

*National College of Business  
Administration & Economics  
Lahore*



**CHROMIUM MANAGEMENT IN  
KASURPANDOKI LINKAGE DRAIN AND ITS  
IMPACTS ON GROUND WATER QUALITY**

**BY**

***MUHAMMAD NAEEM ASHRAF***

**MASTER OF PHILOSOPHY  
IN  
ENVIRONMENTAL MANAGEMENT**

**MAY, 2014**

**NATIONAL COLLEGE OF BUSINESS  
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**A dissertation submitted to  
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**In Partial Fulfillment of the  
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**IN THE NAME OF ALLAH  
THE MOST BENEFICENT  
AND THE MERCIFUL**

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Administration & Economics

## **DECLARATION**

It is to declare that this research work has not been submitted for obtaining similar degree from any other university / college.

**MUHAMMAD NAEEM ASHRAF**  
**May, 2014**

*Dedicated to  
all those  
who have sacrificed  
for their ultimate  
Love to*

*Prophet Muhammad  
(Peace Be Upon Him)*

## ACKNOWLEDGEMENT

*“He will guide them to Success & will Improve their Condition”  
(Al-Quran 47:6)*

Praises & Glories are for the uniqueness, wholeness and unchallengeable “Almighty ALLAH” whose blessings and exaltations flourished thought, ambitions and enables us to discover the unknown, and thus to satisfy our restless nature by contributing our part in the sacred wealth of knowledge.

Salutations, Blessings, Honors, Loves at Heart, Praises, Respects and the past/present/future life come to an end on the ultimate boss of the seekers “HAZRAT MUHAMMAD” (*peace be upon him*).

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Whatsoever there is there in my human flesh is due to the prayers and encouragement of my parents, which helped me to overcome my problems and make me victorious on my mind. May Allah keep them with me so long that I can enjoy their love, prayers and experience/feel their presence at the times of miseries not only but also at my victory, success and progress.

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From the deepest corner of my heart, I am thankful to all my friends, brothers, sisters and colleagues for their fantastic company and internal jealousy, which ultimately caused/pushed me to success.

## **RESEARCH COMPLETION CERTIFICATE**

Certified that the research work contained in this thesis entitled **“Chromium Management in Kasur Pandoki Linkage Drain and its Impacts on Groundwater Quality”** has been carried out and completed by **Muhammad Naeem Ashraf** under my supervision during his **M.Phil. Environmental Management** Programme.

*(Dr. Irshad Khokhar)*  
*Supervisor*

## **SUMMARY**

In the present work, Ground water samples from three sources (Tube well, Donky Pump & Hand Pump) were collected from the area of 10 kilometers along KasurPandoki Linkage Drain (KPLD) and analyzed by using Atomic Absorption Spectrometer for Chromium, which was in abundance in the samples due to the associated leather tanning industries.

Chromium being carcinogenic can directly effect the human health [Environment Protection Agency Pakistan, EPD-2006], so the monitoring of its concentration in Ground-water samples has have its own importance both for the masses and the Government. This work was done in winter and summer of year 2008.

The technique used for the work was Atomic Absorption Spectroscopy, since it is most sensitive, accurate and convenient method.

The experimental results show that the concentration of Chromium in Ground-water samples was very high at Kasur its concentration fell down considerably along the KasurPandoki Linkage Drain.

This work in its documented form will be available to all the stakeholders (authorities, students and the masses) & will help to create awareness. It will help to upgrade the guidelines for groundwater to the Environmental Protection Agency as well as the Local Government to design and implement various Health & Safety programs for all the stakeholders.

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# CHAPTER 1

## INTRODUCTION

Water is the most abundant commodity in nature, but also is the most misused one. Earth is regarded as blue planet because 4/5th of its surface is covered by water. Water is known as universal solvent because different kinds of chemicals are dissolved in it (Charles and Margarete, 1993). Many uses of water include drinking, domestic use, industrial power generation, agriculture use and for disposal of waste material (Masson, 1996).

The hard fact of life is that about 97% of water is locked in the oceans, which is too saline to drink and also not fit for direct use for agriculture or industrial purposes. The remaining 80% of water is trapped in polar ice caps and giant glaciers, from which icebergs break off and slowly melt in sea. Another 10% of it is locked in rocks and minerals, lying as deep as 800 meters, below the earth's crust. This leaves only 0.3% of world's water resources that man can tap for domestic, agriculture and industrial uses.

Different technologies have been developed for utilizing water from oceans and icebergs because water requirement is increasing day by day.

The principal burden on groundwater quality comes from industry, agriculture and households uses. Increased production of goods and the institution of new and more exotic industries have greatly increased the amount of industrial wastes including organic matter, inorganic chemicals and suspended solids. The chief offenders are chemicals, papers, petrochemicals, leather and metal industries. New technologies are producing new complex products and wastes that defy our present ability to treat or control them or even detect their presence in water. Due to human activities, the source of water pollution comprises of wastewater from domestic and industrial establishments. They include water borne wastes coming from domestic sources, animal's waste and from food processing factories. They usually contain soaps and detergents, human excreta, paper, cloth etc. These wastes carry pathogenic agents and contain carbonaceous organic materials that can be oxidized by microorganisms to CO<sub>2</sub> and water. In developing countries, particularly in tropical regions, the problem of water quality is usually even more acute since the collection and treatment of waste-water is not practical. In small settlements, cradle of drinking water and disposal management of water is not concrete and are scarcely parted, whereas congested cities are lacking adequate drainage (Elizbith et al., 1983). Almost a similar situation

may be encountered in Pakistan especially in the areas like Kasur, Lahore and Karachi. There are many industries like fertilizer, food, sugar, paper and pulp, cement, tanneries, electroplating, textile etc. near such cities and they are discharging large amount of pollutants in water. Rapid industrialization is constantly adding toxic organic and inorganic substances in the water. These toxic materials are harmful for human, animals and plants.

District Kasur of Punjab province, is restricted on the north by Lahore, on the south and east by the Indian districts of Ferozepur and Amritsar respectively, Sahiwal is on the west. City Kasur is located 55 km from Lahore on Ferozepur road. & 25 km from Ferozepur (Indian District) in the north. Kasur is well linked to Lahore by road and by rail, which precedes the Raiwind junction and scores up to Lodhran. Before partition, it was also connected to Amritsar and Ferozepur city in India by Rail (Government of Pakistan, 1980).

Kasur is one of the hoariest metropolises of Pakistan. In prehistoric times, it was just a small settlement with katcha houses on the northern row of the old tributary Beas. As per an estimate it turns to a vast village in 1 AD. In 553 AD this was engaged by Khaweshgan. In 1020 AD, Kasur was incorporated in the terrain of Lahore, which was the center of the state under Raja Jaipal (Government of Pakistan, 1980).

When Emperor Babar netted the entire India in 1526 AD, he passed this city to the Afghans as an acceptance of their services for his victory. During the supremacy of Shah Jehan and Aurangzeb, Kasur was lionized and every rich man erected his own palace in Kasur. In 1830 AD Maharaja Ranjeet Singh taken Kasur and it remained under Sikh Rule by the year 1957, after when the British procured control of India.

At that time, Kasur was upgraded as sub-division and was involved in Lahore Civil Division. The Raiwind-GandaSinghwala Railway Line was positioned in 1883, whereas the Kasur-Lodhran Railway Line was finalized in 1910, thereby attaching the town with the rail network. During this period, Kasur functioned as an imperative commercial as well as industrial focus of the region (Government of Pakistan, 1980)

After freedom in 1947, industrial and commercial happenings were reinstated and Kasur funded more and more towards the national economy. In 1976, Kasur was upgraded as district headquarters and successively a number of local offices were established. But due to uncontrolled and haphazard development of tanning industries, the city is under a state of environmental degradation and there is a severe threat to both people and natural resources in Kasur.

Heavy metals are elements consuming atomic weights among 63.546 and 200.590 (Kennish, 1992), and a specific gravity more than 4.0 (Connell et al., 1984). Living organisms need trace amounts of some heavy metals, including cobalt, copper, iron, manganese, molybdenum, vanadium, strontium and zinc. Disproportionate levels of essential metals, however, can be detrimental to the organism. Non-essential heavy metals of specific concern to surface water systems are cadmium, chromium, mercury, lead, arsenic, and antimony (Kennish, 1992).

All heavy metals occur in groundwater in particulate, colloidal, and dissolved phases, although disbanded concentrations are mostly low (Kennish, 1992). The particulate and colloidal metal might be institute in;

- Oxides, hydroxides, sulfides or oxides; or
- Adsorbed to Silica, clay or organic stuff.

The soluble formulas are mostly ions or unionized organo-metallic complexes or chelates. Solubility of trace metals in surface waters is predominately organized by the water pH, the type and concentration of ligands on which the metal could adsorb and the oxidation state of the mineral constituents and the redox atmosphere of the system (Connell et al. 1984).

The behavior of metals in natural waters is a task of the substrate residue composition, the suspended sediment composition, and the water chemistry. Sediment composed of slit and fine sand will usually have higher levels of adsorbed metal than will quartz, feldspar, and detrital carbonate-rich sediment. Metals also have a high empathy for humic acids, organo-clays, and oxides coated with organic matter (Connell et al., 1984).

Chromium composites may be existing in industrial wastes from a wide assortment of routes including tanning, electroplating galvanizing, cooling, cooling tower's effluents and also by the manufacture of dyes, enamel and paints.

Chromium survives in three stable forms in nature: chromium metal, Cr (III) & Cr (IV). Chromium toxicity varies with pH, temperature, the organism exposed and the valence form. In any particular form, toxicity may diverge with the existence of other compounds. Cr (VI) the hazardous form, is used in metal finishing (chrome plating) chromium chemical production, chromium pigments for paints and textile, leather tanning and some wood preservative (Chromate copper arsenate). It is also used in electrical power plants, cooling towers to inhibit corrosion in the cooling loops. Drift from cooling tower can

be an important source of Cr (IV) in the vicinity of electrical power plants. Chromium is also released when municipal refuse is incinerated and when sewage sludge and waste comprising chromium can convert to a hazard when disposed-off in landfills because this form of chromium is very peripatetic in groundwater, whereas Cr (VI) can be high in factories in any of the previously mentioned industries and such factories.

Electroplating procedures, leather tanneries and textile manufacturing are the biggest cradles of water discharges containing chromium. Chromium chemical plants and chromite ore refineries are the largest source of chromium containing solid wastes. There is considerable epidemiological evidence that chromate exposure is associated with bigger frequency of lung cancer. Additionally chromium exposed workers may show sign of proximal renal tubule dysfunction and may undergo nasal septum perforations. Chromium does not bioconcentrate in food chains. Naturally occurring chromium has been accompanying with soil infertility only in few places because of extraordinary concentration. Chromium in the form of chromate chemicals is predominantly toxic to plants, however, chromium salts should be ducked in all plant rising media. For water used in agriculture, lenience of chromic and chromate ions differs with the plant species. More sensitive plants are badly, affected by concentrations of 5mg/l and above.

For community water supplies chromium in the hexa-valent form, should not surpass 0.05mg/l [National Drinking Water Policy Draft-2007] and preferably should be absent entirely. Cr (VI) is also toxic to aquatic life. The existence of chromium in various valance states offers scope for microbial oxidation, although no evidence has been reported in this regard. Many other metals like copper, antimony, selenium, arsenic and beryllium are toxic to plants and animals in high dose. But study reports available on their toxicity are very limited. With the advent of new technologies the use of metals in industries for varied purpose is to increase significantly. It is therefore, worthwhile to undertake detailed studies in the area of metal pollution in order to understand, not only the magnitude of the problem of pollution caused by metals but also to offer solution to solve them.

The existence of abundant chromium anions in the drinking water is commonly due to the addition of industrial waste. The chronic adverse health effects are respiratory and dermatologic (Viessman and Hammer, 1985). Chromium is used as pigment for paints in metal alloys, cements, paper, rubber, and other materials. Shorter exposure can cause skin irritation and ulceration. Long term exposure results in liver as well as kidney impairment, and mutilation to circulatory and nerve tissues. Chromium often hoards in

aquatic life, adding to the threat of eating fish that may have been exposed to high levels of chromium.

## **1.1 WATER SUPPLY IN KASUR**

The Municipal Committee Kasur supplies drinking water in the city and covers the needs of 60% population. The major source is *groundwater* which is brought to earth by means of tube-wells, whereas the outstanding 40% collect drinking water by means of their individual hand pumps. The quality of drinking water is suspicious in respect of chemical and bacteriological traits. The whole situation of water supply is very poor and it is prospective not to accomplish the requirements of the whole population. Considerably the drinking water quality is reasonably under the standards of World Health Organization (WHO). There is no commercial connection in the city whereas the city has lot of industrial accomplishments. It reveals the pitiable management of the drinking groundwater by sanitary division of the municipal committee.

## **1.2 SEWERAGE SYSTEM AND SOLID WASTE DISPOSAL IN KASUR**

Municipal Committee Kasur is answerable for establishment and preservation of sewage system of the city. The solid waste of the city is dumped at several open places. The city is there with the most horrible state of unpleasant and unhealthy environment with no proper management. The staff to onslaught the open drains of sewer is not adequate. Industrial area waste is very hazardous and is dispersed on the open land lying unused near polluted ponds.

## **1.3 SEWAGE & TANNING WASTEWATER IN KASUR**

Kasur, with a population of around 250,000 inhabitants is a city in Pakistan, whose name has become inextricably linked with the tanning industry that has existed there for several years. Tanning industry ranks third in export earnings in Pakistan and Kasur ranks second, but environmentally it is notorious as the worst polluter.

Highly polluted effluent generated by about 200 tanneries, concentrated within the urban fringe area of Kasur, has degraded the environmental conditions in the area, posing a major health hazard to the residents.

