of sample} * 411.6$$

CHEMICALS:

- 1- Barium Chloride 10%

Take 100gm of Barium Chloride and dilute it with distilled water up to 1 lit.

- 2- HCL (1+1) N

Add 50 ml conc. HCL into 50 ml distilled water.

3.6.6 Chloride:

Analytical technique: Argentometric (Pak EPA, February 2010)

Procedure

- 1- Take 10ml well filtered sample in a flask
- 2- Add 40 ml distilled water
- 3- Titrate against 0.0141 N AgNo₃ using K₂CrO₄ as indicator
- 4- End point is yellowish to pinkish

BLANK

- 1- Add 50 ml distilled water
- 2- Add potassium Chromate as indicator
- 3- Titrate against 0.0141 N Ag No₃
- 4- End point will be yellowish to pinkish

Calculation:

Blank reading – Sample reading = D

$D * 400/\text{ml of sample} = \text{mg/1 sulfide}$

Reagents

- 1- AgNo₃ solution (0.0141 N)

Dissolve 2.395 gm AgNO₃ in distilled water and dilute to 1 lit.

- 2- K₂CrO₄ indicator

Dissolve 50 gm in distilled water and dilute to 1 lit.

Calculation

Volume of titrant used in sample – volume of titrant used in blank = D

Mg / lit Chloride = $D \times \text{Normality of AgNO}_3 \times \text{Equivalent weight of Chlorine} \times$
 $1000 / \text{Volume of sample taken.}$

CHAPTER 4: RESULTS AND DISCUSSION

Guidelines for Drinking Water

Parameter	WHO Mg/l	EU Guideline Mg/l	US EPA Mg/l	PSQCA Mg/l
pH	6.5 – 8.5	NGVS	NGVS	6.5 – 8.5
DO	NGVS	NGVS	NGVS	NGVS
EC	NGVS	NGVS	NGVS	NGVS
Chloride	250	250	250	250
Sulfate	250	250	250	400
COD	150 (waste)	5 (Drinking)	NGVS	150 (waste)
T-N	NGVS	NGVS	NGVS	NGVS
T-P	NGVS	NGVS	NGVS	NGVS
Iron	0.3	0.2	0.3	0.50
Copper	2	2	1.5	2
Cadmium	0.003	0.005	0.005	0.01
Lead	0.01	0.01	0.015	0.05
Cobalt	NGVS	NGVS	NGVS	NGVS
TDS	1000	NGVS	NGVS	1000
TSS	200 (waste water)	NGVS	NGVS	200 (waste water)
Magnesium	150	NGVS	NGVS	NGVS
BOD	80 (waste water)	NGVS	NGVS	80 (waste water)

Table 1 showing the parameter guideline for WHO, EU, US EPA, and PSQCA

4.1 Temperature:

The temperature of the collected samples generally reflects the ambient temperature and does not have major effect on the leaching of solid waste.

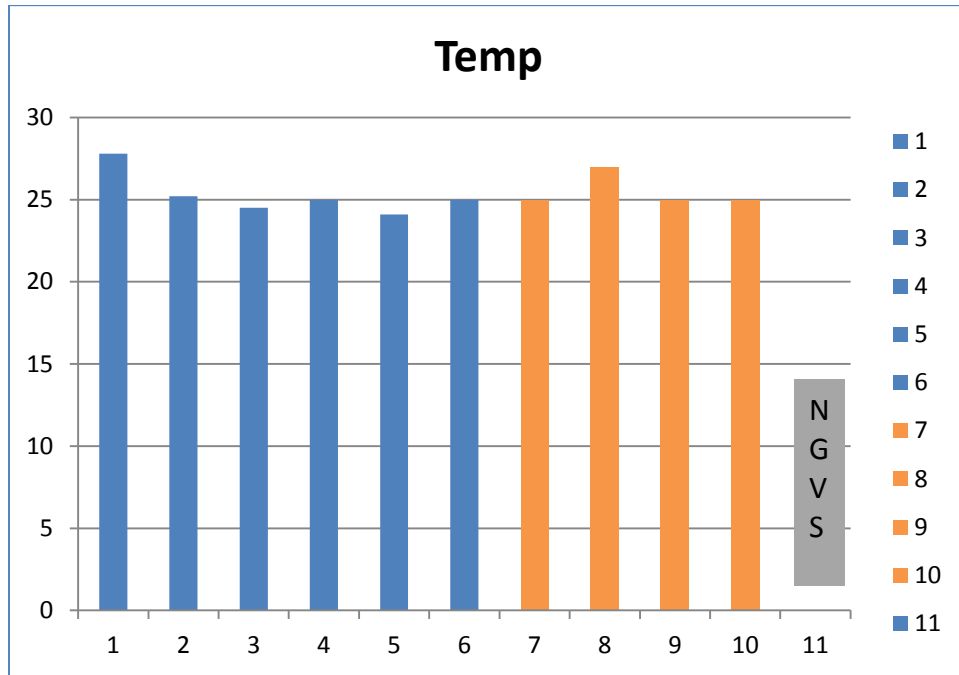


Figure 4.1 showing temperature variations in °C in samples.

4.2 pH:

WHO standard for drinking water: 6.5 – 8.5

Standard value for Pakistan for drinking water: 6.5 – 8.5

Studies have demonstrated that as pH decreases, metals solubility increases; thus metals are more soluble under acidic conditions, which could be attracted to the tendency of metals to form soluble metal oxides in acidic environment (JICA, March 22, 2005). Solubility of some metals, like zinc and

lead, may increase again under extreme alkaline conditions due to their ability to form soluble metal hydroxide compounds (Peirce et al, 1997).

pH is the single most important factor in determining metals leach ability and migration, rather than the total metal concentration in the ash. In general, the longer a solid phase is in contact with the extraction solution the more metal will leach, However , under acidic conditions ($\text{pH} < 4$) the increase in contact time leads to a greater increase in dissolved metal concentration than under neutral or alkaline conditions ($\text{pH} > 4$) (JICA, March 22, 2005).

The maximum pH 8.36 was found at sample location number 08 which is a Running waste water nalla coming from Koh-e-noor mills, and for drinking water the maximum pH was observed at sample location number 01 which is a borehole located in H-12, Whereas minimum pH for drinking water was observed at sample location number 04 which is a borehole located in H-12.

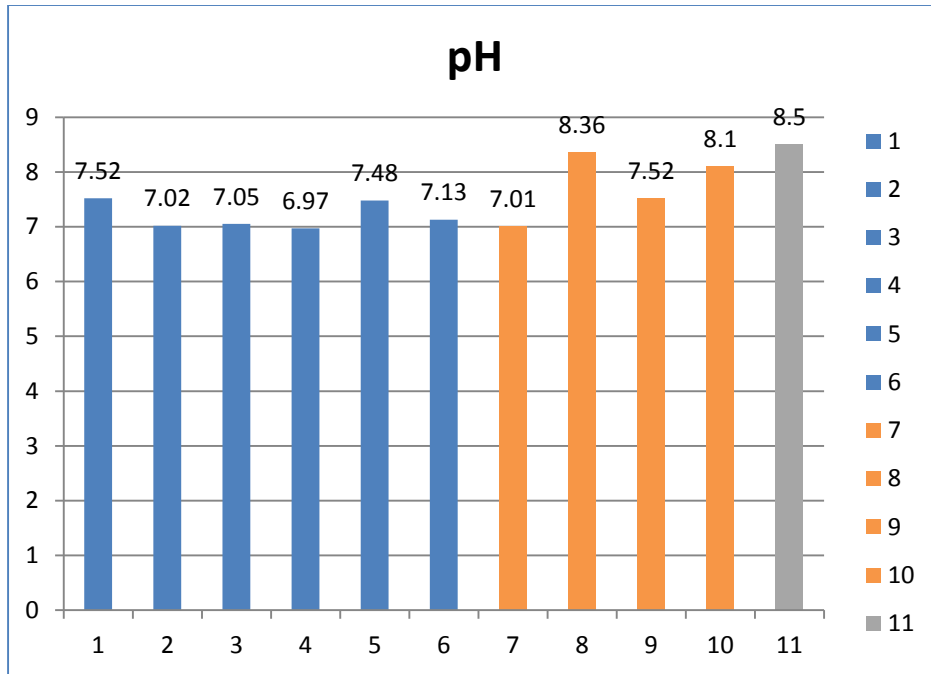


Figure 4.2 showing pH variations in samples.

4.3 Electric Conductivity:

WHO standard for drinking water: NGVS

Standard value for Pakistan for drinking water: NGVS

Conductivity is a numerical expression of the ability of a solution to carry an electric current. This ability depends upon the ions, on their total concentration, and on the temperature of the measurement.

The maximum conductivity $1278 \mu\text{s}/\text{cm}^2$ was found at sample location number 07 for waste water and $1056 \mu\text{s}/\text{cm}^2$ for drinking water at sample location number 05, whereas minimum conductivity at $261 \mu\text{s}/\text{cm}^2$ observed in the sample collected from sample location number 09.

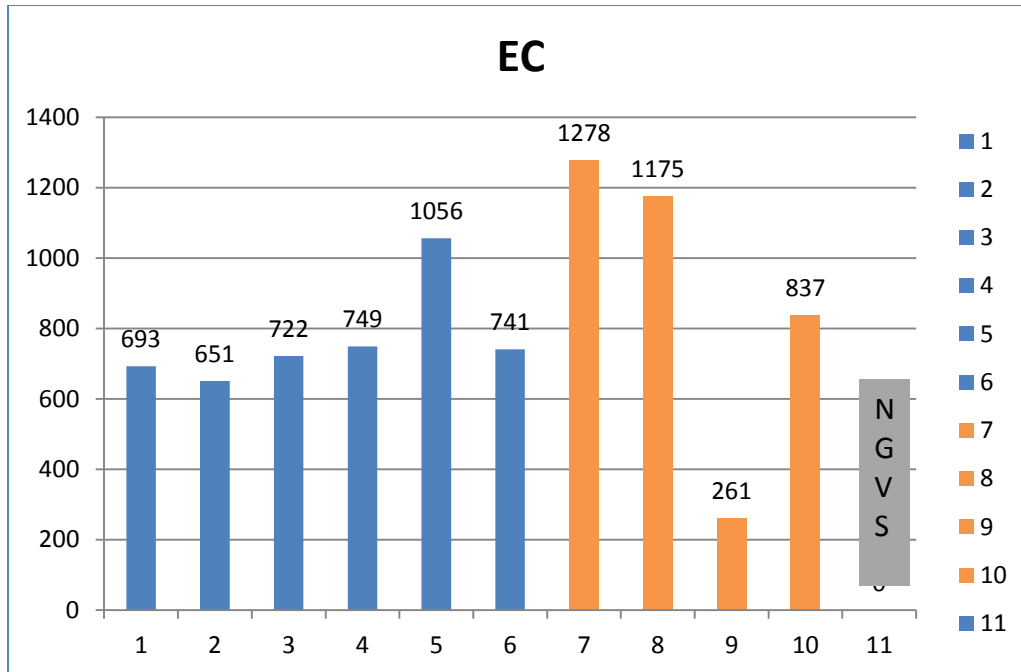


Figure 4.3 showing EC variations in µs/cm² in samples.

4.4 Total Suspended Solids:

WHO standard for drinking water: 200 mg/l for waste water

Standard value for Pakistan for drinking water: 200 mg/l for waste water

The standard available for TSS were of waste water. It was observed that both drinking and waste water samples were way above the permissible limits. The maximum level of TSS was found in sample location number 09 which is 3064 mg/l for wastewater. And for drinking water the maximum level is 534 mg/l found in sample location number 05.

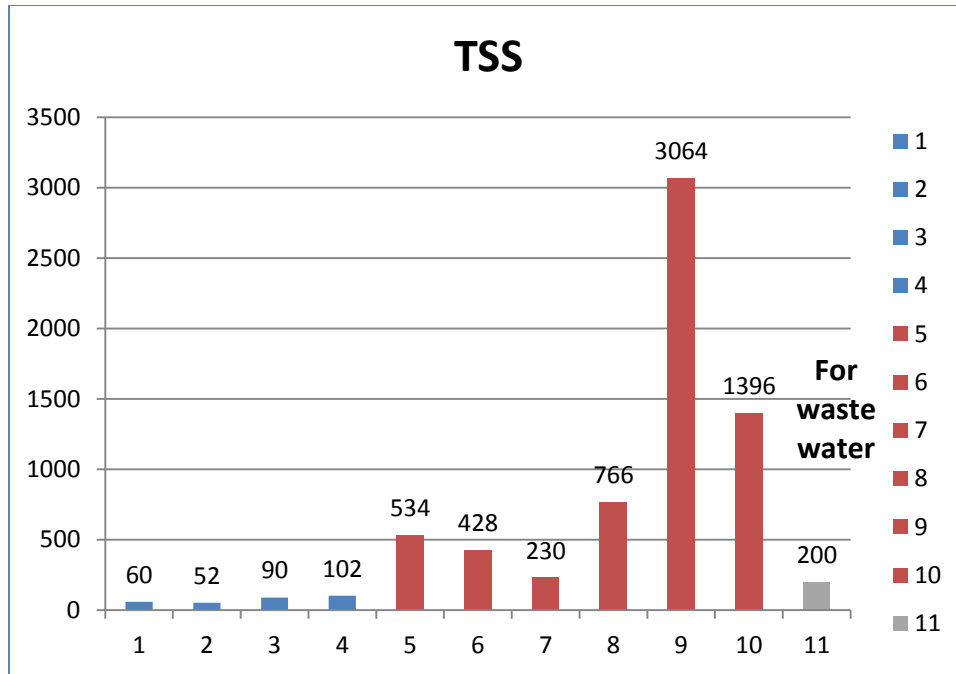


Figure 4.4 showing TSS variations in samples.