“The effluent discharged by these tanneries with high chemical and biological pollution load, with no drainage, has also rendered a big section of productive land into lakes of stagnant wastewater. A nauseating smell permeates the air and the city’s inhabitants suffer from eye diseases, skin irritations and gastrointestinal maladies. Lung cancer has also been diagnosed as the cause of death in some cases.” (Spectrophotometric determination of Cr & Phenol in Tannery Waste Water, Ashraf. M.N. – 2004).

According to estimation, out of a total volume of about 9,000 cubic meters per day of tannery effluent, some 4,500 cubic meters are discharged to the river Satluj, through a natural drain (Kasur Pandoki linkage drain) and the rest goes to stagnant pools. Along the route to the river, the effluent seeps into the water being collected by tube wells.

“This wastewater is massively used for irrigation in the associated areas, due to which the level of certain chemicals and metals is increasing day by day not only in the ground water but also in the soil. The dangerous chemicals contained in the wastewater pollute the crops grown in the area, particularly vegetables, which are easily affected. The other severe effects include health hazards to both human and animal life to a greater extent (IUCN, 1993).”

According to Tanners Association, Kasur, around 15,000 people are working in tanneries. But as revealed by different community members 40-50% of tanners are not members of the Tanners Association. Many people are involved in one or other tanning process within their houses. A large number of people, particularly women are involved with the potentially hazardous process of sheep hair (wool) handling. In addition to this, it is very difficult to estimate the number of employees, as most of them are contract labor. According to a rough estimate about 50,000 people are directly involved with one or the other process within the tanning industry and most of them live in the polluted area (IUCN 1993).

According to an observation, communities are exposed to bad odor, contaminated/odorous/unpalatable ground water, and dust from the buffing processes, dust, hairs (and most probably many allergens) and fumes from different hazardous processes such as “chrome formation”. There are about 70,000 to 90,000 people environmentally exposed, a number which is increasing with increasing population density and which might further increase if reclaimed land is used to build more tanneries.

According to a report of Pakistan Council of Scientific and Industrial Research (PCSIR) in 2004 on Kasur, the entire wastewater from the industries, without any pre-treatment, is being discharged on the virgin land covering an area of about 15 sq. km of which some area was previously under cultivation and now the same has been converted into dirty pools. This wastewater is extending its limits by way of bringing under a vast stretch of agricultural land. The residents immediately affected by the wastewater are estimated at over 40,000.

“The Groundwater in the affected area is around 6-7 meters deep from the ground surface. Due to the high permeability of the soil, groundwater is rapidly adulterated from this wastewater. As many as 25,000 people are getting drinking water from the hand pumps and electric motor pumps sunk in this polluted aquifer.”  
[PCSIR-2004]

#### **1.4 PRESENT SITUATION**

Kasur has been travailing from an environmental dilapidation, not only to air, productive land and *Groundwater*, but also a straight health threat to the people existing and working the affected areas as a result of 9,000 cubic meters of heavily polluted tannery waste water from the three tannery clusters per day. About 5,500 cubic meters of the above tannery effluent together with domestic sewage is discharged into the RohiNallah [Pandoki Drain]. This is used for irrigation in the downstream parts of RohiNallah [Pandoki Drain].

An aggregate of 100-150 tons/day of solid wastes and 150-200 tons/day of solid domestic waste are disposed-off by casual dumping at various places, including the RohiNallah [Pandoki Drain]. [KTWMA-2007]

“Water deliveries from hand pumps and tube wells, and foodstuffs manufactured in the area contained dissolved solids, especially sodium chloride and sulfides. The Environmental Impact Assessment (EIA) report (IUCN, February 1993, page 26) features the groundwater contamination to the tannery effluent, waste waters and stagnant pools.”

Inadequate use and handling of chemicals has rendered workers and residents to hazardous exposures. Skin infection related diseases, Respiratory disorders, diarrhea/dysentery and typhoid are the most severe illnesses amongst the community population etc. at present 70,000 to 90,000 people are exposed to the environmentally polluted surroundings. Most of the tanneries

are small with their proprietors having narrow knowledge of simple methods and ways of improving their tanning process, and work conditions till time.

Tannery pollution load discharged into environment (per annum) is: 4,000 tons of BOD; 11,000 tons of COD; 10,000 tons of SS'; 160 tons of Chromium; and 400 tons of Sulphide (Calculated on basis of 13,000 m<sup>3</sup>/d; 300 days per year). It should be prominent that although being a primary treatment type, the treatment plant at Kasur is projected to eliminate 65 % of the above BOD; 55 % of the COD; 95 % of the suspended solids; 95 % of the chromium; and 98% of the sulphide. [KTWAMA-2008]

In practically all urban interiors, groundwater quantity and quality has deteriorated to the amount that the convenience of good quality raw water has become a thoughtful issue. Over perception has also resulted in diminishing groundwater levels (Pak-SCEA 2006). Uncontrolled withdrawal of groundwater and prolonged dry episodes has also caused its depletion and drying up of some of the sources.

Industrial activities have affected the groundwater quality very severely and have contaminated it. Massive discharge of waste and wastewater from various industries has resulted in the increase of Heavy metal index / level in the groundwater. Some of these heavy metals are even carcinogenic and can affect the human health to a very high degree, in the present study Chromium which is the major contaminant of the area, level is monitored along its discharge to Pandoki Drain.

## **1.5 MAJOR OBJECTIVES**

- 1) To determine the quality of *Waste water* and *Ground water*.
- 2) To examine water pollution sources in Kasur.
- 3) To scrutinize the factors accountable for deteriorating water quality at different places in the area under study.
- 4) To regulate the concentration of Chromium in *Waste water*.
- 5) To conclude the concentration of Chromium and other heavy metals in *Ground water*.
- 6) To regulate the effects of heavy metals like Chromium concentrations in *Waste water* on *Ground water* quality.
- 7) To check the irrigation standards of water of KasurPandoki Linkage Drain.

## CHAPTER 2

### LITERATURE REVIEW

Per capita water accessibility in Pakistan has lessened by 5,000 cubic meters per annum in 1951 to 1,100. The main source of drinking water for the mainstream in Pakistan is groundwater. About 80% of the Punjab has fresh groundwater, but in Sindh, only 30% of groundwater is fresh. In NWFP, accumulative abstraction has caused the wells now to reach saline layers, and most of the part of Balochistan has saline groundwater. As per Government statistics, the Punjab has an excellent rural water supply amongst the provinces; only 7 % of the rural residents hang on a dug well or a river, canal or stream. In Sindh, about 24% of the rural population rest on these sources. The rural water supply condition in NWFP and Balochistan is even poorer; about 46% and 72% respectively of the rural population hang on water from a dug well or from a river/canal/stream (Pak-SCEA 2006).

“There is clear evidence that groundwater in the country is being over-exploited, yet tens of thousands of additional wells are being put into service every year (Pak-SCEA 2006).”

Very little separation of municipal wastewater from industrial discharge in Pakistan is there. Both stream directly into open drains, which then stream into nearby natural water bodies. Monitoring program to measure the quality of the surface and groundwater bodies is nowhere. Same is the case with surface water quality standard/drinking water quality standard in Pakistan. An evaluation of the quality of surface water with the effluent emancipation standard clearly reveals the amount of pollution in the water bodies due to the discharge of industrial/municipal effluent. “About 5.6 million tons of fertilizer and 70 thousand tons of pesticides are consumed in the country every year (Pak-SCEA 2003).” Use of Pesticides is increasing annually at a rate of about 6%. These Pesticides which composed of insecticides, when sprayed on the crops they mix with the water used in irrigation and finally leaches through soil, and enters to the groundwater aquifers. “107 samples of groundwater collected from several localities in the country between 1988 to 2000 (Pak-SCEA 2003), 31 samples were found to have adulteration of pesticides beyond FAO/WHO safety limits. Due to four-fold increase in the use of Pesticides in country since 1990, the adulteration levels are likely to have increased significantly.

“It is estimated that 40 million residents depend on irrigation water for their domestic use, especially in areas where the groundwater is brackish (PCRWR 2004). The associated health risks are grave, as bacteriological contamination of irrigation water often exceeds WHO limits even for irrigation (PCRWR 2004).”

6 cities (Multan, Bahawalpur, Sheikhpura, KASUR, Gujranwala & Lahore) out of 11 of Punjab have shown very high concentrations of ARSENIC, CHROMIUM & FLUORIDE in a latest study. (PCRWR 2004). Worryingly, over 2 million residents of these cities are drinking unsafe water, some with a high arsenic concentration.

Per capita water availability has been declining at a disturbing rate. “It has been decreased from about 5,000 cubic meters per capita in 1951 to about 1,100 cubic meters currently, which is just above the internationally recognized scarcity rate for groundwater available for drinking. It is projected that water availability will be less than 700 cubic meters per capita by 2025” (Pak-SCEA 2006).

Water shortage for Agricultural use is another serious issue. As per SOE 2005, “the shortage has been estimated at 29% for the year 2010 and 33% for 2025”. Today groundwater subsidizes 48% of the water available to the public of Pakistan. The erection of private wells for irrigation has also been encouraged through a policy of high subsidy on electricity cost. Cost hiking in Electricity in 1990, and technology up gradation has increased the use of diesel pumps by 6 times over last 30 years (SOE 2005).

Ground water pollution due to Chromium & Arsenic is turning up to an alarming situation, alongwith municipal and industrial effluents. “In Sindh and the Punjab, approximately 36% of the population is exposed to a level of contamination higher than the prescribed limits (SOE 2005).” Due to impact of water shortage and associated pollution, many wild animals, plants, aquatic species, birds and other flora and fauna are also affected.

In KASUR leather tanneries are contributing major part in water pollution. A common waste water treatment facility has been constructed which is co-financed by the government (Export Promotion Council) and the tanners association Kasur. It started its operations in 2002. Textile industry is another contributor of water pollution. Due to its size, it is at the top of the list in terms of generating environmentally damaging pollutants (SOE 2005).

Polluted Groundwater has resulted in an increased salinity level. Industrial wastewater composed of toxic chemicals, organic matter and heavy metals is discharged directly into public drains without prior treatment. There is reported leaching of wastes into groundwater causing outbreaks of water borne diseases. There is, however, a waste stabilization pond treatment plant, which is insufficient (PCRWR 2004).

PCRWR has conducted a study on groundwater contamination due to fertilizers and pesticides. Similar work has also been done by WAPDA in April 2004 to understand the level of pollutants in the drainage system of Pakistan. The study exposed that in Punjab all drains were carrying saline and sodic waters, Total Dissolved Solids (TDS) and Residual Sodium Carbonate (RSC) or Sodium Absorption Ratio (SAR) are at higher levels in addition to these Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) values are also on very high side. Same is the case with Sindh and Balochistan, where data showed that majority of drains had very high saline waters due to high values of TDS and in ShahdadKot drain this reached as high as 13,187 ppm during 2002, COD values were also above the acceptable limits and at some sampling points these even exceeded the high levels recorded for Punjab and NWFP (SOE 2005).

Chlorides, Sodium & Boron are among the toxic ions, each can cause destruction, individually or in a combination. Chlorides are the most common toxic in irrigation water. It is not absorbed or held back by soils therefore it moves readily with soil water, is taken up by the crop, moves in the transpiration stream and accumulates in leaves. Sodium toxicity is not as easily diagnosed as chloride toxicity but clear cases of the farmer have been recorded as a result of relatively high sodium concentration in the water (High Na or SAR). Pandoki Drain, Kasur, although there are some sewerage collection systems, typically discharging to the nearest water body, collection levels are estimated to be no greater than 50% nationally (less than 20% in many rural areas), with only about 10% of collected sewage effectively treated. Although treatment facilities exist in about a dozen major cities, in some cases these have been built without the completion of associated sewerage networks, and the plants are often either under loaded or abandoned. In effect, only a few percent of the total wastewater generated receives adequate treatment before discharge to the waterways. (Pak-SCEA 2006). Contaminated drinking water and food have direct effect on human beings while sewerage water, contaminated canal water and industrial effluents have indirect effect on crops and vegetables when applied for irrigation purposes. So the lives of human beings as well as the animals and plants adversely affected. Tables in Appendix I & II gives the Guidelines for Water quality for Irrigation and Drinking Water Respectively as per the set standards of EPA Pakistan.

The canal water is used in some areas where other sources are not available. The environmental protection agency has proposed the drinking water standards that are given in the table.

After any analysis of water and waste water, the quality can be checked by seeing the permissible limits given by the environmental quality standards, to check that the given sample is in the range of standards or not. In the following table some environmental quality standards are given proposed by the government of Pakistan.

As per USAID report 2006, an estimated 250,000 child deaths occur each year in Pakistan due to water-borne diseases (Pak- SCEA 2006). The residents of Kasur are at high risk to Chromium and some other toxic heavy metals. There are very strong relations between water quality and health risks. Quality of portable water, inadequate quantity and poor sanitation facilities and practices are giving birth to illnesses such as diarrhoea, typhoid, intestinal worms and hepatitis. As per an estimation more than 1.6 million DALYs<sup>1</sup> (Disability Adjusted Life Years) are lost annually as a result of death and disease due to diarrhoea, and almost 900,000 as a result of typhoid. Diarrhoeal and typhoid impermanence in children accounts for the majority of the losses, replicating the susceptibility of children to these diseases. The total health costs are projected at Rs: 114 billion, or approximately 1.81 percent of GDP. The high parts of costs due to premature child deaths, followed by the mortality impacts of typhoid in the older people are striking (Pak- SCEA 2006).