4.5 Total Dissolve Solids:

WHO standard for drinking water: 1000 mg/l

Standard value for Pakistan for drinking water: 1000 mg/l

The maximum level of TDS was found in sample location number 08 which is 802 mg/l for wastewater. And for drinking water the maximum level is 480 mg/l found in sample location number 04. All the samples were below the permissible limits.

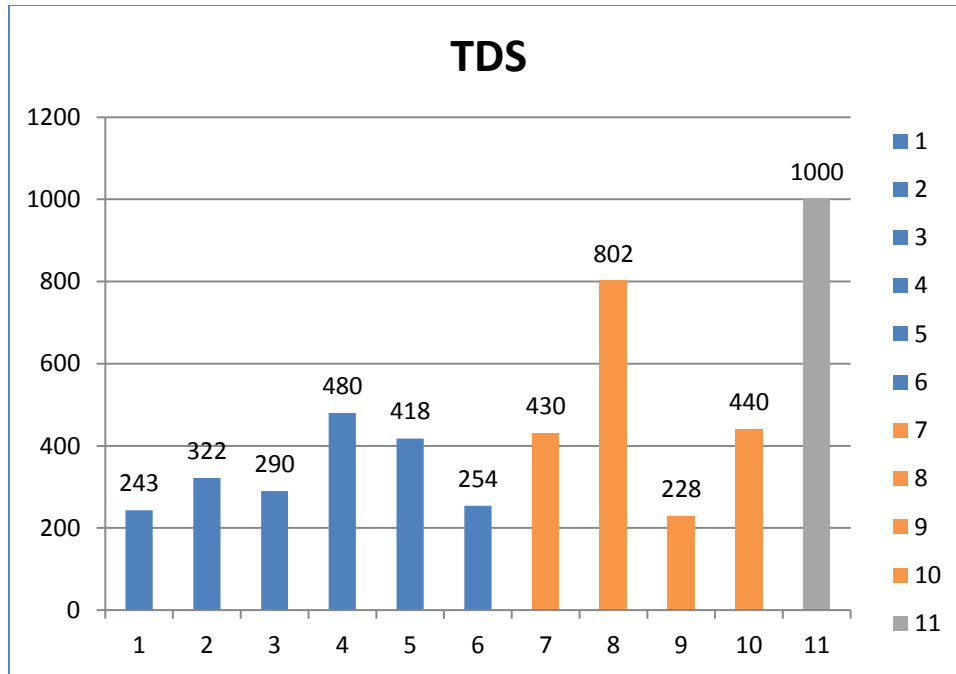


Figure 4.5 showing TDS variations in samples.

4.6 Dissolved Oxygen (DO):

WHO standard for drinking water: NGVS

Standard value for Pakistan for drinking water: NGVS

Dissolved oxygen (DO) refers to the volume of oxygen that is contained in water. The amount of dissolved oxygen often determines the number and types of organisms living in that body of water. Decay of organic material in water caused by either chemical processes or microbial action on untreated sewage or dead vegetation can severely reduce dissolved oxygen concentration. A high DO level in water supply is good because it makes drinking water taste better. However, high DO levels speed up corrosion in water pipes. The amount of oxygen water can hold depends upon temperature (more oxygen can be

dissolved in colder water), pressure (more oxygen can be dissolved in water at greater pressure), and salinity (more oxygen can be dissolved in water of lower salinity) (Peirce et al, 1997).

The minimum concentration of Dissolve Oxygen was 1.05 mg/l found in sample location number 05 which is borehole hand pump supplying drinking water for a community.

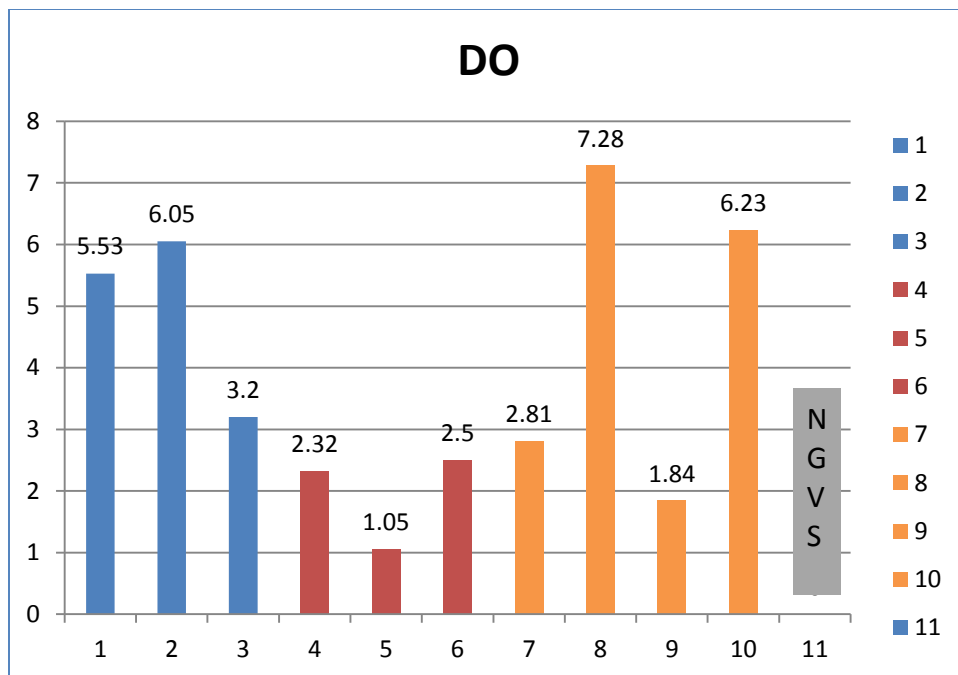


Figure 4. 6 showing DO variations in mg/l in samples.

4.7 Chloride:

WHO standard for drinking water: 250 mg/l

Standard value for Pakistan for drinking water: 250 mg/l

Drinking Water Standards require chloride levels not to exceed 250 mg/L. Criteria for protection of aquatic life require levels of less than 600 mg/L for chronic (long-term) exposure and 1200 mg/L for short-term exposure (kywater.org).

The maximum level of chloride for waste water was 72.74 mg/l was found in location number 08. For ground water the maximum level is 58.62 mg/l found in location number 05.

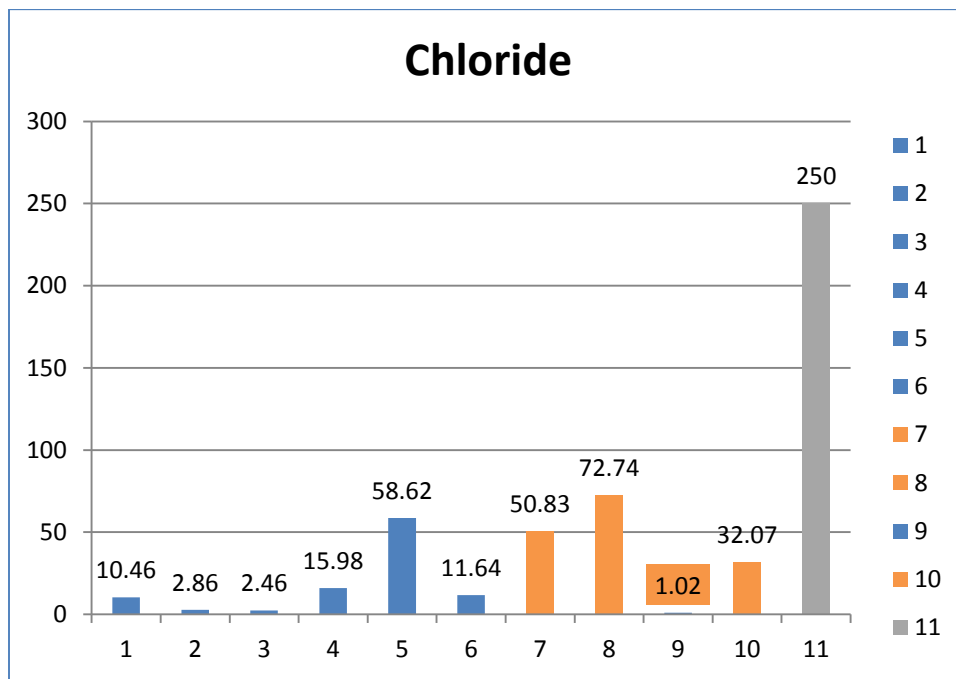


Figure 4.7 showing Chloride variations in mg/l in samples.

4.8 Sulfate:

WHO standard for drinking water: 250 mg/l

Standard value for Pakistan for drinking water: 400 mg/l

At high levels, sulfate can give water a bitter or astringent taste and can have laxative effects. Animals are also sensitive to high levels of sulfate. In young animals, high levels may be associated with severe, chronic diarrhea, and in few instances, death (WHO, 2004).

Sulfate in drinking water was below the allowed limits. The maximum concentration of sulfate was found at location number 07 of about 324.75 mg/l which is a wastewater. The minimum concentration 44.86 mg/l was found in location 02.

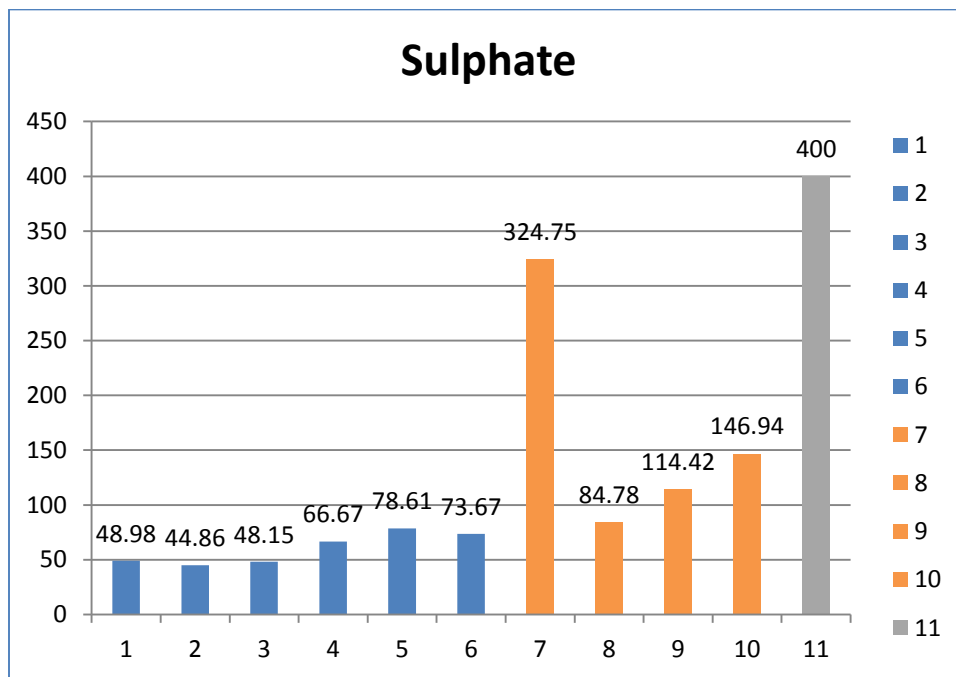


Figure 4.8 34 show sulfate variations in mg/l in samples.

4.9 Total Nitrogen:

WHO standard for drinking water: NGVS

Standard value for Pakistan for drinking water: NGVS

The maximum concentration of Total Nitrogen was found at location number 10 of about 53.92 mg/l. The minimum concentration 1.01 mg/l was found in location 02.

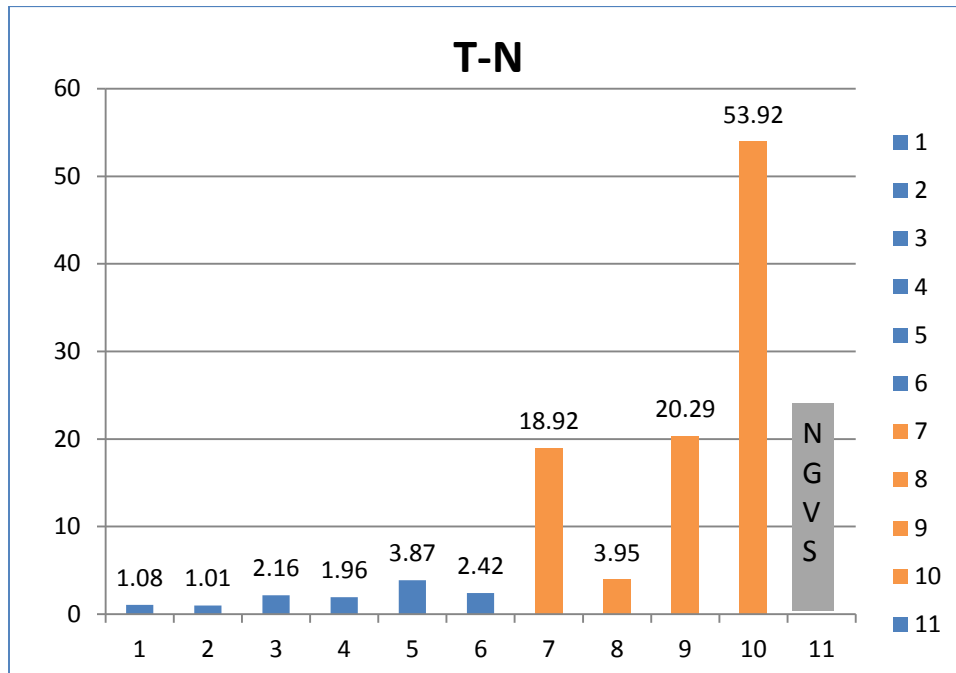


Figure 4.9 showing Total Nitrogen variations in mg/l in samples.

4.10 Total Phosphate:

WHO standard for drinking water: NGVS

Standard value for Pakistan for drinking water: NGVS

The maximum concentration of Total Phosphate was found at location number 10 of about 5.85 mg/l. The minimum concentration 0.024 mg/l was found in location 01.

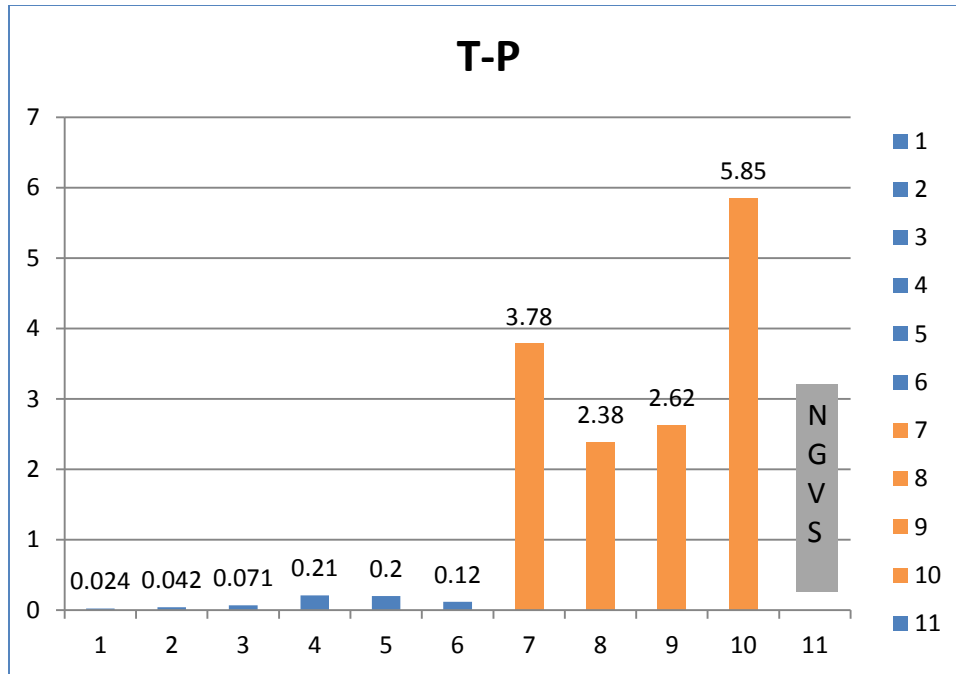


Figure 4.10 showing Total Phosphate variations in mg/l in samples

4.11 Chemical Oxygen Demand (COD):

WHO standard for drinking water: 150 mg/l for waste water

Standard value for Pakistan for drinking water: 150 mg/l for waste water

Chemical oxygen demand is the measure of oxygen equivalent to the portion of organic matter in waste water that is susceptible to oxidation by potassium dichromate. COD is an important test. This gives a quick measure of pollution load of stream, sewage and industrial waste water, well water samples. It allows wastewater/leached measurement in terms of total quality of oxygen required for oxidation to carbon dioxide and water (Peirce et al, 1997).

COD observed during the survey was varied from 10mg/l to 58 mg/l for drinking water. Almost all the values of COD were above the permissible limit.

The maximum value of COD for waste water was found at location number 09 which is 121 mg/l and minimum at location 08 which is 57 mg/l.

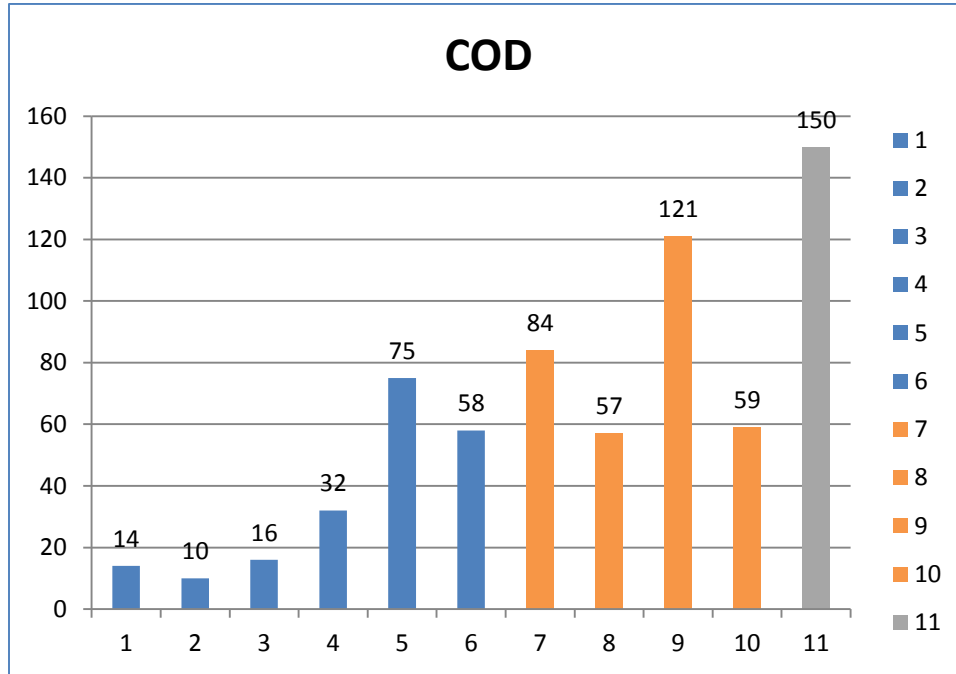


Figure 4.351 showing COD variations in mg/l in samples.

4.12 Biological Oxygen Demand (BOD):

WHO standard for drinking water: 80 mg/l for waste water

Standard value for Pakistan for drinking water: 80 mg/l for waste water

Biological oxygen demand stands for the biodegradability of the total organic matter dissolved or suspended in water under study. Along with dissolved oxygen, this is the most common reported water quality indicator. Sewage or other organic pollutants, especially in warm water already low in dissolved oxygen, could lead to severe oxygen depletion with adverse impact on aquatic life. Rivers is said to be seriously polluted if they have a BOD of 6.5

mg/1 or more, that is, if more than 6.5mg/1 of oxygen would require oxidizing the organic matter in a liter of water. (Peirce et al, 1997)

Analysis of BOD was only done with waste water. The maximum concentration of 82.28 mg/1 was found in sample location number 09 which was stagnant rain water and minimum concentration of 14.75 was present in sample location number 08.

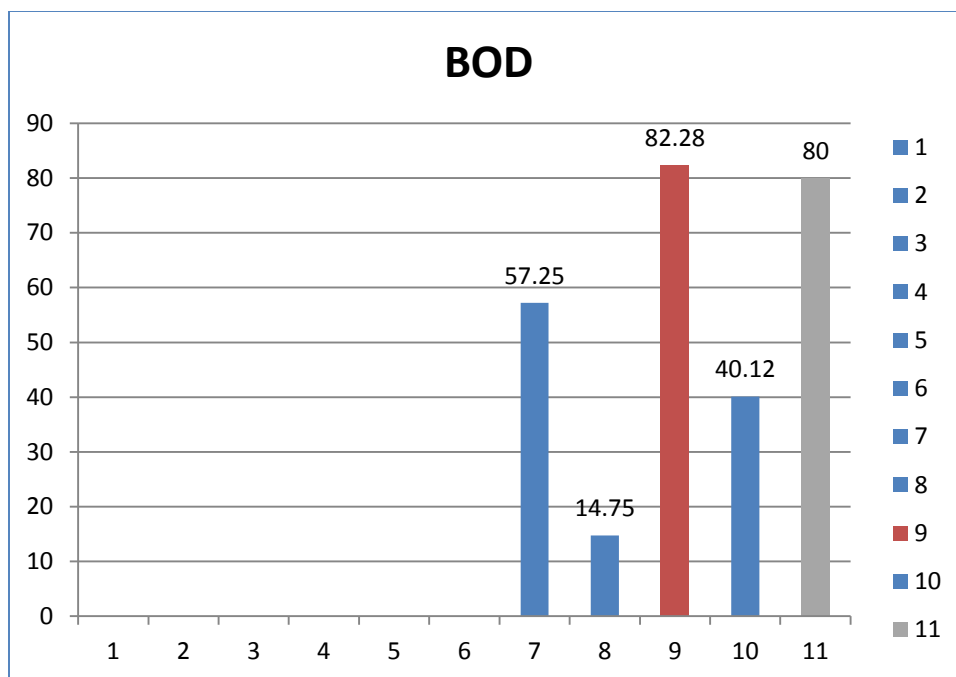


Figure 4.362 showing BDO variations in mg/l in samples.

4.13 Magnesium:

WHO standard for drinking water: 150 mg/1

Standard value for Pakistan for drinking water: NGVS

Analysis of Magnesium was only done with drinking water. The maximum concentration of Magnesium was found at location number 01 of about 13.7 mg/l, which is within the range of allowed limit. The minimum concentration 6.6 mg/l was found in location 05.

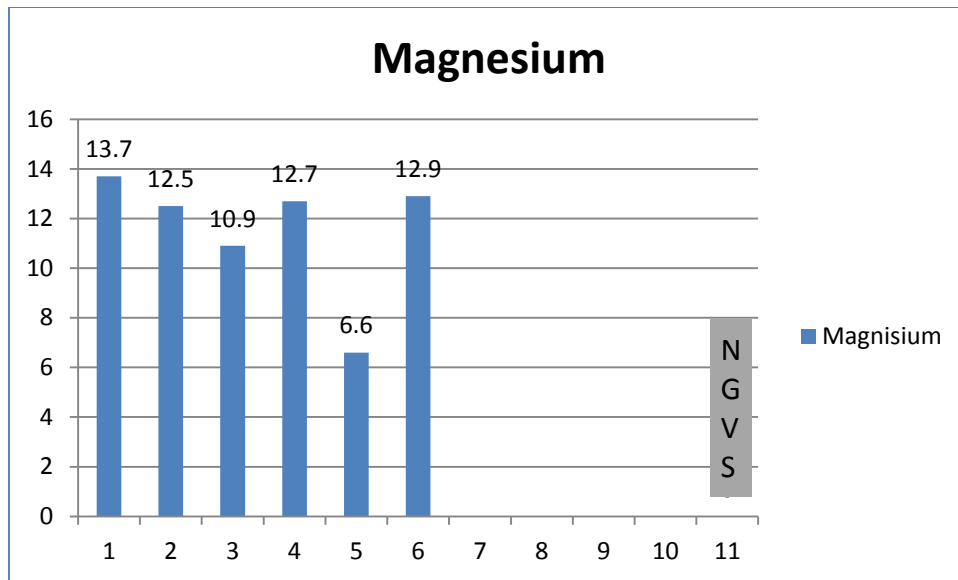


Figure 4.13 showing Magnesium variations in mg/l in samples.

4.14 Heavy Metals:

The term heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations. Examples of heavy metals include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Tl), and lead (Pb) (European Commission, February 2002).

Heavy metals are natural components of the Earth's crust. They cannot be degraded or destroyed. To a small extent they enter our bodies via food,

drinking water and air. As trace elements, some heavy metals (e.g. copper, selenium, zinc) are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning. Heavy metal poisoning could result, for instance, from drinking-water contamination (e.g. lead pipes), high ambient air concentrations near emission sources, or intake via the food chain (JICA, March 22, 2005).