Table in Appendix IV gives National Environmental Quality Standards for Sewage and Industrial Effluents. The Guidelines for Water quality for Irrigation shows that the concentration of Chromium in the water used for Irrigation should not be more than 1.0mg/l whereas the same concentration for Drinking water is 0.5mg/l as per NEQS EPA-Pakistan 2007.

Multiple articles have been written in national newspapers regarding water borne diseases in district Kasur and the country Pakistan.

Article titled “NOT A DROP TO DRINK” by “ARDESHIR COWASJEE” published on March 11, 2007 in “THE DAWN” states that “Contaminated water causes major health problems; 20-40% of the people in hospitals are suffering from water-borne diseases --- gastroenteritis, typhoid, cholera, dysentery, hepatitis, cancer, birth defects and other serious diseases. Agricultural surfeit is infected with pesticides and fertilizers. Chemical pollutants are found in drinking water in Karachi, Hyderabad, Quetta, Peshawar, Abbotabad, Multan, KASUR, Lahore and even Islamabad.

Shockingly, but not surprisingly, the appeal cognizant our leaders and us that: “Every Third Pakistani Drinks Unsafe Water”. Water of 14 districts of Punjab test results failed by 85% samples and the water is found unfit for human usage, compelling over two million people to drink unsafe water. In Islamabad 75% & in Rawalpindi 87% of water is unsafe for human use. 15 out of 48 bottled water brands were found unfit. About 99% of industrial sewage and 92% of urban wastewater is drained rivers and the sea untreated. Water borne diseases are resulting about 250,000 child deaths each year

Another article published in “DAWN MAGAZINE” on August 03, 2003 bearing the title “PAKISTAN FACING TOXIC WATER APOCALYPSE” by “MUHAMMAD SHEHZAD” states that “One place where such pollution is happening is Kasur 55km south of Lahore, the Punjab’s capital, where the toxic waste of leather tanneries is discharged into open space. The accumulated water has taken the shape of a stream, which has poisoned the only source of drinking water in Kasur its groundwater. Chemical analysis has shown that the water is overloaded with metals like Chromium, Mercury and Lead. The problem has been intensified by a water shortage as the rains are yet to reach. An increasing people in the area have been condemned to drink contaminated water.

“My worry about this water is that it is being infected from different sources, waste from the drains and chemicals from the industry around us,” said Dr. Javaid Afzal, a water expert at the LEAD.”

“People are intake food that is grown with this water. So, the chemicals have become part of the food chain. We have already started noticing the effects of this contamination as far as human health in the area is concerned. The kinds of problems we are undergoing include cancer, and numerous types of poisoning, prominent to skin and respiratory diseases,” Afzal added.

Article on “WATER-BORNE DISEASES ON THE RISE IN MULTAN” published on February 04, 2006 in “The News” replicates that the constant use of polluted drinking water, due to corroding and leakage of very old underground drinking water supply pipes, is producing extensive gears of ulcer, cholera, acute dehydration, diarrhea, intestinal hitches in Multan city. Officially in a report it has been revealed that adulterated drinking water transport bacteria and virus both in domestic water supply resulting in chronic water borne diseases hepatitis and gastroenteritis in remote areas due to trickle of damaged pipes by ex-filtration and infiltration.

Statistics from Kasur District Hospital has shown more than 295 deaths due to water-borne diseases, besides registration of 46,166 cases of chronic diseases, 5,921 cases with district hospital, and 7,689 cases with municipal dispensaries in this linking. 50 % of the population of Kasur city has been waiting for fresh drinking water from contaminated sources.

Ex. President of Pakistan General Pervez Musharraf has also accepted that up-to 60% diseases in Pakistan are water borne, and there would be an incredible saving in monetary terms if safe drinking water availability to the masses is ensured. "This would help control almost 60% of diseases in the country," he said, adding that it would also aid in the reduction of the load on hospitals, basic health centers and rural health centers.

<http://southasia.oneworld.net/article/view/137648/1/>

In his article "WATER WOES" on July 10, 2005 by "AMNA NASIR MALIK JAMAL" published in "Dawn Magazine" states that "According to various WHO reports, in developing countries about 60-70% of diseases are water-borne. Outbreaks, like those in Kasur and BhaiPheroo, have been on the rise where industrial waste created serious epidemic. Even birth of mentally retarded and deformed children has been reported from the affected areas.

In a workshop dated March 28-29<sup>th</sup>, 2000 on SUSTAINABLE DEVELOPMENT THROUGH PARTICIPATION arranged by HAMZA FOUNDATION it was indicated that "The most serious matter is that the patients in Kasur were mostly under the age of 20". Women and children were the major targets of the pollution. Increasing diseases among youth is an indication that urgent health reforms, action or management is deadly in-need.

"In a report by Environmental Protection Department (EPD) Punjab, in 1997 the groundwater in Kasur has been detected extremely polluted with Chromium as compared with WHO standards. Chromium (VI) is termed as carcinogenic (Cancer Causing). Its presence in the air as aerosols of Chromium and in groundwater can result in several chronic diseases leading to cancer." [EPD-Punjab, 1997]

Nriagu (1980) has suggested that over one billion human beings are currently unprotected to elevated concentration of toxic metals and metalloids in the environment and several million people may be suffering from subclinical metal poisoning.

"Environmental pollution by Heavy Metals" was widely recognized with the "Minamata Disaster" in Japan in early 1950. In 1932, a factory producing acetaldehyde and Vinyl Chloride began to use mercuric oxide as

catalyst and effluents containing mercury were discharged into Minamata Bay. In the early 1950, a nervous disease began to effect dogs, cats and pigs. In 1956, there was first recorded human case, a young girl, suffering from speech disturbances, delirium and difficulties in walking. A number of similar cases were detected over the coming months and an investigation team was set up in 1956 who investigated that the cause of illness was the consumption of sea food from Minamata Bay containing high level of mercury.

Zelenakova & Holub (1985) reported that soil and water samples contained different concentrations of Ni and it was due to Ni industry, 4,000 meters away, throwing industrial wastes into the water. Washed maize leaves from vicinity of the stockpile contain about 10 times more heavy metals and from a distance of 4000 meters, more than double amount of Ni, Cr and Co was present than the leaves of control plants.

Beyer and Chromate (1987) investigated the concentrations of Pb, Zn, Cd, Cr and As in earthworms and soil from diverse sites. The maximum concentration of Pb was 2100 ppm, Zn 1600 ppm, Cd 23 ppm & Se 7.6 ppm.

Belyakova & Ponarina, (1988) worked on ecological aspects of heavy metals in geo-chemicals landscapes of Ural River basin. They found that river receives large amount of heavy metals from industrial effluents. It was found that rate of esophageal cancer correlates with quantity of carcinogenic element contained in the landscape components.

William & Dusenbery (1991) worked on aquatic toxicity by using nematodes. They found that a nematode *Caenorhabditis elegans* had low values of Pb, Zn & Cd whereas other species had high values of these heavy metals. Comparison indicated that *Caenorhabditis elegans* was more sensitive to Pb, Cr, Be and less sensitive to As than any of the other organisms that have been tested.

M.I. Lone et al. (1992) carried out the survey and experimental work in the industrial area of Lahore, Sheikhpura and Kala Shah Kaku. Effluent samples were collected from outside the industries. The surface and ground water samples close to these industries are also collected and analyzed in laboratory for salinity and heavy metals contents such as Cu, Zn, Cr, Cd, Pb, Mn, Al, and Ni by using analytical and other techniques, which showed very high concentrations of these metals.

Jordo & Pereira (1993) assessed the contamination of tannery discharge into river in the state of Gerais, Brazil. Samples of sediment, water and fish were analyzed by using AAS technique and high concentration of Cr was

found. When compared with the standard values of Cr. Concentration in fish, it was higher 35 times.

Malea & Haritonidis, (1994) find out the accumulation of heavy metals like Cd, Cr, Hg & Pb etc. in seven species of red algae is due to discharge of waste from an Aluminum factory.

Von-Heerden & Jenkin (1994) reported the death of a woman who drank 400 ml tanning solution containing 48g of basic chromium sulphate. The patient died of cardiogenic shock and haemorrhages.

Presence of some heavy metals Cd, Cr, Ni, Pb, Cu and Zn from sewage water of Faisalabad was estimated by Nazeen (1995). She found that these metals were in various proportions in different samples.

The incinerated tannery wastes in pilot plant based on fluidized bed combustion at 500°C which facilitated global thermal degradation of the materials was studied by Dest. The system had control of the oxidation process to prevent Cr (III) to Cr (IV) reaction. The antibiotic manufacturing waste water containing aluminum oxychlorides were effective in the removal of the suspended solids and chromium from tanning waste water. This method was used by Shut'ko) and other scientists. Thus 1.5 liter of 10% coagulant solution per meter cube of waste water give suspended solid and chromium removals of 77% and 90% respectively.

Another method for recovery and recycling of chromium from tannery waste water was developed by Trotsos and Dimitrios and others. The collected waste water was treated with Magnesium oxide and produced sludge was re-dissolved in sulphuric acid. This solution was fed back into tannery drums by standardized technique thus resulting in saving of "Fresh" chromium. The removal efficiency was almost complete producing a clean supernatant with a chromium content of <2mg/l.

A synopsis for the cleaning of chromium contamination from soil at a leather tanning site was given by Haase. The ability of cost effective adsorbents material in elimination of Cr (VI) from waste water was studied by Due and other scientists. They were proficient of eliminating completely Cr (VI) from dilute aqueous solution. However, if the concentration of Cr (VI), is high, the percent removal was low. Their method is only effective under normal conditions therefore it needs no adjustments of pH and is cheap and convenient.

## **CHAPTER 3**

### **MATERIAL AND METHODS**

Commercial and Industrial activities were re-established after independence in 1947 in Kasur. It contributed more and more towards the national economy. In 1976, Kasur was upgraded to the status of district headquarters and successively a number of local offices were established. But due to uncontrolled and haphazard development of tanning industries, the city is under a state of environmental degradation and there is a severe threat to both people and natural resources in Kasur.

#### **3.1 CLIMATE**

The area comes under 'Semi-Arid Sub-Tropical Climatic Zone' with extreme summer heat and cold winters. In April the temperature increases fast and the two succeeding months i.e. May and June are the hottest with an average temperature of about 41°C, and sometimes it rises even up to 45°C. The monsoon season starts at the end of June and remains to the mid of September but average minimum temperature remains steady at about 36°C. January is the coldest month with a mean lowest temperature of about 5°C.

The rainfall of the area is subject to large variations from year to year. The average annual rainfall is about 490 millimeters. About two thirds of the total annual rain falls during the monsoon season. Light to moderate rain also occurs during January and February. The area is under the influence of monsoon winds. In winter season its direction is north and northwest and in summer southeast. Westerly storms or cyclones usually disturb the wind direction.

#### **3.2 SOIL AND AGRICULTURE**

This area is generally known as Hithar of Sutlej River. The soil is mostly soft alluvial. There is much sandy waste towards the river on which sarkanda or river jungle naturally grows abundantly and is used as cattle fodder. The menace of water logging has taken place in the Raiwind area and threatens to assume serious proportions in other parts of the district as well.

Wheat is the most important Rabi Crop and occupies about 39% of the total cropped area. It is grown largely on the canal-irrigated and flood-watered land. The second important crop is fodder, occupying about 22% of the total cropped area. The main crops grown during Kharif are cotton and sugarcane (Government of Pakistan, 1980). Kasur situated in a NW-Se range fenced by a flat landscape. The land is considered with low permeability of the top soil. Win erosion and water logging depreciates soil abilities which diminishes land areas suitable for agriculture. Agriculture depends on irrigation, using ground water and private tube wells. Rigorous irrigation has changed the soil construction. Water logging and high salinity decreases the productivity of the agriculture sector.

### **3.3 DEMOGRAPHY**

Kasur, the second largest leather producing center in Pakistan after Karachi, reflects a steady growth of population. The population data is available since 1901. It is observed that the population of Kasur in 1981 was 155,523 persons, which became 800,000 approx. In 2010, thereby registering 8 times increase in the period of eight decades.

### **3.4 INDUSTRIAL GROWTH**

Kasur has grown very fast in respect of industry in general and tanning industry in particular. The industrial growth accelerated during last twenty years. The industry includes power looms, saw machines, wooden furniture and tanneries.

Employment Perspective, The tanning industry and power looms are predominantly labour intensive industries thus employing a major portion of the job opportunities to the residents of Kasur. The total of 1,580 industrial units is employing about 9,775 workers, which are about 3.74% of the total population of Kasur. Majority of industries has workers ranging from one to four, thus reflecting the scale of industrial activities.

The overwhelming majority of industrial units mainly comprise of medium and small-scale units. The largest number of units is attributed to power looms whereas tanneries rank second. But regarding the area occupied and the labour employed in tanning industry ranks first in the city. The power looms industry is very commonly established in the city and there is no distinction of residential and industrial area. Many industries are established in homes. This industry is causing noise pollution in the city. Woodworks and

saw machines rank third and fourth respectively in terms of number of units and people employed.

A former river, RohiNallah, is snaking through the town. Natural water sources to this river has been cut off and today the water in it comprises of the domestic sewage from the town and some of the waste water from the tanning industry. The river bed is also the dumping site for garbage and other solid wastes. Farmers along this ex-river are using the mixed sewage for irrigation, watering of buffaloes and washing of clothes.

### **3.5 POPULATION DENSITY AND POLLUTED AREAS**

The total area of the municipal committee within its limits is 4,955 acres with a population of 237,744 persons. The city is divided into 39 zones (wards) by the municipality. If a general standard of 50 persons/acre (as prescribed by H&PP department Punjab) is taken as good population density for residential areas within each ward, there are only 10 wards qualifying this standard, and seven wards are on the other extreme with population density of higher than 200 persons per acre. The big tracts of vacant land used for refuse disposal or discharge of industrial effluent is the reason behind comparatively low density in wards where tanning industry flourished in last several years. Ward number seven has the highest value of population density i.e. 363 persons/acre. Ward number 12, 14, 15, and 17 are having clusters of tanning industry and people living here are heavily exposed to the chemical effluent discharged from these industries.