Heavy metals are dangerous because they tend to bioaccumulate. Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. Compounds accumulate in living things any time they are taken up and stored faster than they are broken down (metabolized) or excreted chain (JICA, March 22, 2005).

Heavy metals can enter a water supply by industrial and consumer waste, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers, and groundwater chain (JICA, March 22, 2005).

4.14.1 Cadmium:

WHO standard for drinking water: 0.003 mg/l

Standard value for Pakistan for drinking water: 0.01 mg/l

Cadmium derives its toxicological properties from its chemical similarity to zinc an essential micronutrient for plants, animals and humans. Cadmium

is biopersistent and, once absorbed by an organism, remains resident for many years (over decades for humans) although it is eventually excreted (European Commission, February 2002).

In humans, long-term exposure is associated with renal dysfunction. High exposure can lead to obstructive lung disease and has been linked to lung cancer, although data concerning the latter are difficult to interpret due to compounding factors. Cadmium may also produce bone defects (osteomalacia, osteoporosis) in humans and animals (European Commission, February 2002).

The concentration of cadmium for drinking water which is above the permissible limit was found at location number 05 which is 0.08 mg/l, and location number 04 which is 0.02 mg/l, where as no concentration of cadmium was found in location 01 and 06. The maximum concentration for waste water was found in location number 07 of about 0.57 mg/l.

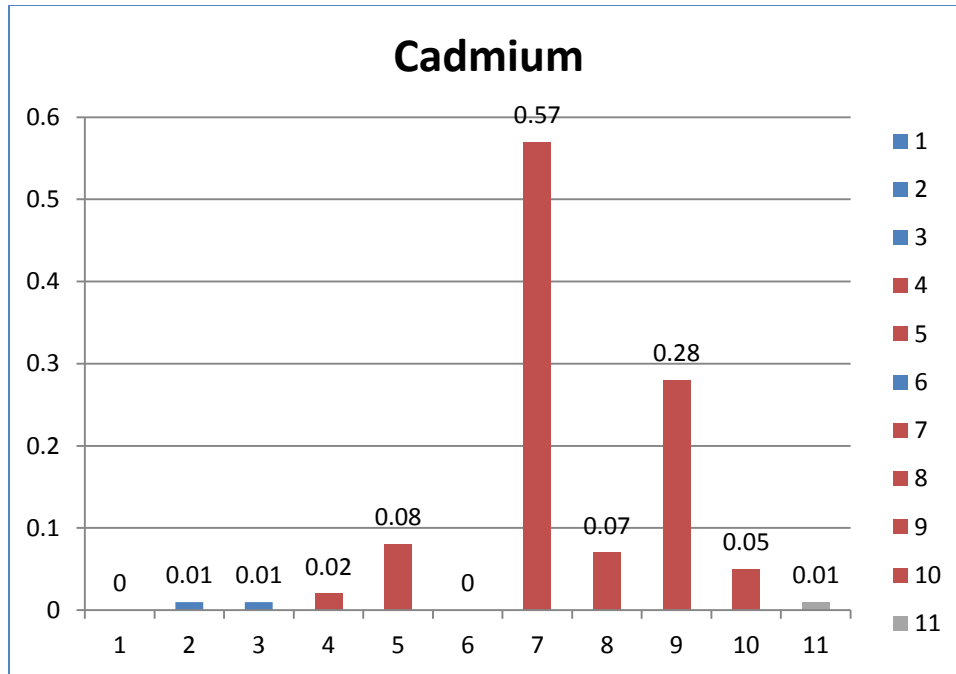


Figure 4.14 showing Cadmium variations in mg/l in samples.

4.14.2 Copper:

WHO standard for drinking water: 2 mg/l

Standard value for Pakistan for drinking water: 2 mg/l

Copper is an essential substance to human life, but in high doses it can cause anemia, liver and kidney damage, and stomach and intestinal irritation. Copper normally occurs in drinking water from copper pipes, as well as from additives designed to control algal growth (lenntech.com).

The maximum concentration of copper was found at location number 05 of about 0.68 mg/l which is drinking water tube well. The minimum

concentration 0.02 mg/l was found in location 09. No concentration of copper was found in location 02.

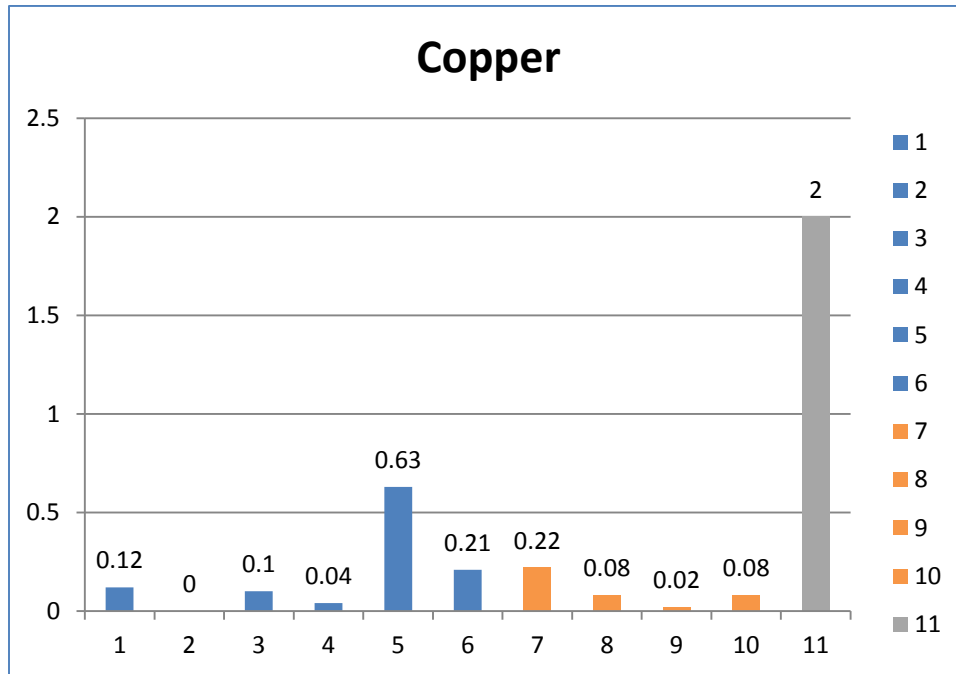


Figure 4.375 showing Copper variations in mg/l in samples.

4.14.3 Lead:

WHO standard for drinking water: 0.010 mg/l

Standard value for Pakistan for drinking water: 0.050 mg/l

In humans exposure to lead can result in a wide range of biological effects depending on the level and duration of exposure. Various effects occur over a broad range of doses, with the developing fetus and infant being more sensitive than the adult. High levels of exposure may result in toxic biochemical effects in humans which in turn cause problems in the synthesis of hemoglobin, effects on the kidneys, gastrointestinal tract, joints and

reproductive system, and acute or chronic damage to the nervous system (European Commission, February 2002).

Lead was not found in all samples in and around the solid waste dumping site at H-12 Islamabad. Lead is not found in location number 01 and 02. The concentration of lead for drinking water which was above the permissible limit was about 0.85 mg/l, 0.63 mg/l, 0.12 mg/l was found in sample location number 05, 04, 06. Maximum concentration for waste water of about 1.21 mg/l was observed in location number 07.

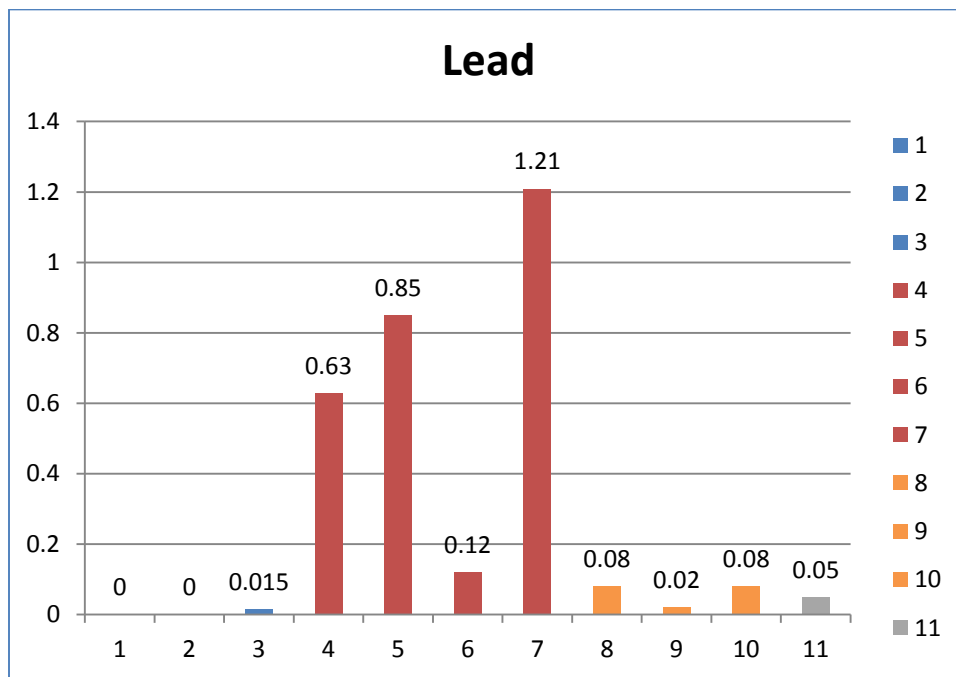


Figure 6.16 showing Lead variations in mg/l in samples.

4.14.4 Iron:

WHO standard for drinking water: 0.3 mg/l

Standard value for Pakistan for drinking water: 0.5 mg/l

Iron is one of the most abundant metals in the earth's crust .It is found in natural fresh water at level ranging from 0.5 to 50 mg/l. Iron is also essential element in human nutrition. Maximum concentration 5.91 mg/l of iron is present in sample number 10 which is waste water stream and for drinking water maximum concentration of about 3.05 mg/l was found in sample location number 05 which is very above the permissible limit. Minimum concentration of about 0.052 mg/l was found in location number 02. No concentration of iron was found in location 04.

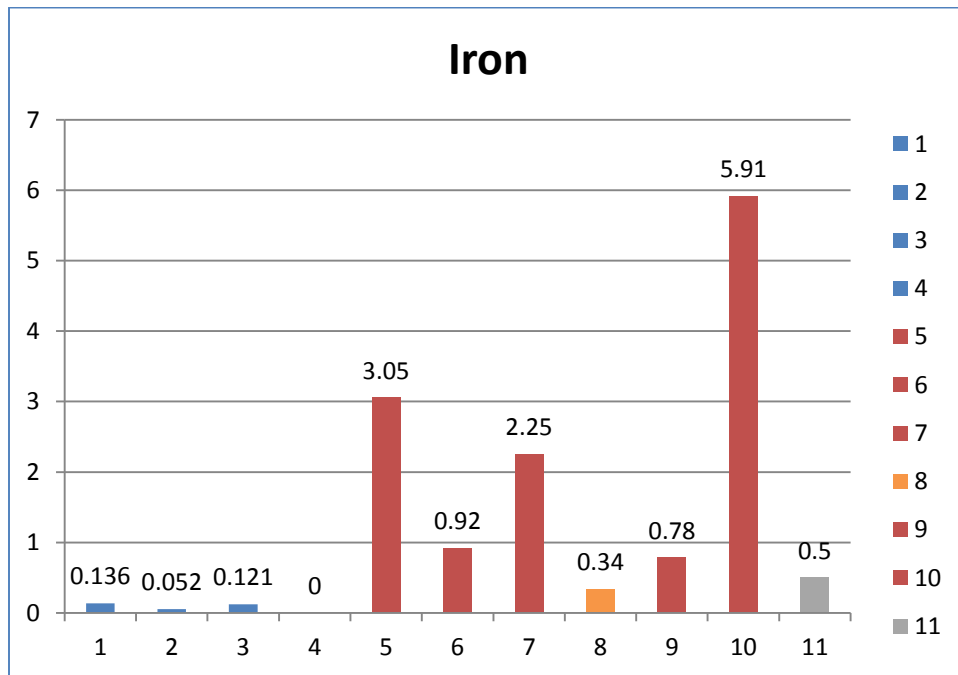


Figure 4.17 showing Iron variations in mg/l in samples.

4.14.5 Cobalt:

WHO standard for drinking water: NGVS

Standard value for Pakistan for drinking water: NGVS

Cobalt is beneficial for humans because it is a part of vitamin B12, which is essential for human health. Cobalt is used to treat anemia with pregnant women, because it stimulates the production of red blood cells. The total daily intake of cobalt is variable and may be as much as 1 mg, but almost all will pass through the body unabsorbed, except that in vitamin B12. However, too high concentrations of cobalt may damage human health (lenntech.com).

Analysis of Cobalt was only done with waste water. Maximum concentration 0.58 mg/l of Cobalt is present in sample number 08, and minimum concentration of about 0.052 mg/l was found in location number 09.