Although the tanning industry contributes to a major share of employment in the city but due to mismanagement of municipal committee and other law enforcing agencies, the discharge of tanning industrial effluent without any treatment has brought severe threat to the life and the environment as well. The total discharge of tannery effluent, mixed with some household wastewater was measured by Pakistan Council of scientific and Industrial Research (PCSIR-2008) during a 24 hours period at some 135,291 cubic feet, which is equivalent to some 3,833 cubic meters.

A careful securitization of processing parameters (daily input in terms of number, weight of hides and skins, and water consumption per ton etc.) resulted in an estimated discharge of 4,264 cubic meters/day (1.72 cusec). This wastewater has affected vast agricultural land in villages namely Bangla Kumboh, Kaiser Garh, Maan, BahmniWala, DoleyWala and NazamPura. The wastewater is standing at about 210 acres of land at different spots in the above

mentioned localities. The agricultural activities have also been stopped due to seepage in the nearby areas thus causing economic loss to the farmers.

### **3.6 KASUR PANDOKI LINKAGE DRAIN [KPLD]**

#### **3.6.1 A Brief Description**

KasurPandoki Linkage Drain [KPLD], is the surface water source for irrigation and other purposes. Tube wells and KasurPandoki Linkage Drain Kasur are the major sources of water near the city of Kasur for irrigation, whereas for drinking purposes water is directly pumped from ground by means of hand pumps, tube wells and wells.

KasurPandoki Linkage Drain established by KTWMA (Kasur Tannery Waste Water Management Authority) under KCPCP (Kasur City Pollution Control Project) and it starts from water treatment facility of KTWMA and joins with Pandoki Drain near BhadarPura, it irrigates areas like DolayWala, BhadarPura, ToloWala, FaqeryeyWala, Sheikh Ammad, and so many other agricultural areas which are associated to it.

KasurPandoki Linkage Drain takes off from KTWMA head office towards south of Kasur City to Pandoki drain. Whereas a natural river passing through the city Kasur containing the sewerage and waste water from the city joins it near DolayWala which is only 1.5 kilometers away from its start. Its length is 8.3 kilometers. Bed width and depth are 6.2 ft. Its total discharge is 207cs.

KasurPandoki Linkage Drain passes through the adjacent areas of the city and its water is being used for irrigation of agricultural land in all seasons. This drain is also acting as ground water recharge.

Industrial activities like TANNING and DYING which are the major industries of city Kasur and sewage waste dumped in to this drain water. Animal feces, animal hair, domestic garbage (solid and liquid) is involved in increasing pollutants in KasurPandoki Linkage Drain. Some factories along the KasurPandoki Linkage Drain like hedges washing factories, Shoe factories, flour mills, poultry farms, and Tanneries generating leather, contribute the contamination of water. Some housing colonies like DeenGadh, Bangla Kamboh, Malik Ahmed Khan Town &ToloWala are also disposing their garbage and wastewater of toilets in KasurPandoki Linkage Drain.

KasurPandoki Linkage Drain is at the lower surface level from the normal height so it gets maximum load of pollution.

### 3.7 SCOPE OF THE STUDY

KasurPandoki Linkage Drain water is used for irrigation over a large area and this drain flows round the year, where cleaning is done periodically without disturbing the flow of drain. Due to the contaminants and massive addition of various heavy metals, the quality of water becomes very poor so the study of water quality of this drain for agriculture and environment is considered extremely important. On the other hand the water from this drain is been used for irrigation, while the most common agriculture activity of the area is the production of vegetables, due to associated main DepalPur Road. The Chromium from this contaminated water is absorbed in the vegetables which are directly affecting human health.



**Figure 3.1: Detailed Map of the Study Area**

Pollution of this drain is due to the industrial and human population growth; both produce waste products that cannot be disposed-off as fast as they are produced. Waste water from the Tanneries and other Textile sector containing very heavy load of some of the heavy metals especially Chromium in addition to animal flesh, hair and some other tanning waste is thrown into this drain. Sewage mixture of human excreta, urine, and water used for flushing toilets, for personal hygiene, laundry and in the kitchen dump in to this drain. Considering this fact, present investigation has been carried out of the drain. The results are calculated to check the quality of water whether this water is suitable for irrigation and drinking.

The interpretation of results of drain water analysis would be most useful to a farmer making the best use of particular type of irrigation water under the existing conditions. Results may also helpful in providing guidelines for policy planners and researchers while considering waste water pollution and related environment factor of other cities. Drains like this are passing through irrigated areas in major cities of all the provinces like Sargodha, Faisalabad, Bahawalpur, Peshawar, Rahim Yar Khan etc. Some of which are also serving as drinking water supply source for such cities.

### **3.8 SITE SELECTION**

For the collection of samples, 8 spots were selected from KTWMA to BhadrPura along with Kasur-Depalpur Road. In this case total 10 km distance is covered for survey and for collecting the drain water samples.

### **3.9 PLACE OF WORK AND TESTING**

This research work is been completed by working in the following Institutions/ Laboratories.

- EPD Labs.
- Irza Pharmaceuticals Laboratory.
- Water & Soil Testing Laboratory, Thokar Niaz Baig, Lahore.

### **3.10 PLAN OF WORK AND METHODOLOGY**

The KasurPandoki Linkage drain containing the waste water from the sewage of Kasur city and tannery effluent is focused for the effect of heavy metal especially Chromium concentration on drinking water quality. It is originated from the KTWAMA water treatment plant and ends at Pandoki drain after covering 8 km of distance through DolayWala, Dost Pura, ToloWala, FaqeeryeWala, Sheikh Amad & BhadrPura.

Water level in KasurPandoki Linkage Drain is different in different seasons. In rainy season, water level rises while in normal conditions it is low. Upstream from the polluted area, water in drain does not favor any animal or plant because of its very high toxicity of various chemicals. After covering about 1.5 km the sewage from city Kasur joins it.

### 3.11 SAMPLING AND PRESERVATION OF WATER SAMPLES

#### 3.11.1 Survey

A field survey of the KPLD (KasurPandoki Linkage Drain) from KTWAMA to Pandoki Drain and village Kaloon in the month of December 2007 was carried out and points were selected for the collection of samples of ground water.

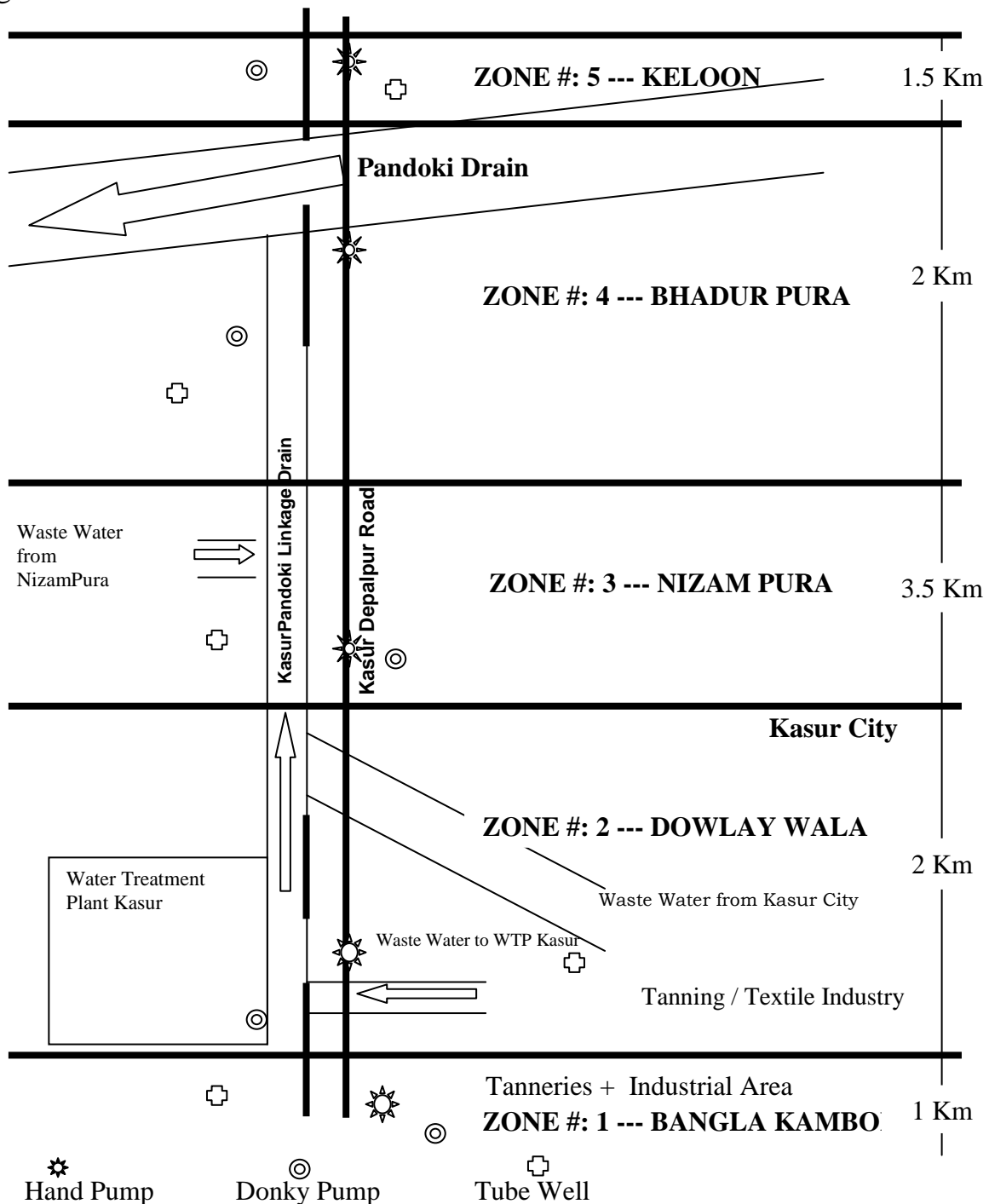


Figure 3.2: Zone Classification of the Area under Study

### **3.11.2 Intensity of Sampling**

The samples collected in the following seasons;

1. Summer [June, July, August]
2. Winter. [December, January, February]

75 samples are collected in each season from different locations of the selected area

### **3.11.3 Sample Collection**

Samples are collected according to the standard methods for the examination of water and wastewater. The figure below will show the active break down of the study areas in respective zones for sampling.

### **3.11.4 Sampling and Sample Quantity**

Taking a sample of water is difficult operation since it determines the analytical results and their interpretation. Water samples were taken from Tube Wells, Turbines and Hand Pumps from various places discussed below.

Samples collected from various sources in the plastic bottles of 2.5 liters capacity. Before using these bottles for sampling, they were treated with 20ml of saturated solution of  $\text{KMnO}_4$  and then 10ml of  $\text{H}_2\text{SO}_4$  was used. Then these bottles were washed with distilled water. Before taking the samples, bottles were washed three times with sample water and then sample of water was taken. Physical parameters like pH, Electrical Conductivity and Hardness of the samples are measured at the time of sampling. As the chemical nature of the water sample can be changed with the passage of time. So preservation technique was used for better results.

For the estimation of Chromium  $\text{HNO}_3$  was used which was 2ml/l of sample. Then samples were stores at  $4^\circ\text{C}$  in refrigerator. As the study under consideration involves the impact of heavy metal “Chromium” on the ground water, so ground water samples are collected from three major sources of water as follows:

- Tube Well
- Donkey Pumps
- Hand Pump

A total number of 75 samples of ground water from above said sources were collected in both the seasons (5 samples per source three times in every season from each zone), whereas five waste water samples were also collected in each season.

### 3.12 DETAILS OF GROUNDWATER SAMPLES COLLECTED FOR TESTING IN SUMMER (JUNE, JULY, AUGUST)

**Table 3.1**  
**Details of Groundwater Samples Collected in Various Zones in the month of JUNE, JULY, AUGUST (Summer).**

S.No.	Sample Site	Depth (FEET Avg.)	No of Samples Collected	Sample Codes
<b>ZONE 1 BANGLA KAMBOH</b>				
1	Tube Well	70-600	15	Z1-T-Ss
2	Donkey Pump	40-70	15	Z1-D-Ss
3	Hand Pump	35-55	15	Z1-H-Ss
<b>ZONE 2 DOWLAY WALA</b>				
4	Tube Well	70-600	15	Z2-T-Ss
5	Donkey Pump	40-70	15	Z2-D-Ss
6	Hand Pump	35-55	15	Z2-H-Ss
<b>ZONE 3 NIZAM PURA</b>				
7	Tube Well	70-600	15	Z3-T-Ss
8	Donkey Pump	40-70	15	Z3-D-Ss
9	Hand Pump	35-55	15	Z3-H-Ss
<b>ZONE 4 BHADUR PURA</b>				
10	Tube Well	70-600	15	Z4-T-Ss
11	Donkey Pump	40-70	15	Z4-D-Ss
12	Hand Pump	35-55	15	Z4-H-Ss
<b>ZONE 5 KELOON</b>				
13	Tube Well	70-600	15	Z5-T-Ss
14	Donkey Pump	40-70	15	Z5-D-Ss
15	Hand Pump	35-55	15	Z5-H-Ss

where:

T = Tube Well

D = Donkey Pump

H = Hand Pump

s = Summer

### 3.13 DETAILS OF GROUNDWATER SAMPLES COLLECTED FOR TESTING IN WINTER (DECEMBER, JANUARY, FEBRUARY)

**Table 3.2**  
**Details of Groundwater Samples Collected in Various Zones**  
**in the month of DECEMBER, JANUARY, FEBRUARY (Winter).**

S.No.	Sample Site	Depth (FEET Avg.)	No of Samples Collected	Sample Codes
<b>ZONE 1 BANGLA KAMBOH</b>				
1	Tube Well	70-600	15	Z1-T-Sw
2	Donkey Pump	40-70	15	Z1-D-Sw
3	Hand Pump	35-55	15	Z1-H-Sw
<b>ZONE 2 DOWLAY WALA</b>				
4	Tube Well	70-600	13	Z2-T-Sw
5	Donkey Pump	40-70	15	Z2-D-Sw
6	Hand Pump	35-55	15	Z2-H-Sw
<b>ZONE 3 NIZAM PURA</b>				
7	Tube Well	70-600	15	Z3-T-Sw
8	Donkey Pump	40-70	15	Z3-D-Sw
9	Hand Pump	35-55	15	Z3-H-Sw
<b>ZONE 4 BHADUR PURA</b>				
10	Tube Well	70-600	13	Z4-T-Sw
11	Donkey Pump	40-70	15	Z4-D-Sw
12	Hand Pump	35-55	14	Z4-H-Sw
<b>ZONE 5 KELOON</b>				
13	Tube Well	70-600	14	Z5-T-Sw
14	Donkey Pump	40-70	15	Z5-D-Sw
15	Hand Pump	35-55	15	Z5-H-Sw

where:

T = Tube Well

D = Donkey Pump

H = Hand Pump

w = Winter

For the convenience in study the total area of 8 kilometers is divided into 5 zones, from where the samples were taken from the Drain as well as from all the three major sources as described above. These five zones and their respective sampling points were as follows. Figure above can depict the clear picture of the work under consideration.

Although the samples were collected from five different sample points, three times for each source but every time all these five samples for each source were mixed to proceed for analysis.

### **3.14 METHODOLOGY**

All the methods followed are given in Standard Methods for the examination of water and wastewater by WPCF, AWWA & APHA.

### **3.15 ANALYTICAL TECHNIQUES BEING USED**

#### **3.15.1 General Parameters**

In order to assess the quality of the water samples, various parameters were determined, which are given below:

1. PH
2. EC
3. TDS

### **3.16 ANALYTICAL TECHNIQUE USED IN METAL ANALYSIS**

#### **3.16.1 Atomic Absorption Spectroscopy**

As the metal under study is Chromium which is analyzed by using Atomic Absorption Spectroscopy, on Atomic Absorption Spectrophotometer (Analyst 200 Perkin Elmer).

More sophisticated technique “Atomic Absorption Spectroscopy” was used to determine the quantity of metal “Chromium” from the sample solutions.

Atomic absorption spectroscopy has gained wide application for environmental analysis because of its versatility for measurement of trace elements in water. The atomic absorption spectroscopy is a technique in which the amount of radiation absorbed by ground state atoms in flame is measured.

The sample solution is aspirated into a flame as the sample is transformed to atomic power. The flame then comprises atoms of that element, the flame thermally stimulates some, but most stay in ground state. The ground state atoms can absorb radiation given off by a special source made from that element. The wavelengths of radiation off by source are identical as those absorbed by the atoms in flame. The absorption follows Beer's law that "Absorbance is directly proportional to path length in the flame to the concentration of atomic vapor in flame". Both of these variables are difficult to determine but the path length can be held constant and the concentration of the atomic vapor is directly proportional to the concentration of the analyte in the solution, being aspirated.

The atomic absorption spectrophotometer consists of:

- Light source
- A cell (flame)
- Monochromator &
- Detector.

The flame is placed between the source and the monochromator.

A sharp line source is required in atomic absorption because the width of the absorption line is very narrow. The source used almost exclusively is a hollow cathode lamp. It consists of a cylinder hollow cathode made of the element to be determined or an alloy of it. The most widely used flames for the atomic absorption are air acetylene flame with premix burner.

### **3.16.2 Procedure**

Standard solution of metal Chromium was prepared of different types of ranges in mg/l. The usual practice is to prepare stock solutions, which contain about 100mg/l of required element, and the working standards were prepared by suitable dilutions of stock solutions. Then by atomic absorption spectrophotometer, the values of known solutions were calculated which are plotted on the graph paper to obtain linear curve, further the results of required

metals in water samples were also calculated by comparing their absorbance with the standard linear curve.

From all the heavy metals only Chromium is estimated because the concentration of all other heavy metals is very low, and not harmful for human as well as animal life.

### **3.17 ESTIMATION OF CHROMIUM BY ATOMIC ABSORPTION SPECTROPHOTOMETER**

#### **3.17.1 Standard Stock Solution (1000ppm)**

3.735g of  $K_2CrO_4$  is dissolved in water and volume is made up of 1 Liter with deionized water.

#### **3.17.2 Working Standards**

Working standards (0.5, 1.0, 1.5, 2.0 & 2.5ppm) of Chromium are prepared by diluting the stock solution of 1000ppm with de-ionized water for the required range of unknown solutions, and to obtain the standard curve.

Standard solutions of Chromium were simultaneously run in the concentration range of unknown samples on Atomic Absorption Spectrophotometer.

#### **3.17.3 Sample Preparation**

100 ml of each unfilled and well mixed sample was taken in a beaker and then 10 ml mix of Conc.  $HNO_3$  and  $HCl$  (1 : 3) was added. This mixture was evaporated to 100 ml and then subjected to Atomic Absorption Spectrophotometer (Perkin Elmer, Analyst 200) for the determination of metal Chromium under 357.9nm, after necessary dilutions.

#### **3.17.4 Flame Used**

Air-acetylene (rich yellow color) flame is used in the determination of chromium. The absorption is sensitive to the fuel-to-air ratio. Sensitivity is reduced in case nitrous oxide-acetylene flame is used however it reduces or eliminates chemical interference.

### 3.17.5 Interferences

Chromium absorption is suppressed in the air-acetylene flame by the presence of iron and nickel. The interference can be lessened in the case a lean flame is used, but this also results in the decreased intensity. By adding 2% ammonium chloride (NH<sub>4</sub>Cl) to sample and standard solutions interference caused by iron can be minimized. Excessive phosphate will depress the chromium response and can be minimized by the addition of calcium. Cr (VI) and Cr (III) exhibit different sensitivities. It is recommended that if Cr (III) is present, it be oxidized to give Cr (VI).

### 3.17.6 Operating Parameters

Standard analytical conditions set on AAS for the determination of Chromium are as follows:

Atomization	:	Flame
Lamp Current	:	30mA
Wavelength	:	357.90 nm
Slit	:	0.20 nm
Atomizer	:	Air – Acetylene (rich, yellow)
Oxidant (air)	:	1 liter/min
Fuel (Acetylene)	:	3 liter/min
Burner Height	:	7.5 mm

### 3.17.7 Calculations

The calculations are done by using the following formulae.

$$\text{Chromium in ppm} = B \times (A/C)$$

where

- A = ppm of Chromium in diluted Sample.
- B = volume of diluted solution in ml.
- C = liquid volume taken for dilution in ml.

or

$$\text{Cr. in ppm} = \frac{\text{Sample Absorption}}{\text{Standard Absorption}} \times \text{Standard Conc. Ppm}$$

or

$$\text{Chromium Concentration in ppm} = \frac{\text{Sample Absorbance}}{\text{Standard Absorbance}} \times \frac{\text{Std. Concentration}}{\text{Sample Concentration}} \times \text{Factor}$$

## **CHAPTER 4**

### **EXPERIMENTAL WORK**

All the samples collected in both the seasons were subjected to laboratory analysis; study of the basic physical parameters was done on spot, while for metal estimation the samples were preserved by using the preservation techniques as described in the WHO guidelines for drinking water quality to have the accuracy in results. Table 4.1 and Table 4.2 shows the results of the Physical Parameters (pH, TDS & EC) for the groundwater samples

These preserved samples were analyzed by using the most accurate technique “Atomic Absorption Spectroscopy” on “Atomic Absorption Spectrophotometer (Perkin Elmer Analyst 200)” according to the method as given in Standard Methods for the examination of water and wastewater by WPCF, AWWA & APHA.

**Table 4.1**  
**Representation of the (Groundwater) Results of Physical Parameters**  
**(pH, TDS & EC) in Summer (June, July, August)**

S.No.	Sample Site	Sample Codes	pH	EC (µs/cm)	TDS mg/l
<b>ZONE 1</b>	<b>BANGLA KAMBOH</b>				
1	Tube Well	Z1-T-Ss	8.43	1604	1292
2	Donkey Pump	Z1-D-Ss	8.24	1991	1359
3	Hand Pump	Z1-H-Ss	8.38	2407	1457
<b>ZONE 2</b>	<b>DOWLAY WALA</b>				
4	Tube Well	Z2-T-Ss	7.59	1296	1280
5	Donkey Pump	Z2-D-Ss	7.71	1457	1960
6	Hand Pump	Z2-H-Ss	7.83	2319	1969
<b>ZONE 3</b>	<b>NIZAM PURA</b>				
7	Tube Well	Z3-T-Ss	7.55	1301	1630
8	Donkey Pump	Z3-D-Ss	7.49	2074	1615
9	Hand Pump	Z3-H-Ss	7.63	2307	1653
<b>ZONE 4</b>	<b>BHADUR PURA</b>				
10	Tube Well	Z4-T-Ss	7.51	1568	609
11	Donkey Pump	Z4-D-Ss	7.42	1897	591
12	Hand Pump	Z4-H-Ss	7.40	2101	578
<b>ZONE 5</b>	<b>KELOON</b>				
13	Tube Well	Z5-T-Ss	7.21	110	212
14	Donkey Pump	Z5-D-Ss	7.24	229	376
15	Hand Pump	Z5-H-Ss	7.34	270	409

where

Z = Zone, T = Tube Well, D = Donkey Pump,  
H = Hand Pump, s = Summer

**Table 4.2**  
**Representation of the (Ground Water) Results of Physical Parameters**  
**(pH, TDS & EC) In Winter (December, January, February)**

S.No.	Sample Site	Sample Codes	pH	EC ( $\mu\text{s}/\text{cm}$ )	TDS mg/l
<b>ZONE 1 BANGLA KAMBOH</b>					
1	Tube Well	Z1-T-Sw	8.17	1524	1243
2	Donkey Pump	Z1-D-Sw	8.09	1909	1301
3	Hand Pump	Z1-H-Sw	8.29	2339	1394
<b>ZONE 2 DOWLAY WALA</b>					
4	Tube Well	Z2-T-Sw	7.37	1219	1107
5	Donkey Pump	Z2-D-Sw	7.48	1370	1739
6	Hand Pump	Z2-H-Sw	7.61	2028	1829
<b>ZONE 3 NIZAM PURA</b>					
7	Tube Well	Z3-T-Sw	7.34	1239	1519
8	Donkey Pump	Z3-D-Sw	7.29	1890	1576
9	Hand Pump	Z3-H-Sw	7.41	2100	1527
<b>ZONE 4 BHADUR PURA</b>					
10	Tube Well	Z4-T-Sw	7.22	1419	524
11	Donkey Pump	Z4-D-Sw	7.18	1783	519
12	Hand Pump	Z4-H-Sw	7.19	1900	537
<b>ZONE 5 KELOON</b>					
13	Tube Well	Z5-T-Sw	7.17	93	101
14	Donkey Pump	Z5-D-Sw	7.19	176	119
15	Hand Pump	Z5-H-Sw	7.25	213	207

where

Z = Zone, T = Tube Well, D = Donkey Pump,  
H = Hand Pump, w = Winter

## 4.1 ESTIMATION OF CHROMIUM IN WASTE WATER BY ATOMIC ABSORPTION SPECTRO-PHOTOMETER

### 4.1.1 Standard Stock Solution (1000 mg/l)

Dissolve 3.735 g of Potassium Chromate,  $K_2CrO_4$ , in deionized water and dilute to 1 liter with deionized water.

### 4.1.2 Working Standards

Working standards (0.00, 1.0, 2.0, 3.0, 4.0 & 5.0 mg/l) of Chromium are prepared by diluting the stock solution of 1000ppm with de-ionized water for the required range of unknown solutions, and to obtain the standard curve.

Standard solutions of Chromium were simultaneously run in the concentration range of unknown samples on Atomic Absorption Spectrophotometer.

### 4.1.3 Sample Preparation

100 ml of each unfilled and well mixed sample was taken in a beaker and then 10 ml mix of Conc.  $HNO_3$  and  $HCl$  (1: 3) was added. This mixture was evaporated to 100 ml and then subjected to Atomic Absorption Spectrophotometer (Perkin Elmer, Analyst 200) for the determination of metal Chromium under 357.9nm, after necessary dilutions.

### 4.1.4 Calculations

The calculations are done by using the following formulae.

$$\text{Chromium in mg/l} = B \times (A/C)$$

where

A = mg/l of Chromium in diluted Sample.

B = volume of diluted solution in ml.

C = volume of liquid taken for dilution in ml.

or

$$\text{Cr. in mg/l} = \frac{\text{Sample Absorption}}{\text{Standard Absorption}} \times \text{Standard Conc. mg/l}$$

#### 4.2 STANDARD ANALYTICAL CONDITIONS SET ON A.A.S. FOR THE DETERMINATION OF CHROMIUM IN WASTE WATER

Table below will shows the standard conditions set for the determination of Chromium in waste water.