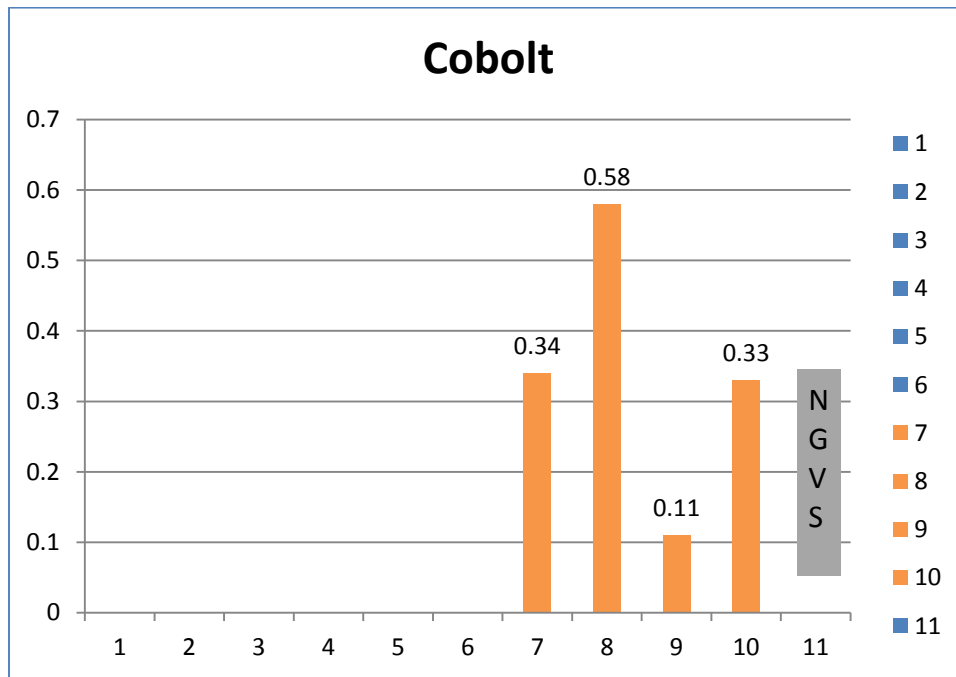


Figure 4.1838 showing Cobalt variations in mg/l in samples.

CHAPTER 5: STATISTICAL RELATIONSHIP

The interpretation was done after the samples were analyzed on the basis of results. Few of the parameters of the samples were correlated with each other to observe whether they have strong correlation, weak correlation or have no correlation with each other. Spatial correlation of all the parameters was also developed with latitude and longitude, to identify that the specific parameter might be present in maximum concentration at a specific location.

5.1 Correlation of Temperature and pH:

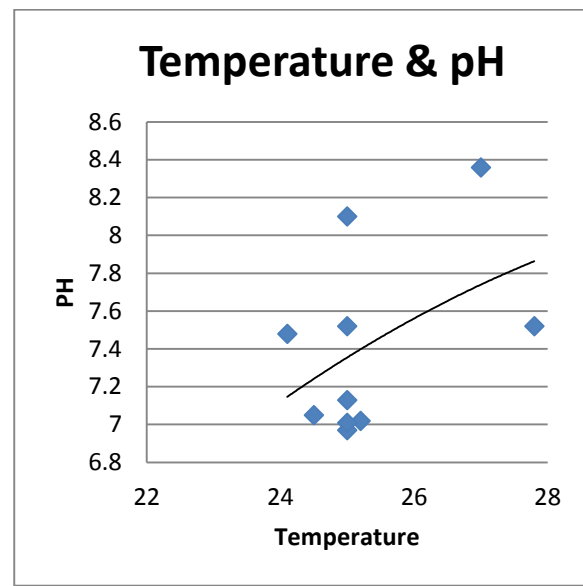
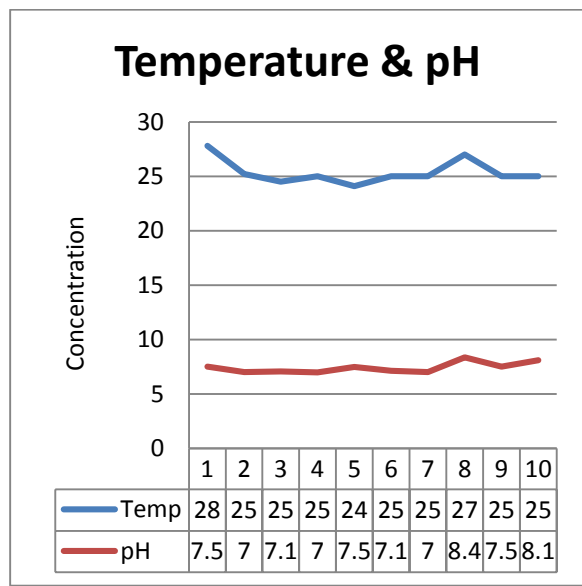


Figure 5.39 showing the trend of pH and temperature in the study area

Figure 5.40 showing co-relation between pH and temperature

Figure 5.1 shows the trend of temperature and pH in the sample, it indicates that by increasing the temperature, the pH also increases. Furthermore Figure 5.2 is showing the correlation between Temperature and pH. It is

observed that in the region between 24 & 25(along x-axis), almost 7 data points are available and there is a linear polynomial relationship between pH and Temperature. It is observed that by increasing temperature the pH will also increase in this region.

5.2 Correlation of Temperature and DO:

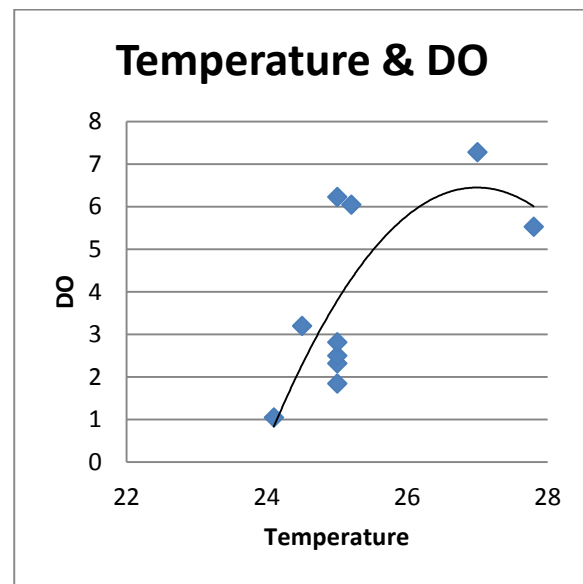
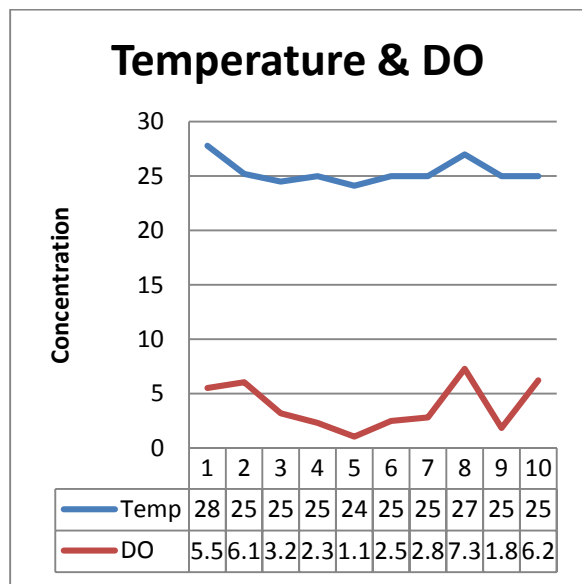


Figure 5.41 showing the trend of DO and Figure 5.42 showing co-relation between DO and temperature in the study area

Figure 5.3 is showing a slight similarity in trend between temperature and DO. Where as figure 5.4 show that, it is a parabolic graph in nature, which is increasing in the start and slightly decreasing in the end. It is observed that in the range of temperature between 24 and 25 maximum number of data

points is available. It is noted that by increasing the temperature the DO will also increase.

5.3 Correlation of pH and Cadmium:

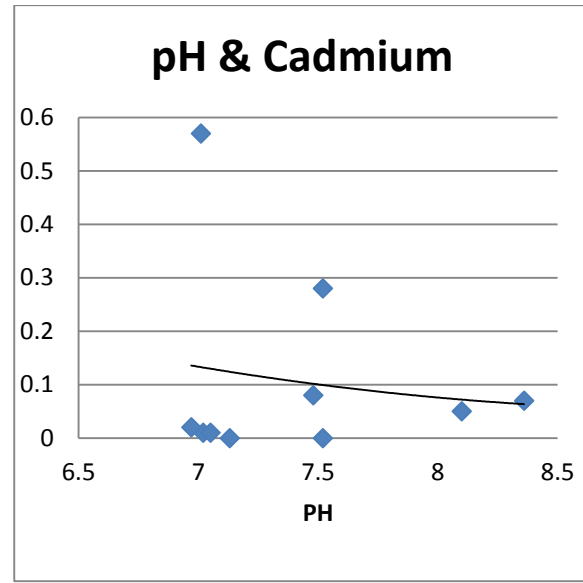
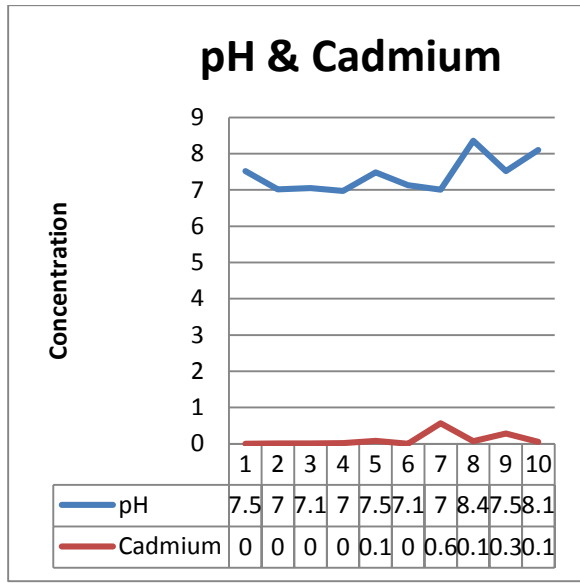


Figure 5.43 showing the trend of pH and cadmium in the study area

Figure 5.44 showing co-relation between pH and cadmium

Figure 5.5 does not show any kind of similarity in trend between pH and cadmium. As cadmium is rare in the sample so figure 5.6 shows that there is a decreasing trend from the start till end of the graph.

5.4 Correlation of pH and Lead:

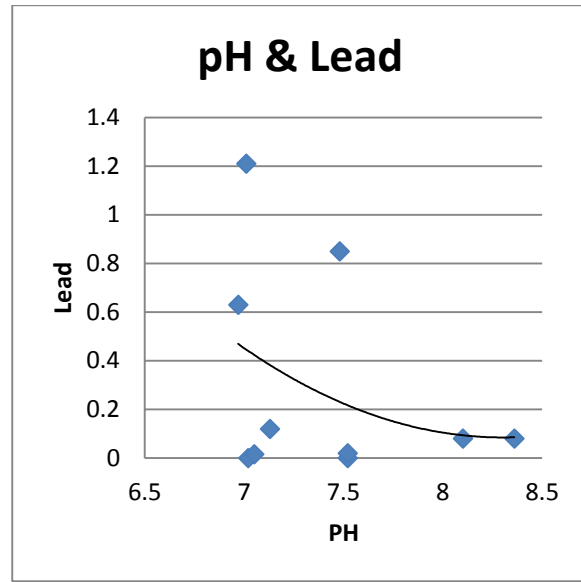
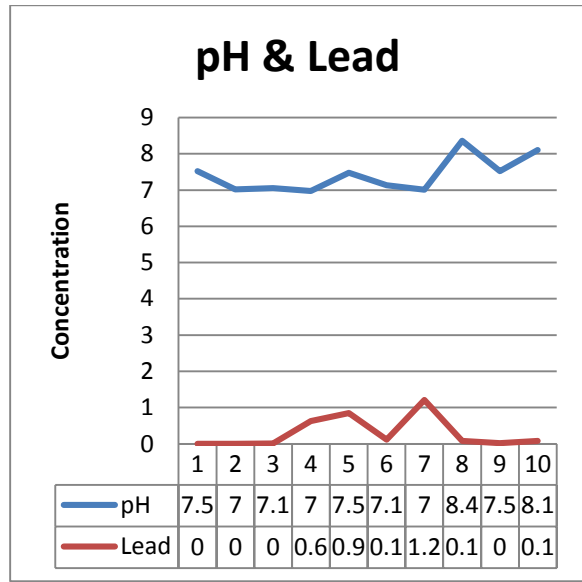


Figure 5.45 showing the trend of ph and lead in the study area

Figure 5.46 showing co-relation between ph and lead

In Figure 5.8, it is observed that the graph is continuously decreasing indicating that lead is also rare in the available samples. It is further observed that the linear graph lead versus ph decreases and touch the x-axis at ph 8.5.