**Table 4.3**  
**Standard Analytical Conditions Set on AAS**  
**for the Determination of Chromium**

S.No.	Description	Detail
01	Atomization	Flame
02	Lamp Current	30 mA
03	Wavelength	357.90 nm
04	Slit	0.2 nm
05	Atomizer	Air – Acetylene
06	Oxidant (Air)	One Liter/Minute
07	Fuel (Acetylene)	Three Liter/Minute
08	Burner Height	7.5 mm

#### 4.3 ABSORBANCES OF STANDARD SOLUTIONS ON A.A.S. FOR THE DETERMINATION OF CHROMIUM IN WASTE WATER

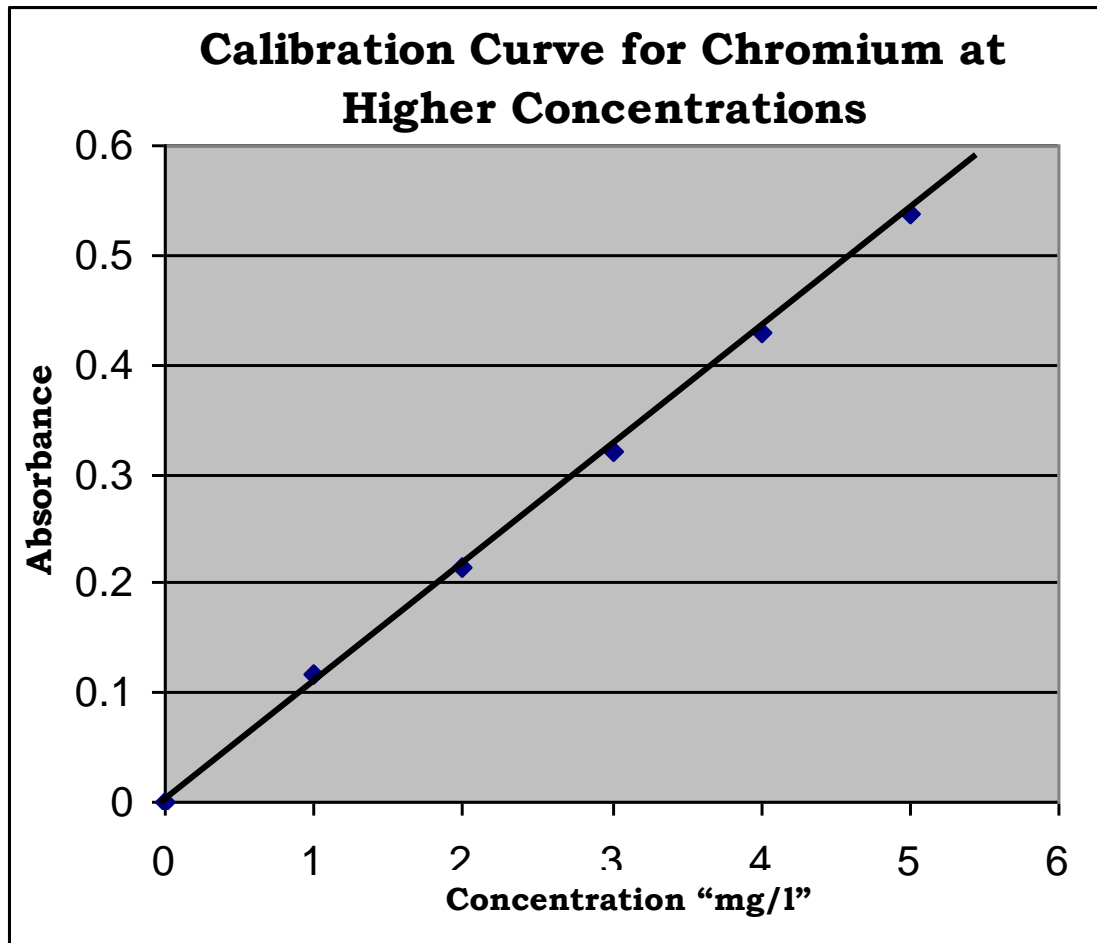
Table below will shows the standard absorbance with the respective concentration for the determination of Chromium in waste water.

**Table 4.4**  
**The Absorbance of Standard Solutions with their**  
**Respective Concentrations at 357.9nm**

S.No.	Concentration of Chromium	Absorbance
01	0.00 mg/liter	0.0000
02	1.00 mg/liter	0.1163
03	2.00 mg/liter	0.2154
04	3.00 mg/liter	0.3207
05	4.00 mg/liter	0.4299
06	5.00 mg/liter	0.5369

#### 4.4 CALIBRATION CURVE FOR DETERMINATION OF CHROMIUM IN WASTE WATER

The Calibration curve in Graph # 4.1 by plotting the absorbance Vs Standard Solutions Concentrations (0.00, 1.00, 2.00, 3.00, 4.00 & 5.00ppm) with their respective Concentrations on atomic absorption spectrophotometer at 357.9nm was as follows:



**Graph 4.1: Calibration Curve for Chromium at Higher Concentrations.**

#### 4.5 REPRESENTATION OF THE RESULTS OF WASTE WATER SAMPLES COLLECTED IN SUMMER

**Table 4.5**  
**Representation of the Absorbance with the Respective Concentration for Waste Water Samples in Summer**

<b>Zone</b>	<b>Sample Site</b>	<b>Sample Code</b>	<b>Absorbance</b>	<b>Concentration of Chromium mg/l</b>
<b>ZONE 1</b>	BANGLA KAMBOH	Z1- Ss	0.3889	3.6
<b>ZONE 2</b>	DOWLAY WALA	Z2- Ss	0.3653	3.4
<b>ZONE 3</b>	NIZAM PURA	Z3- Ss	0.3137	2.9
<b>ZONE 4</b>	BHADUR PURA	Z4- Ss	0.3132	2.9

#### 4.6 REPRESENTATION OF THE RESULTS OF WASTE WATER SAMPLES COLLECTED IN WINTER

**Table 4.6**  
**Representation of the Absorbance with the Respective Concentration for Waste Water Samples in Winter**

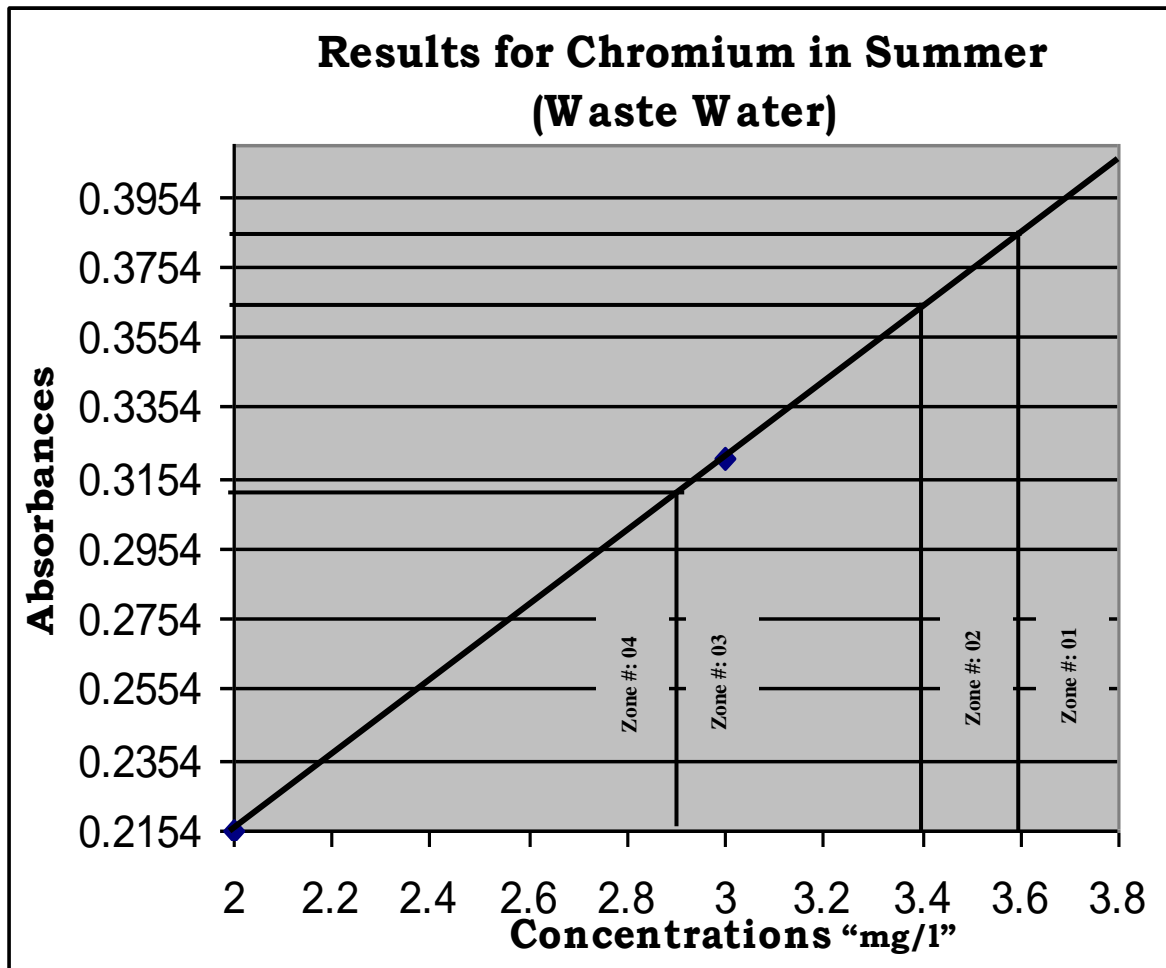
<b>Zone</b>	<b>Sample Site</b>	<b>Sample Code</b>	<b>Absorbance</b>	<b>Concentration of Chromium mg/l</b>
<b>ZONE 1</b>	BANGLA KAMBOH	Z1- Sw	0.3653	3.4
<b>ZONE 2</b>	DOWLAY WALA	Z2- Sw	0.3024	2.8
<b>ZONE 3</b>	NIZAM PURA	Z3- Sw	0.2917	2.7
<b>ZONE 4</b>	BHADUR PURA	Z4- Sw	0.2813	2.6

where

Z = Zone, T = Tube Well, D = Donkey Pump, H = Hand Pump,  
w = Winter, s = Summer

#### 4.7 GRAPHICAL INTERPRETATION OF THE RESULTS OF WASTE WATER (KPLD) SAMPLES IN SUMMER

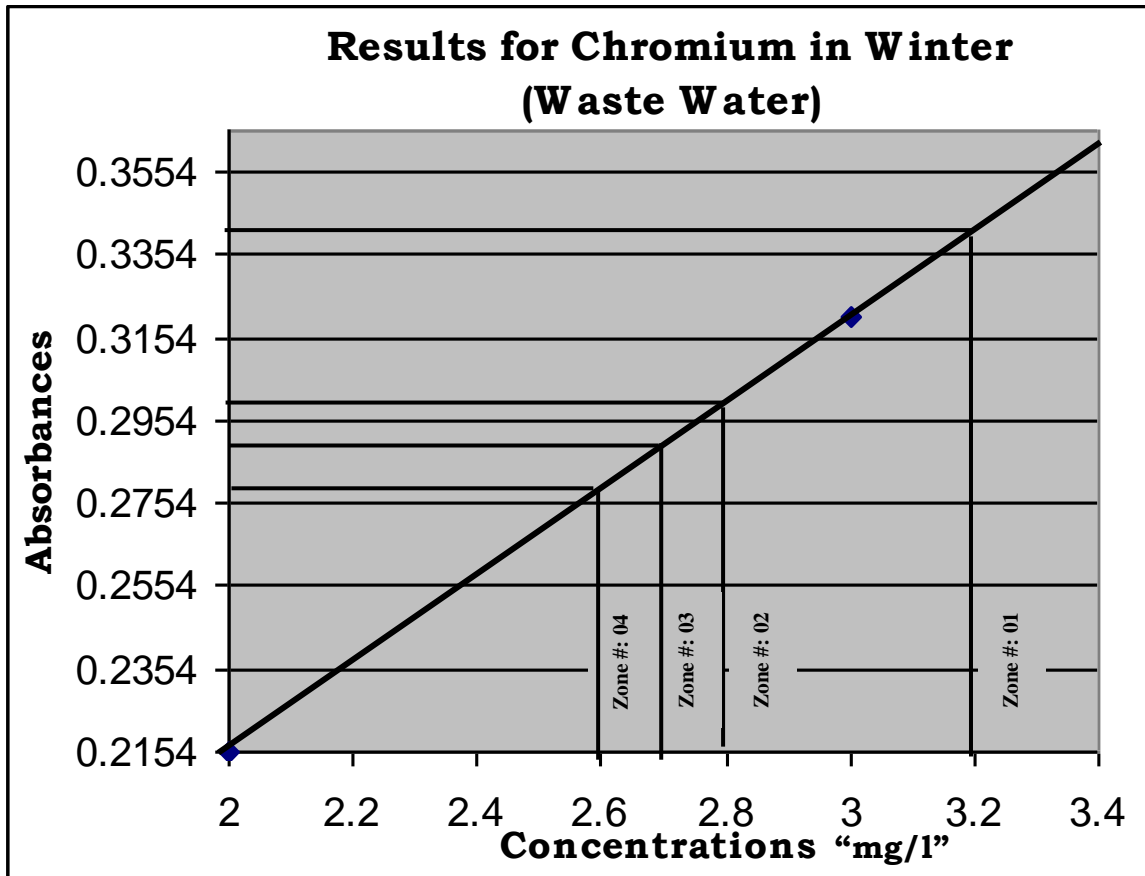
The Graph below shows the Concentration of Chromium (mg/l) in the waste water samples being collected from KPLD in the month of June along with their respective absorbance on atomic absorption spectrophotometer.