5.5 Correlation of TDS and EC:

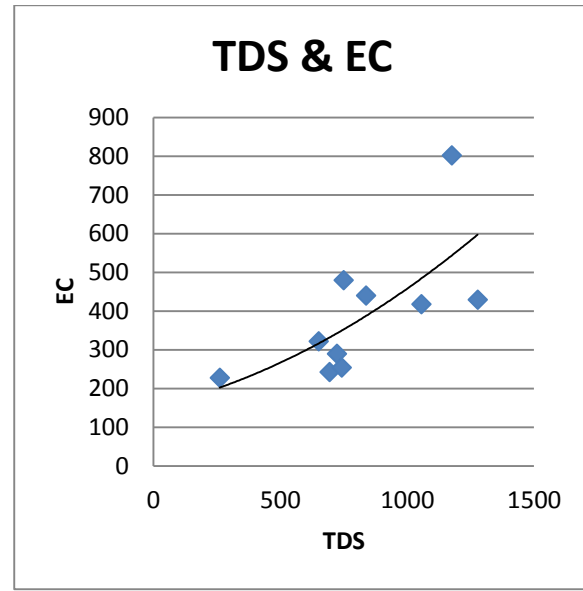
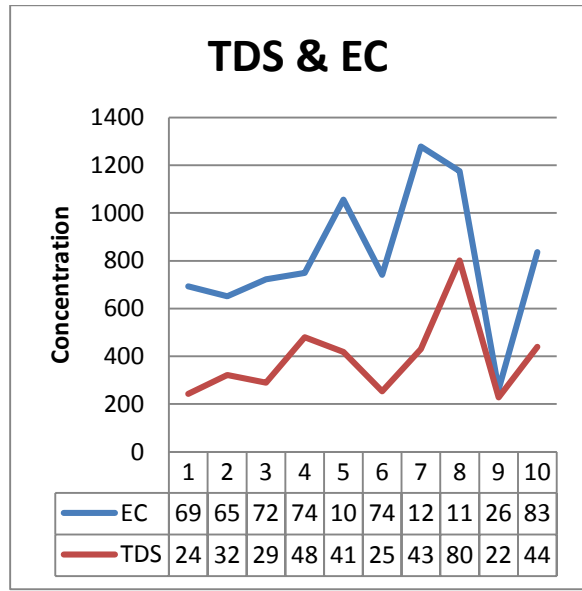


Figure 5.47 showing the trend of TDS and EC in the study area Figure 5.10 showing co-relation between TDS and EC

While observing the figure 5.9 and 5.10, it is noted that TDS and EC has a strong co-relation. Figure 7.10 shows a linear polynomial relationship which is continuously increasing from start till end. It is observed that by increasing TDS the EC will also increase and vice versa.

5.6 Correlation of Total Nitrogen and Total Phosphate:

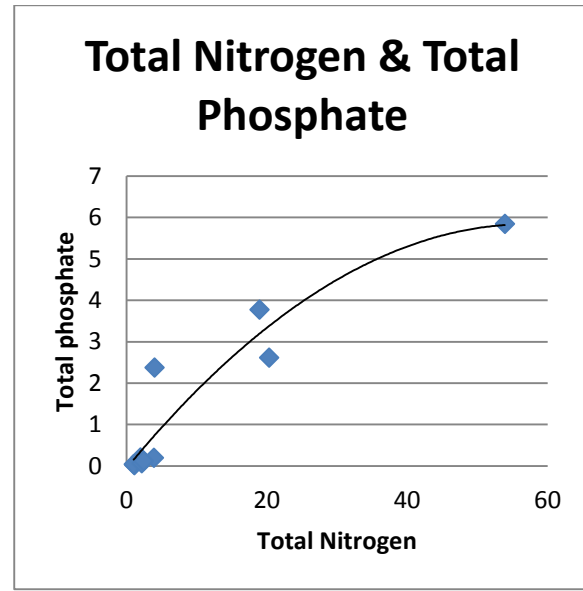
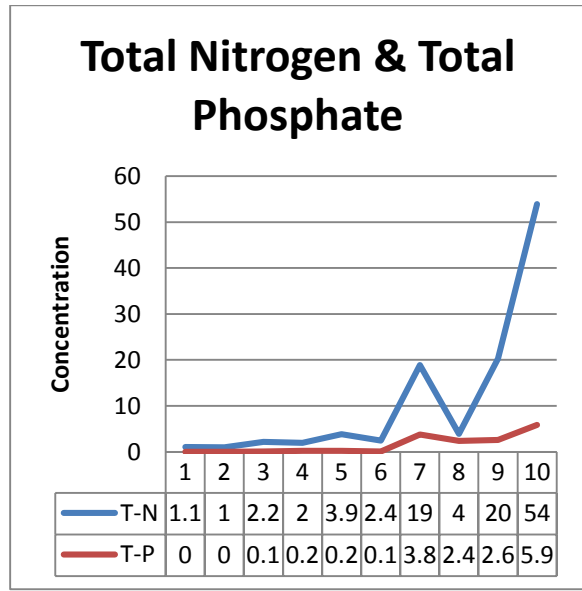


Figure 5.48 showing the trend of T-P and T-N in the study area Figure 5.49 showing co-relation between T-P and T-N

In figure 5.12, the region between 0 & 5(along x-axis), maximum number of data points are available and there is a parabolic polynomial relationship between T-N and T-P. It is observed that by increasing T-P the T-N will also increase in this region.

5.7 Correlation of Iron and Copper:

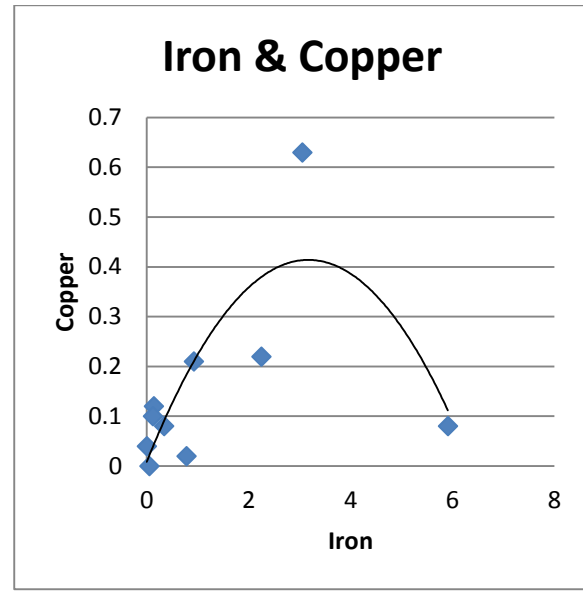
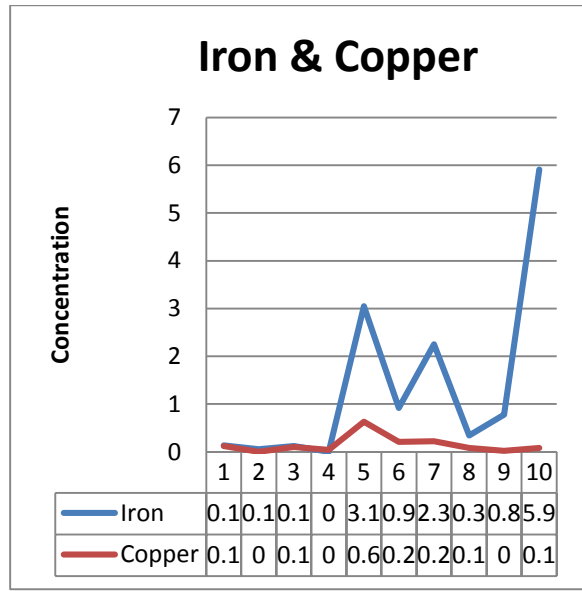


Figure 5.13 showing the trend of Iron and Copper in the study area and Figure 5.50 showing co-relation between Iron and copper

In the above figure 5.14, the data points are concentrated at the start of the graph. Some of the data points are scattered in the plan. The parabolic graph depicts an increasing trend from the start of the graph up till approximately 3.5 and tends to decrease up till end. This behavior of the figure indicates hybrid behavior of the data points in the plan. The curve reliability is more towards the start where the trend is increasing.

5.8 Correlation of Iron and Cadmium:

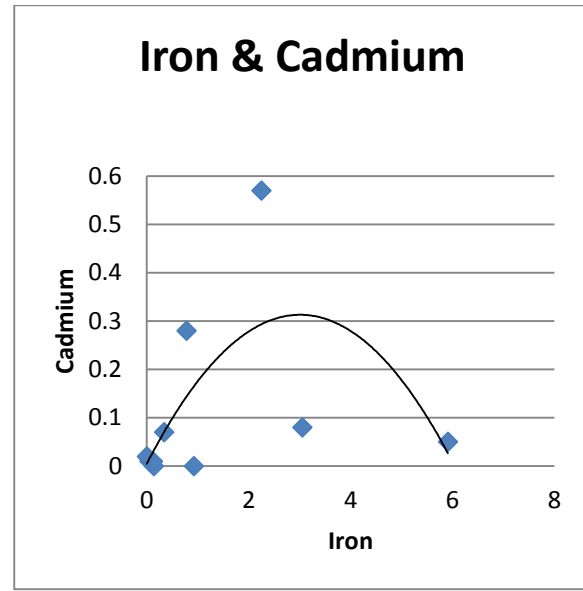
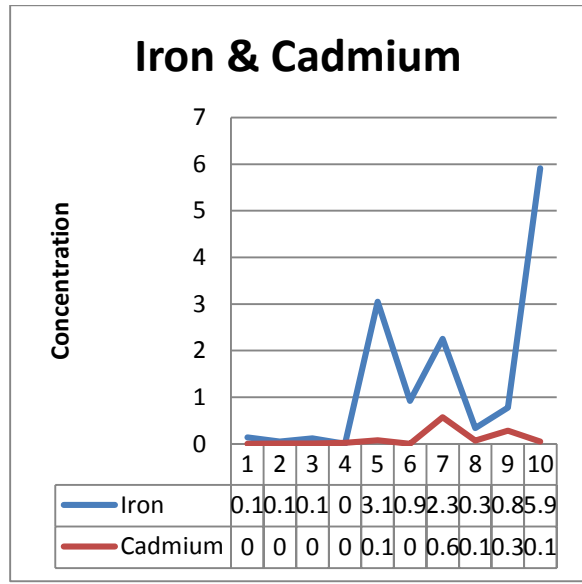


Figure 5.15 showing the trend of Iron and cadmium in the study area

Figure 5.51 showing co-relation between Iron and cadmium

The trend in figure 5.15 shows very slight similarity between iron and cadmium. Where as figure 5.16 show that the polynomial relation between iron and cadmium is almost the same as the relationship between iron and copper. It is also a parabolic graph showing increasing from the start of the graph and then tends to decrease up till end.

5.9 Correlation of Lead and Cadmium:

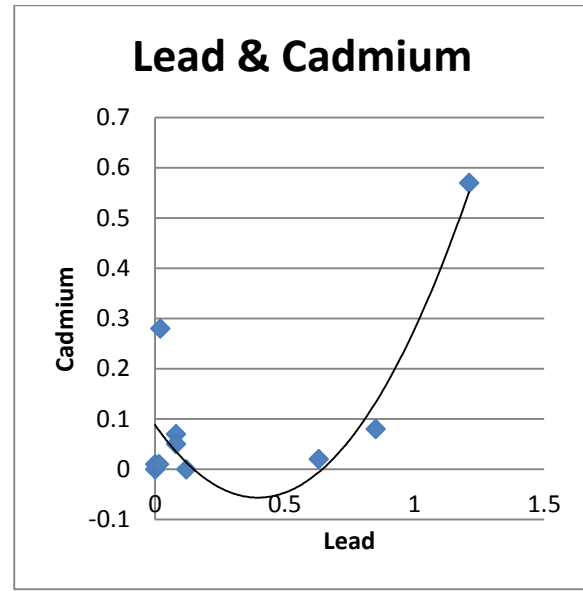
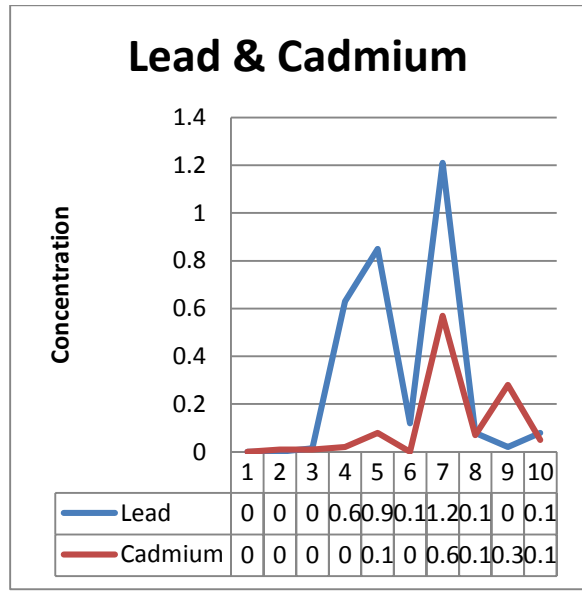


Figure 5.52 showing the trend of lead and cadmium in the study area and Figure 5.53 showing co-relation between lead and cadmium

Figure 5.18 shows that the maximum data points are concentrated at the start of the graph where the parabolic trend is decreasing and from the value 0.5 the trend starts increasing up till end, where only 3 data point are available.