**Graph 4.2: Results of Chromium (KPLD) Wastewater with their Respective Absorptions Summer**

#### 4.8 GRAPHICAL INTERPRETATION OF THE RESULTS OF WASTE WATER (KPLD) SAMPLES IN WINTER

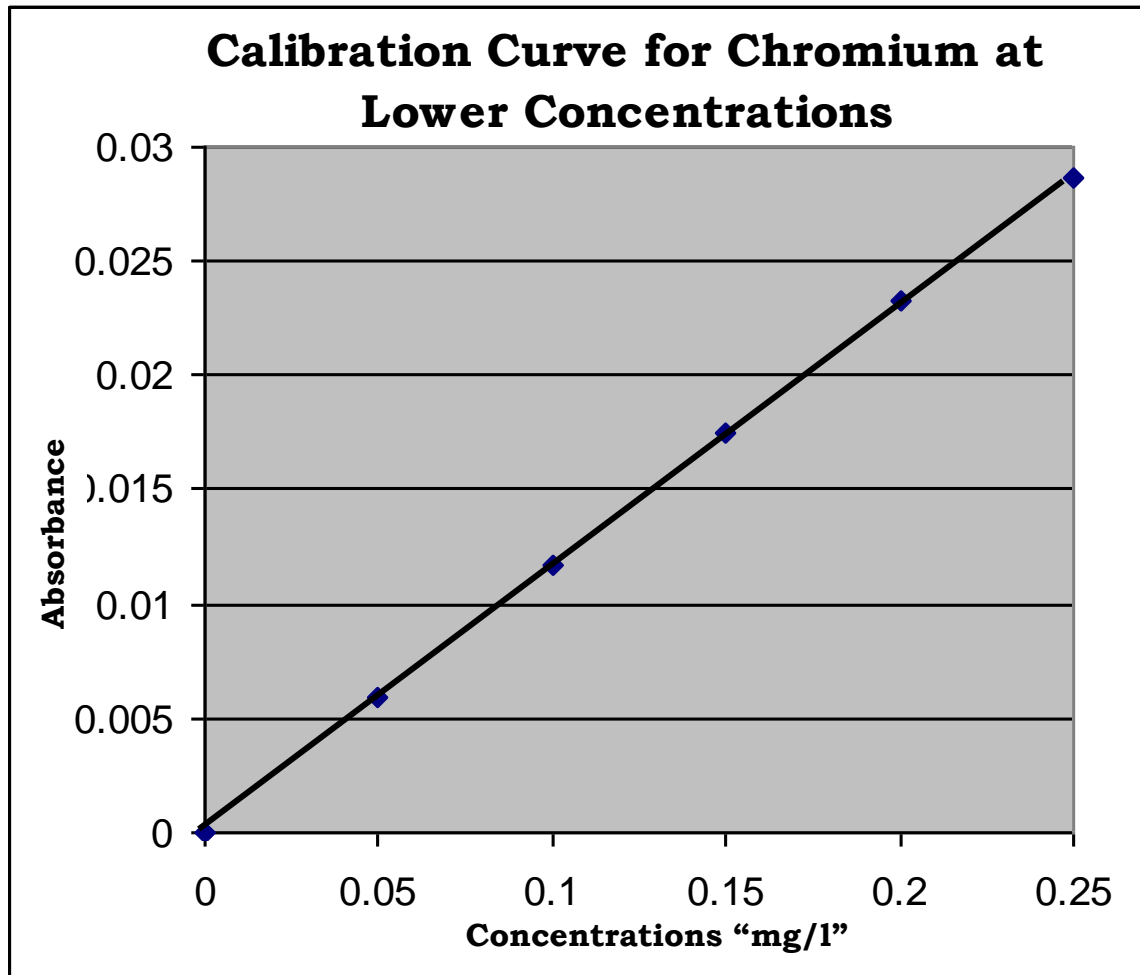
The Graph below shows the Concentration of Chromium (mg/l) in the waste water samples being collected from KPLD in the month of June along with their respective absorbance on atomic absorption spectrophotometer.



**Graph 4.3: Results of Chromium (KPLD) Wastewater with their Respective Absorptions Winter**

#### 4.9 CALIBRATION CURVE FOR DETERMINATION OF CHROMIUM IN GROUND WATER SAMPLES

The Calibration curve by plotting the absorbance Vs Standard Solutions Concentrations (0.00, 0.05, 0.10, 0.15, 0.20 & 0.25 mg/liter) with their respective Concentrations on atomic absorption spectrophotometer at 357.9nm was as follows:



**Graph 4.4: Calibration Curve for Chromium at Lower Concentrations**

#### 4.10 REPRESENTATION OF THE RESULTS OF GROUND WATER SAMPLES COLLECTED IN SUMMER

**Table 4.7**  
**Results for Chromium in Groundwater Samples in Summer**

S.No.	Sample Site	Sample Codes	Absorbance	Concentration of Chromium mg/l
<b>ZONE 1 BANGLA KAMBOH</b>				
1	Tube Well	Z1-T-Ss	0.0174	0.15
2	Donkey Pump	Z1-D-Ss	0.0197	0.17
3	Hand Pump	Z1-H-Ss	0.0244	0.21
<b>ZONE 2 DOWLAY WALA</b>				
4	Tube Well	Z2-T-Ss	0.0071	0.06
5	Donkey Pump	Z2-D-Ss	0.0104	0.09
6	Hand Pump	Z2-H-Ss	0.0186	0.16
<b>ZONE 3 NIZAM PURA</b>				
7	Tube Well	Z3-T-Ss	0.0058	0.05
8	Donkey Pump	Z3-D-Ss	0.0081	0.07
9	Hand Pump	Z3-H-Ss	0.0139	0.12
<b>ZONE 4 BHADUR PURA</b>				
10	Tube Well	Z4-T-Ss	0.0045	0.04
11	Donkey Pump	Z4-D-Ss	0.0058	0.05
12	Hand Pump	Z4-H-Ss	0.0104	0.09
<b>ZONE 5 KELOON</b>				
13	Tube Well	Z5-T-Ss	0.0038	0.03
14	Donkey Pump	Z5-D-Ss	0.0037	0.03
15	Hand Pump	Z5-H-Ss	0.0057	0.05

where

Z = Zone, T = Tube Well, D = Donkey Pump,  
H = Hand Pump, s = Summer

#### 4.11 REPRESENTATION OF THE RESULTS OF GROUNDWATER SAMPLES COLLECTED IN WINTER

**Table 4.8**  
**Results for Chromium in Groundwater Samples in Winter**

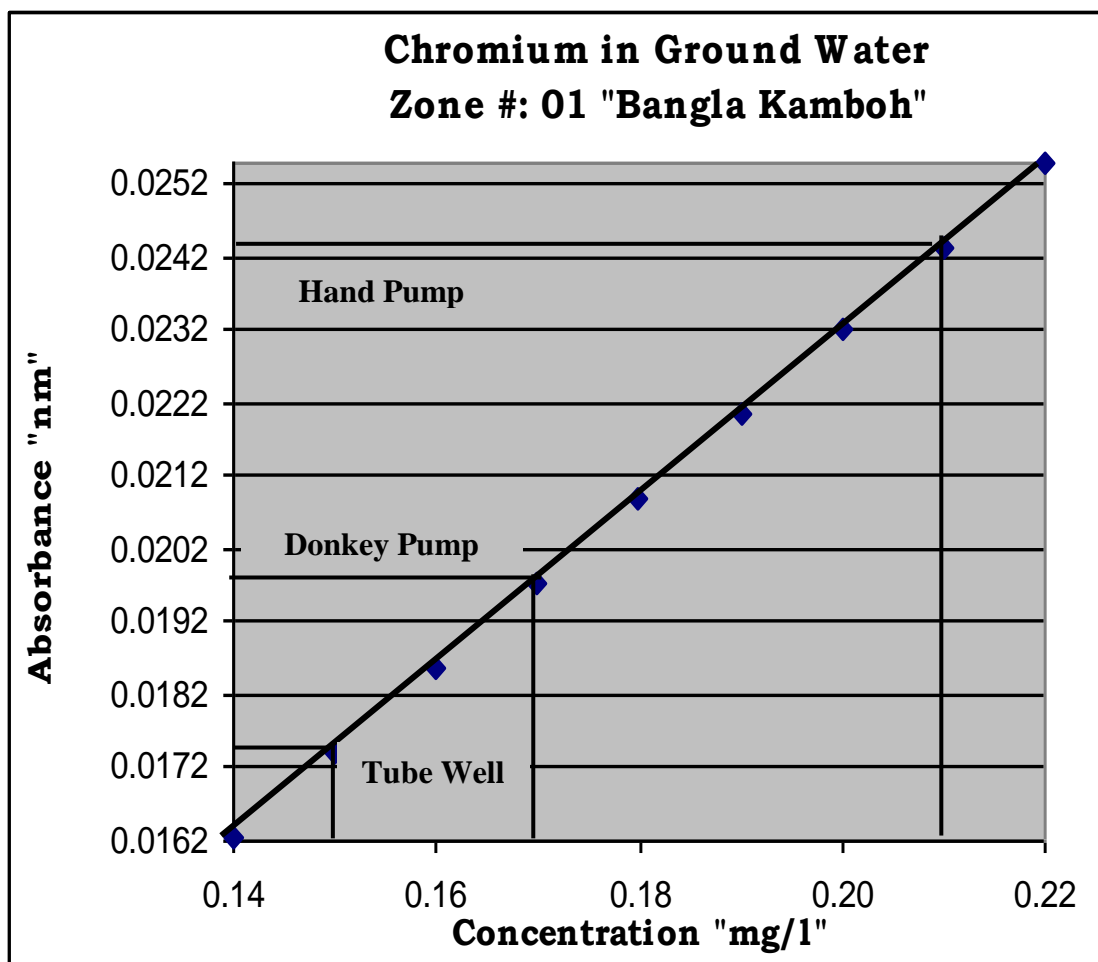
S.No.	Sample Site	Sample Codes	Absorbance	Concentration of Chromium mg/l
<b>ZONE 1</b>	<b>BANGLA KAMBOH</b>			
1	Tube Well	Z01-T-Sw	0.0164	0.13
2	Donkey Pump	Z01-D-Sw	0.0176	0.15
3	Hand Pump	Z01-H-Sw	0.0209	0.18
<b>ZONE 2</b>	<b>DOWLAY WALA</b>			
4	Tube Well	Z02-T-Sw	0.0046	0.04
5	Donkey Pump	Z02-D-Sw	0.0081	0.07
6	Hand Pump	Z02-H-Sw	0.0151	0.13
<b>ZONE 3</b>	<b>NIZAM PURA</b>			
7	Tube Well	Z03-T-Sw	0.0046	0.04
8	Donkey Pump	Z03-D-Sw	0.0070	0.06
9	Hand Pump	Z03-H-Sw	0.0128	0.11
<b>ZONE 4</b>	<b>BHADUR PURA</b>			
10	Tube Well	Z04-T-Sw	0.0044	0.04
11	Donkey Pump	Z04-D-Sw	0.046	0.04
12	Hand Pump	Z04-H-Sw	0.0093	0.08
<b>ZONE 5</b>	<b>KELOON</b>			
13	Tube Well	Z05-T-Sw	0.0023	0.02
14	Donkey Pump	Z05-D-Sw	0.0038	0.03
15	Hand Pump	Z05-H-Sw	0.0046	0.04

where

Z = Zone, T = Tube Well, D = Donkey Pump,  
H = Hand Pump, w = Winter

#### 4.12 GRAPHICAL INTERPRETATION OF THE RESULTS OF GROUND WATER SAMPLES IN ZONE # 1 “BANGLA KAMBOH” SUMMER

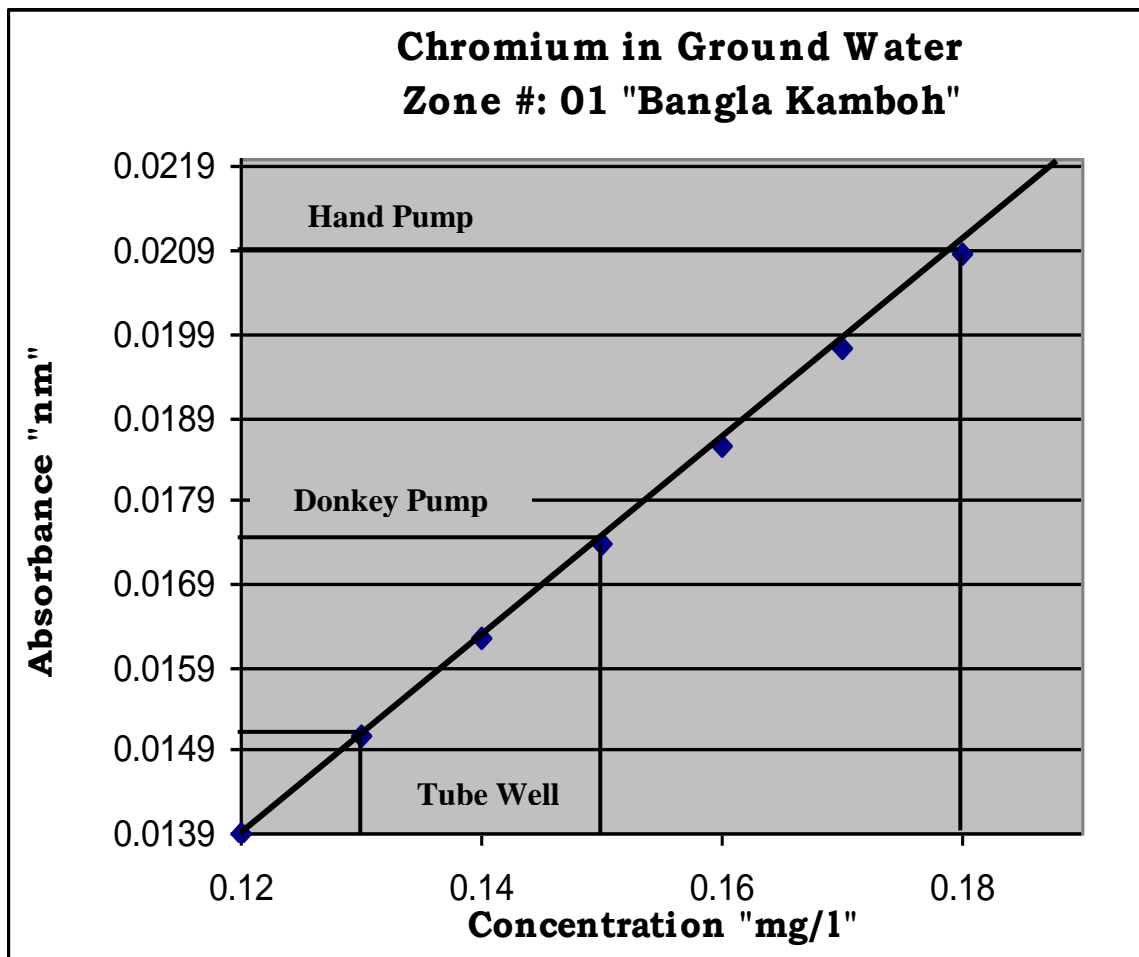
The Graph below shows the Concentration of Chromium (mg/l) in the Ground Water samples being collected from Zone # 1 “Bangla Kamboh” from all the three major sampling sites described in sampling, in the month of June along with their respective absorbance on atomic absorption spectrophotometer.