5.10 Spatial Correlation of different parameters with Latitude and Longitude

PARAMETERS		CORRELATION	
1	2	DRINKING	SURFACE
Temperatu	Longitude	Null	Negative
PH	Longitude	Positive	Positive
DO	Longitude	Negative	Positive
EC	Longitude	Positive	Negative
TSS	Longitude	Positive	Positive
TDS	Longitude	Null	Negative
Chloride	Longitude	Positive	Negative
Sulfate	Longitude	Positive	Negative
COD	Longitude	Positive	Null
T-P	Longitude	Positive	Positive
T-S	Longitude	Positive	Positive
Iron	Longitude	Positive	Positive
Copper	Longitude	Positive	Negative
Cadmium	Longitude	Positive	Negative
Lead	Longitude	Positive	Negative

Table 2 showing spatial correlation of parameters with longitude

PARAMETERS		CORRELATION	
1	2	DRINKING	SURFACE
Temperature	Latitude	Negative	Negative
PH	Latitude	Negative	Negative
DO	Latitude	Negative	Negative
EC	Latitude	Negative	Positive
TSS	Latitude	Negative	Negative
TDS	Latitude	Negative	Negative
Chloride	Latitude	Negative	Negative
Sulfate	Latitude	Negative	Positive
COD	Latitude	Negative	Positive
T-P	Latitude	Negative	Positive
T-N	Latitude	Negative	Positive
Iron	Latitude	Negative	Positive
Copper	Latitude	Negative	Positive
Cadmium	Latitude	Negative	Positive
Lead	Latitude	Negative	Positive

Table 3 showing spatial correlation of parameters with latitude

5.11 Spatial Correlation of Latitude and Longitude with various drinking water parameters:

Latitude

Longitude

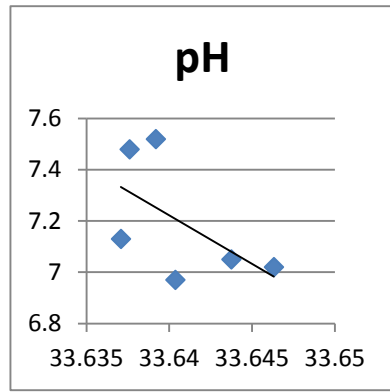


Figure 5.54

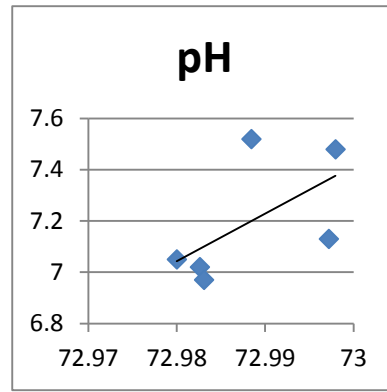


Figure 5.55

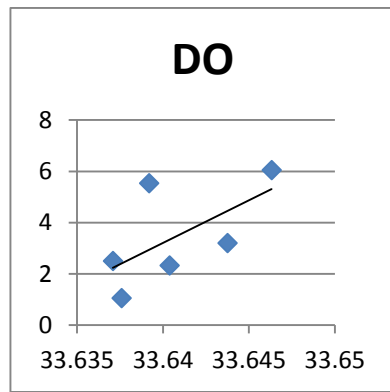


Figure 5.56

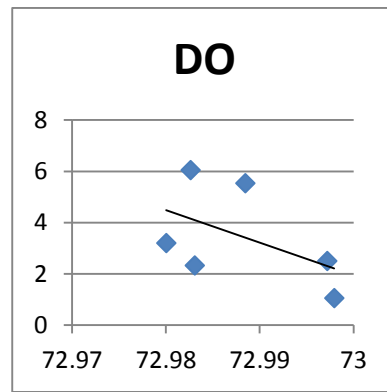


Figure 5.22

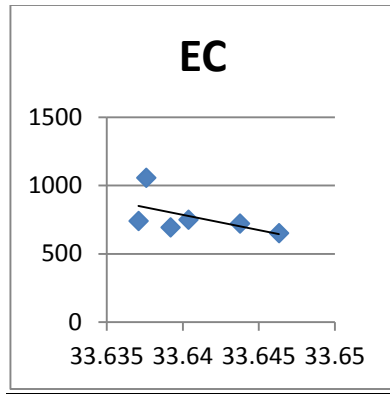


Figure 5.573

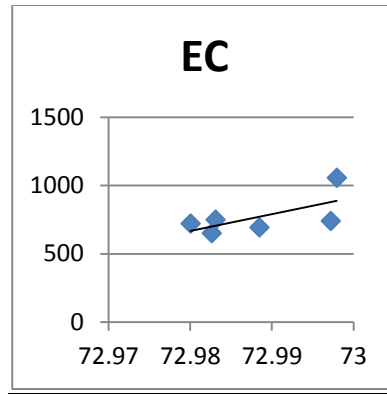


Figure 5.258

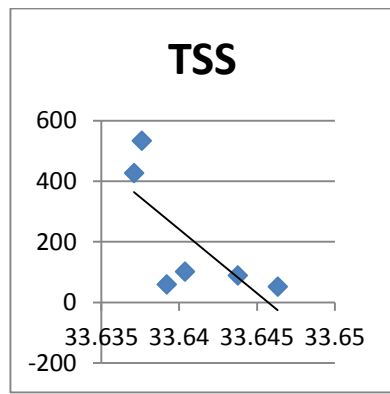


Figure 5.25

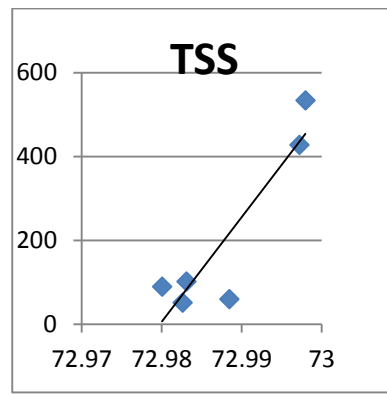


Figure 5.26

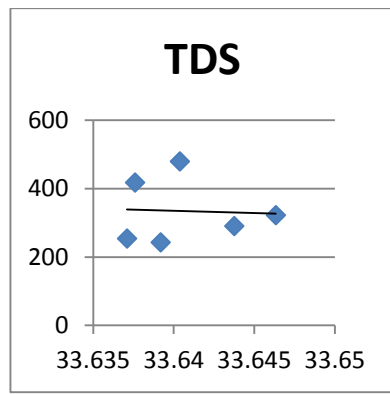


Figure 5.27

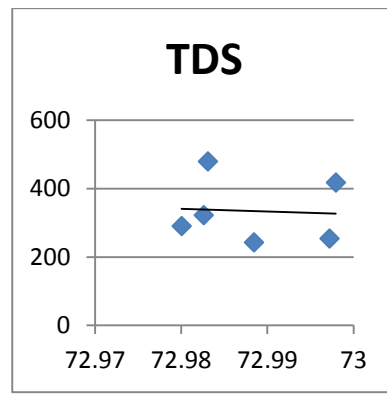


Figure 5.28

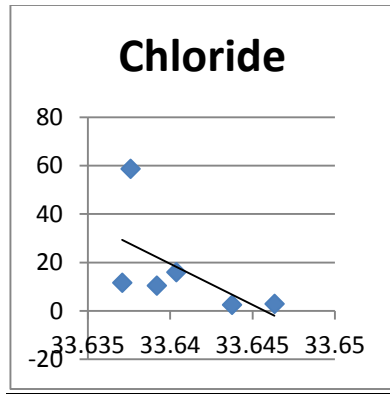


Figure 5.29

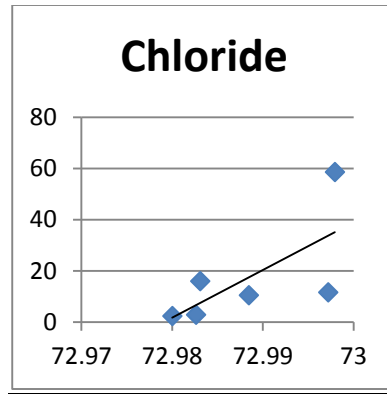


Figure 5.30

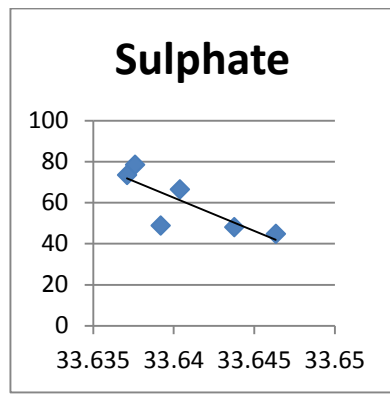


Figure 5.31

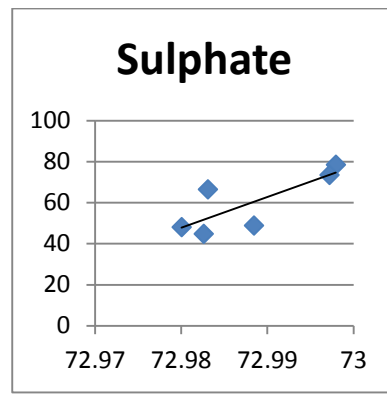


Figure 5.32

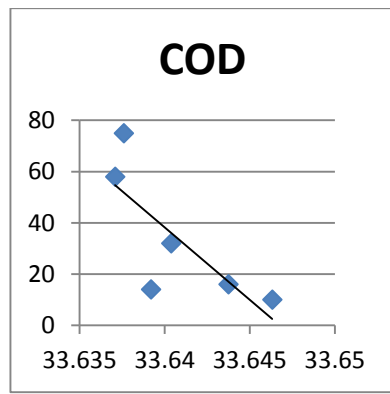


Figure 5.33

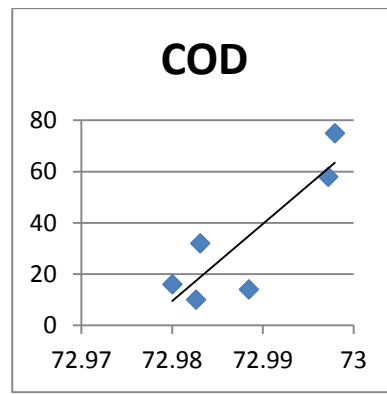


Figure 5.34

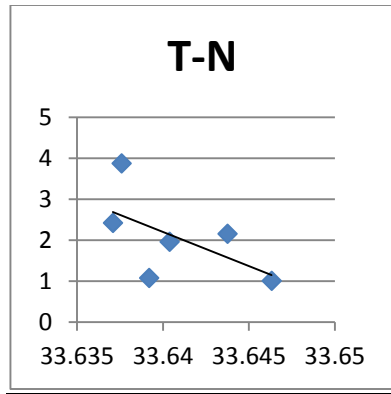


Figure 5.35

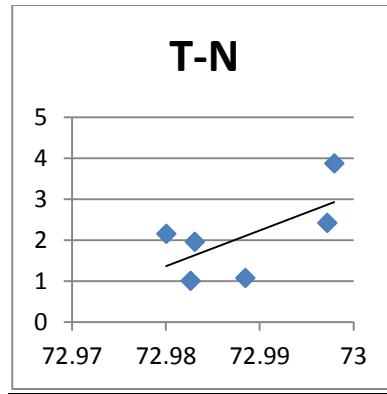


Figure 5.36

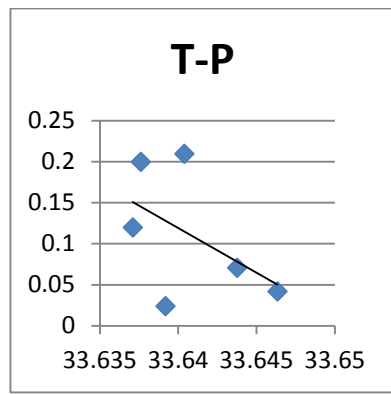


Figure 5.37

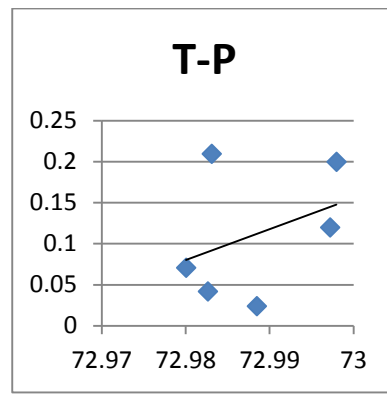


Figure 5.38

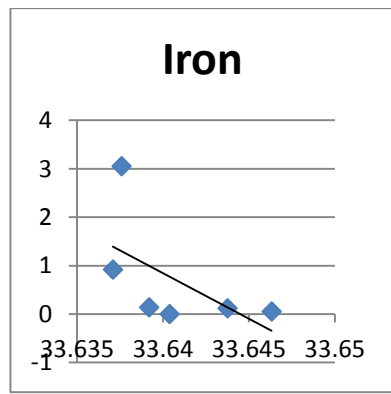


Figure 5.3959

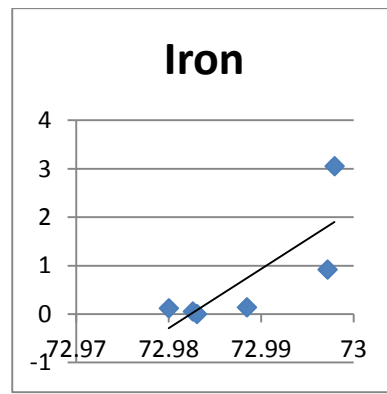


Figure 5.40

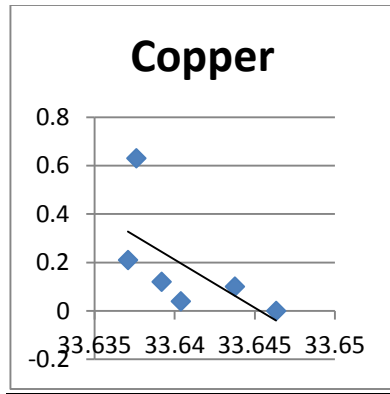


Figure 5.41

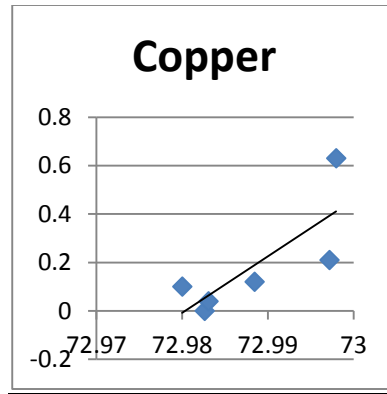


Figure 5.42

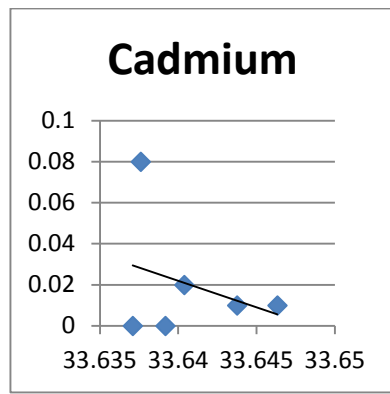


Figure 5.43

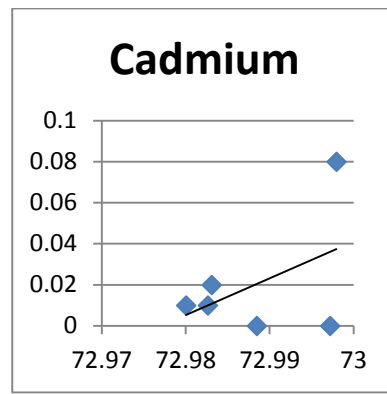


Figure 5.44

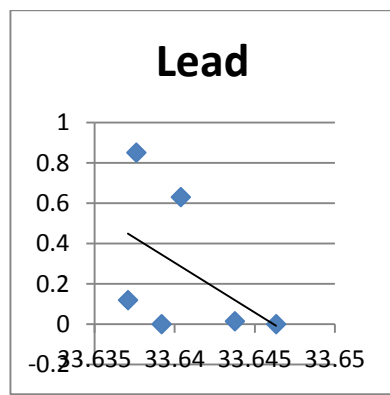


Figure 5.45

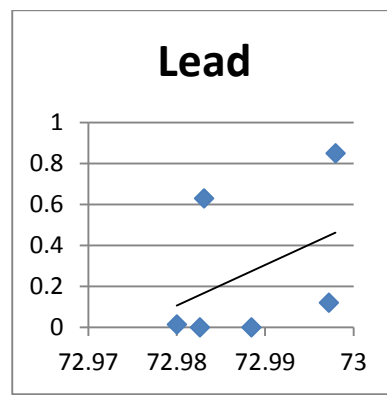


Figure 5.46

After doing the correlation of latitude and longitude with various parameters, it is observed that almost all the drinking water parameters were showing the increasing trends in concentration towards the south east direction. This is because the elevation of earth surface is towards the south east in this area and the dumping site was present at higher elevation. So the ground water movement was also towards the south east and the concentrations of parameters were higher towards this side.

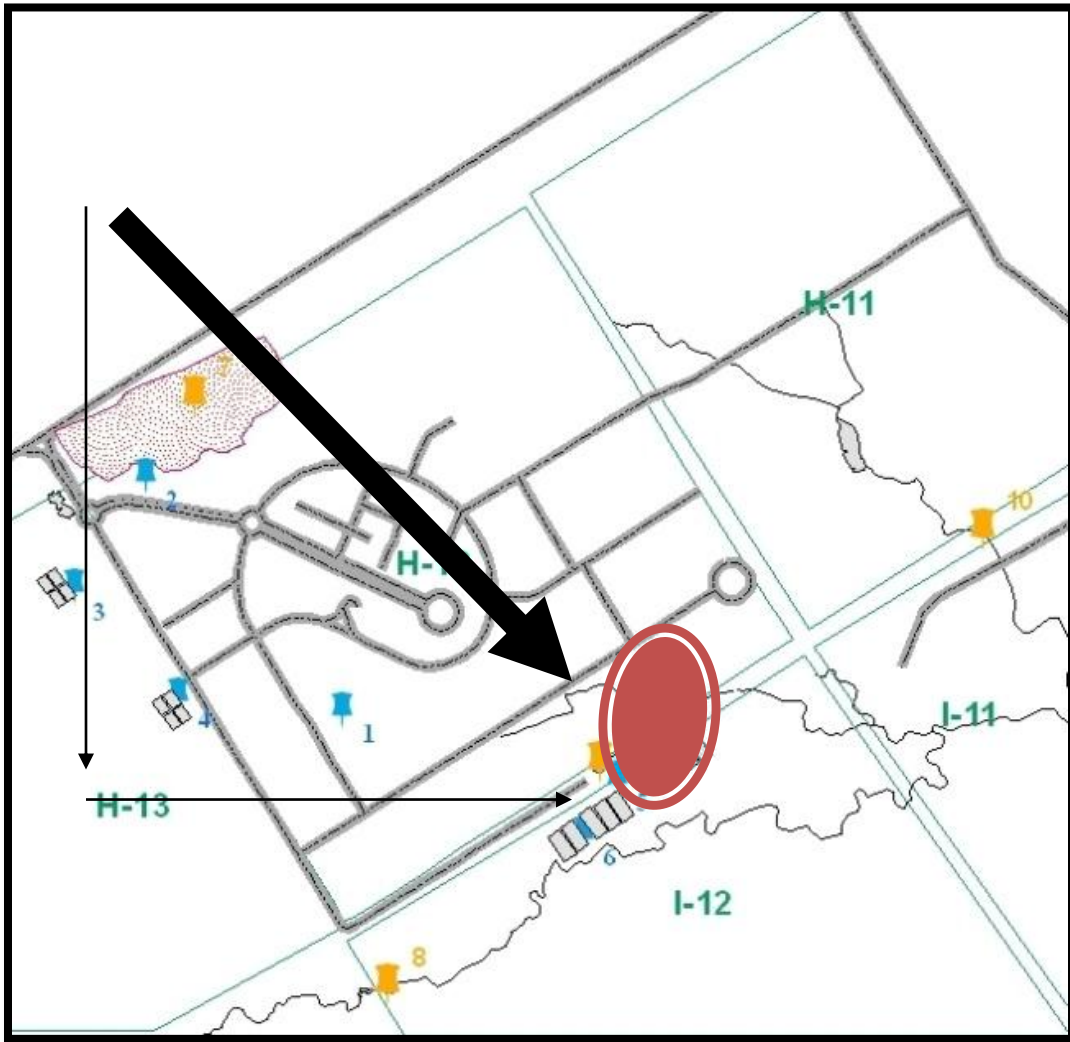


Figure5.47 showing the increase concentration of parameters for drinking water

5.12 Spatial Correlation of Latitude and Longitude with various waste water parameters:

The spatial correlation of latitude and longitude with waste water does not show any specific trend. It means the spatial correlation of parameters for waste water does not exist.

5.13 Conclusion:

- 1) The parameters for drinking water samples were within the permissible limits except for sample number 04, 05, 06.
- 2) The concentration of heavy metals was found high in samples 05 and 06 which is used for drinking purpose.
- 3) Lead concentration was above the permissible limit in sample number 04, 05 and 06. Cadmium was high in sample number 04 and 05. Whereas iron was above the permissible limits in sample number 05 and 06.
- 4) It was observed that the permissible limit for total suspended solid is 200mg/l for waste water. All waste water samples were found above the permissible limit. It was observed that the TSS concentration was very high in sample number 05 and 06. Both the samples were way above the permissible limit set for waste water. Even though they were used for drinking purpose.
- 5) Dissolved Oxygen was very low in sample number 05 and 06, which ensures that other chemicals are present in high concentration which could not be analyzed in this research work.
- 6) The correlation was very strong between parameters such as pH-Temperature and TDS-EC, whereas weak correlation was observed between Lead and Cadmium in the samples.
- 7) The spatial correlation of latitude and longitude with drinking water samples showed that all the parameters were increasing towards south

east direction, whereas the elevation of ground surface is showing decreasing trend in elevation towards south east.

- 8) The spatial correlation of latitude and longitude with waste water showed no trend, which indicate that spatial correlation with waste water does not exist.
- 9) After scrutinizing all the results it is concluded that sample number 05 is unfit for dinking.
- 10) From the above discussion it is clear that open dumping of solid waste does contaminate the ground water in a large quantity.

5.14 Recommendations:

- 1) 3 R's (reduce waste, reuse waste, and recycle waste).
- 2) Protected landfills should be made.
- 3) Land filling should not be made near the residential and water recharge area.
- 4) Instead of open dumping proper waste treatment methods should be used.

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Appendix:

Description of the Sampling Locations

Sample Number: 1

Type: Drinking

Location: Located in sector H-12

Coordinates: Latitude = $33^{\circ}38'21.06''\text{N}$,

Longitude = $72^{\circ}59'18.41''\text{E}$

Area Elevation: 1779 ft

Depth of Borehole: 300 ft



Sample Number: 2

Type: Drinking

Location: Located in sector H-12

Coordinates: Latitude = $33^{\circ}38'46.76''\text{N}$

Longitude = $72^{\circ}58'57.40''\text{E}$

Area Elevation: 1820 ft

Depth of Borehole: 300 ft



Sample Number: 3

Type: Drinking

Location: Sector H-13, Located on the border between sector H-12 and H-13.

Coordinates: Latitude = 33°38'37.49"N

Longitude = 72°58'48.07"E

Area Elevation: 1837 ft

Depth of Borehole: 200 ft



Sample Number: 4

Type: Drinking

Location: Sector H-13, Located on the border between sector H-12 and H-13.

Coordinates: Latitude = 33°38'25.33"N

Longitude = 72°58'59.06"E

Area Elevation: 1829 ft

Depth of Borehole: 250 ft



Sample Number: 5

Type: Drinking

Location: Sector I-12, Located on the border between sector H-12 and I-12. This is the residential area for afghan mahajreen.

Coordinates: Latitude = 33°38'15.33"N

Longitude = 72°59'52.60"E

Area Elevation: 1775 ft

Depth of Borehole: 85 ft



Sample Number: 6

Type: Drinking

Location: Sector I-12, Located on the border between sector H-12 and I-12. This is the residential area for afghan mahajreen.

Coordinates: Latitude = 33°38'13.50"N

Longitude = 72°59'49.88"E

Area Elevation: 1779 ft

Depth of Borehole: 100 ft



Sample Number: 7

Type: Waste water

Description: Stagnant rain water

Location: Located on the previous solid waste dumping site sector H-12.

Coordinates: Latitude = 33°38'56.12"N

Longitude = 72°59'0.95"E

Area Elevation: 1888 ft



Sample Number: 8

Type: Waste water

Description: Running waste water nala coming from Koh-e-noor mills

Location: Located in sector I-12.

Coordinates: Latitude = 33°37'54.30"N

Longitude = 72°59'25.56"E

Area Elevation: 1789 ft



Sample Number: 9

Type: Waste water

Description: Stagnant rain water

Location: Sector I-12, Located on the border between sector H-12 and I-12.

Coordinates: Latitude = 33°38'16.32"N

Longitude = 72°59'51.58"E

Area Elevation: 1778 ft



Sample Number: 10

Type: Waste water

Description: Running waste water nala coming from sector G-13.

Location: Located in I-11.

Coordinates: Latitude = 33°38'22.99"N

Longitude = 73° 0'27.72"E

Area Elevation: 1702 ft