**Graph 4.5: Chromium Results for Summer in Groundwater “Zone # 1”**

**4.13 GRAPHICAL INTERPRETATION OF THE RESULTS OF GROUND WATER SAMPLES IN ZONE # 1 “BANGLA KAMBOH” WINTER**

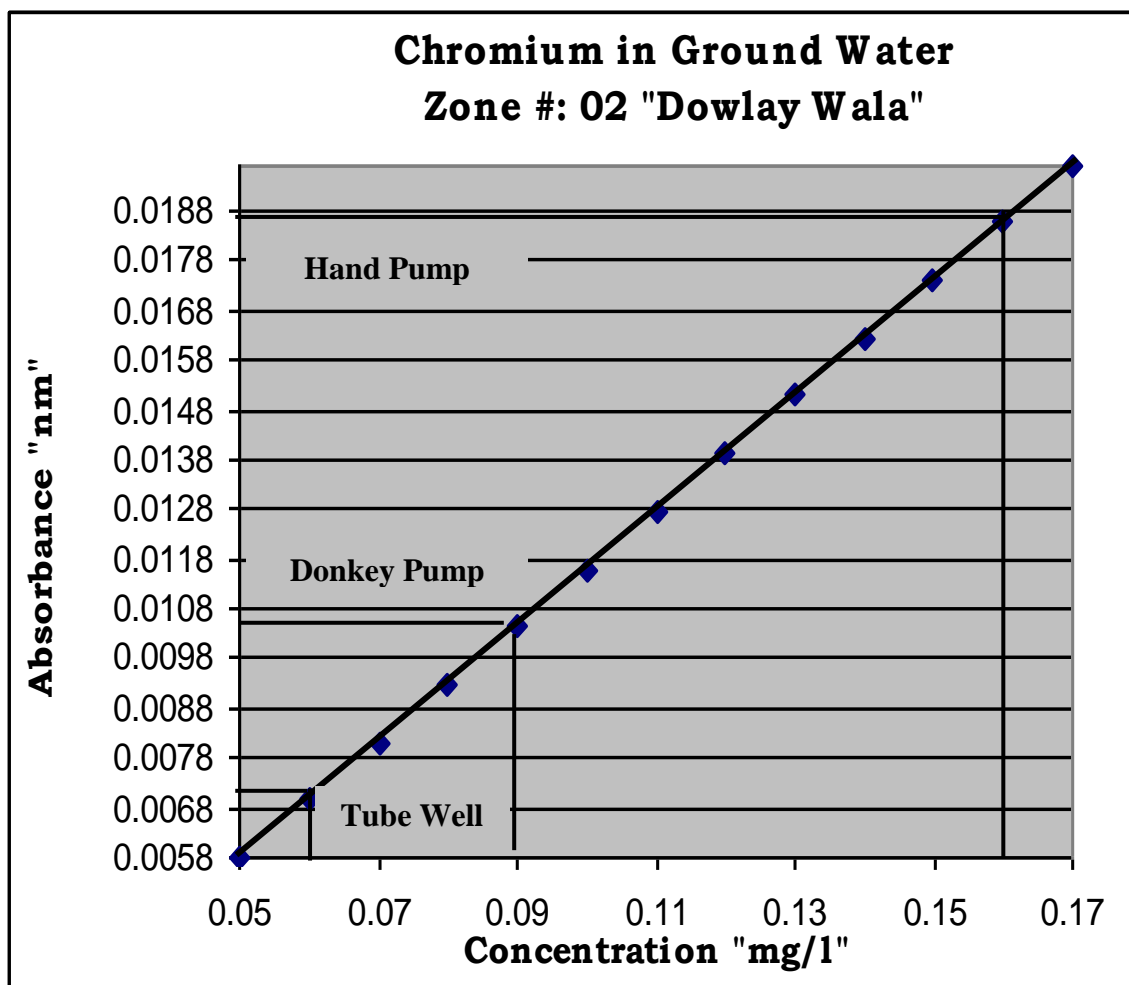
The Graph below shows the Concentration of Chromium (mg/l) in the Ground Water samples being collected from Zone # 1 “Bangla Kamboh” from all the three major sampling sites described in sampling, in the month of December along with their respective absorbance on atomic absorption spectrophotometer.



**Graph 4.6: Chromium Results for Winter in Groundwater “Zone # 1”**

**4.14 GRAPHICAL INTERPRETATION OF THE RESULTS OF GROUND WATER SAMPLES IN ZONE # 2 “DOWLAY WALA” SUMMER**

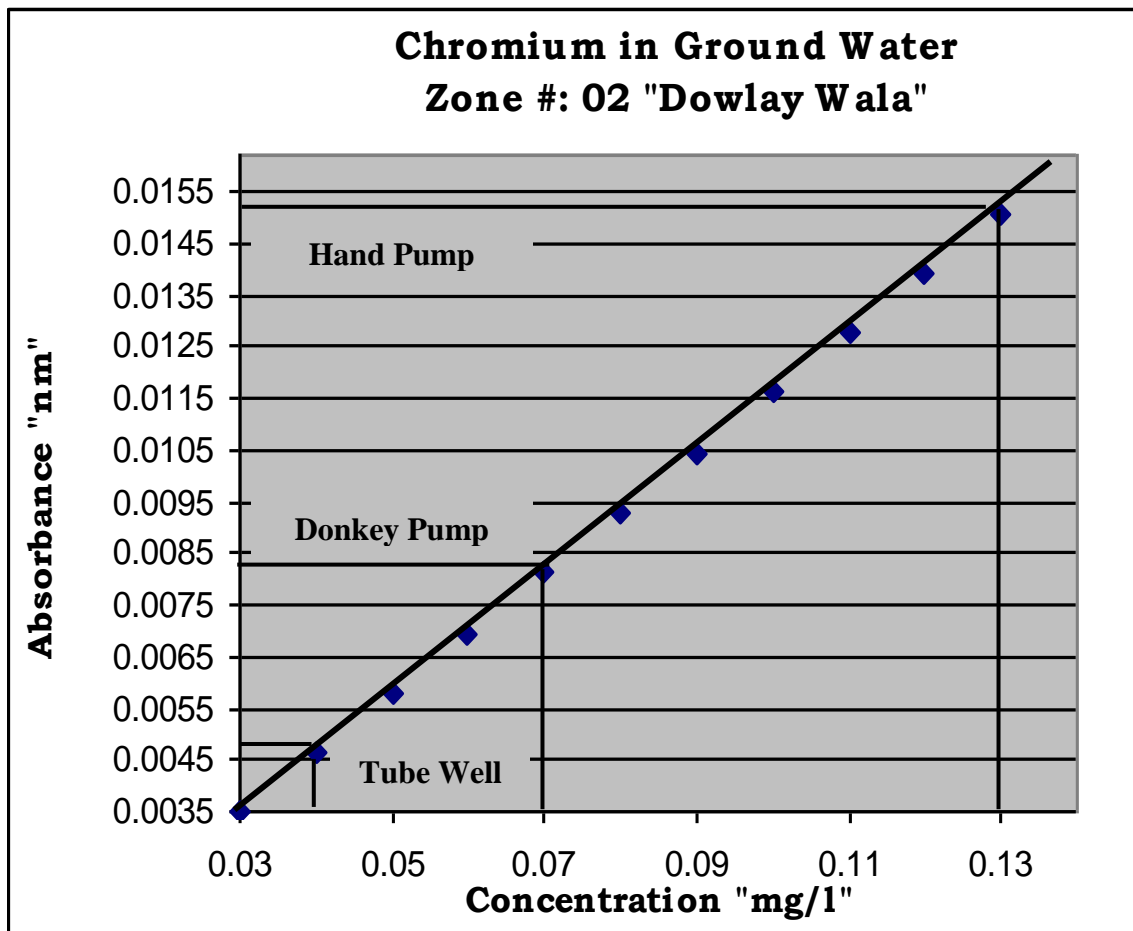
The Graph below shows the Concentration of Chromium (mg/l) in the Ground Water samples being collected from Zone # 2 “DowlayWala” from all the three major sampling sites described in sampling, in the month of June along with their respective absorbance on atomic absorption spectrophotometer.



**Graph 4.7: Chromium Results for Summer in Groundwater “Zone # 2”**

#### 4.15 GRAPHICAL INTERPRETATION OF THE RESULTS OF GROUND WATER SAMPLES IN ZONE # 2 “DOWLAY WALA” WINTER

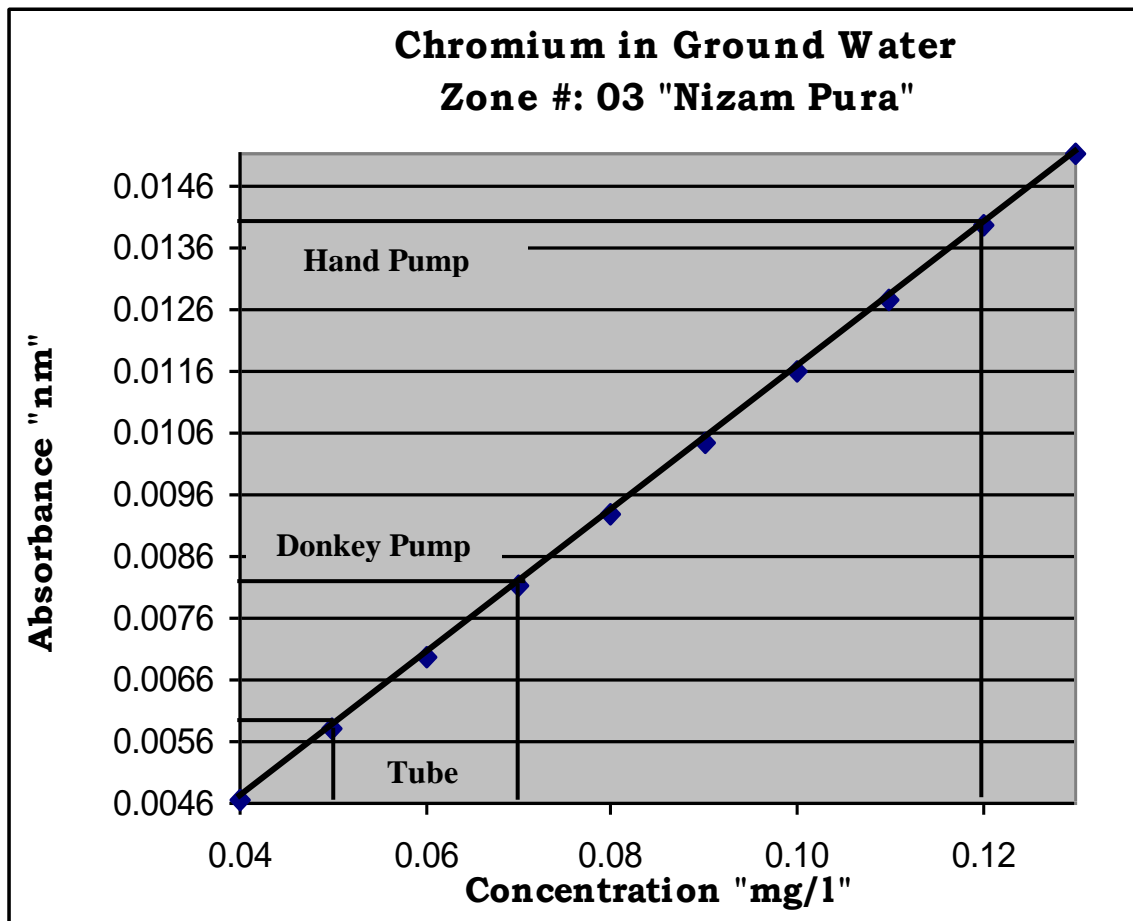
The Graph below shows the Concentration of Chromium (mg/l) in the Ground Water samples being collected from Zone # 2 “DowlayWala” from all the three major sampling sites described in sampling, in the month of December along with their respective absorbance on atomic absorption spectrophotometer.



**Graph 4.8: Chromium Results for Winter in Groundwater “Zone # 2”**

**4.16 GRAPHICAL INTERPRETATION OF THE RESULTS OF GROUND WATER SAMPLES IN ZONE # 3 "NIZAM PURA" SUMMER**

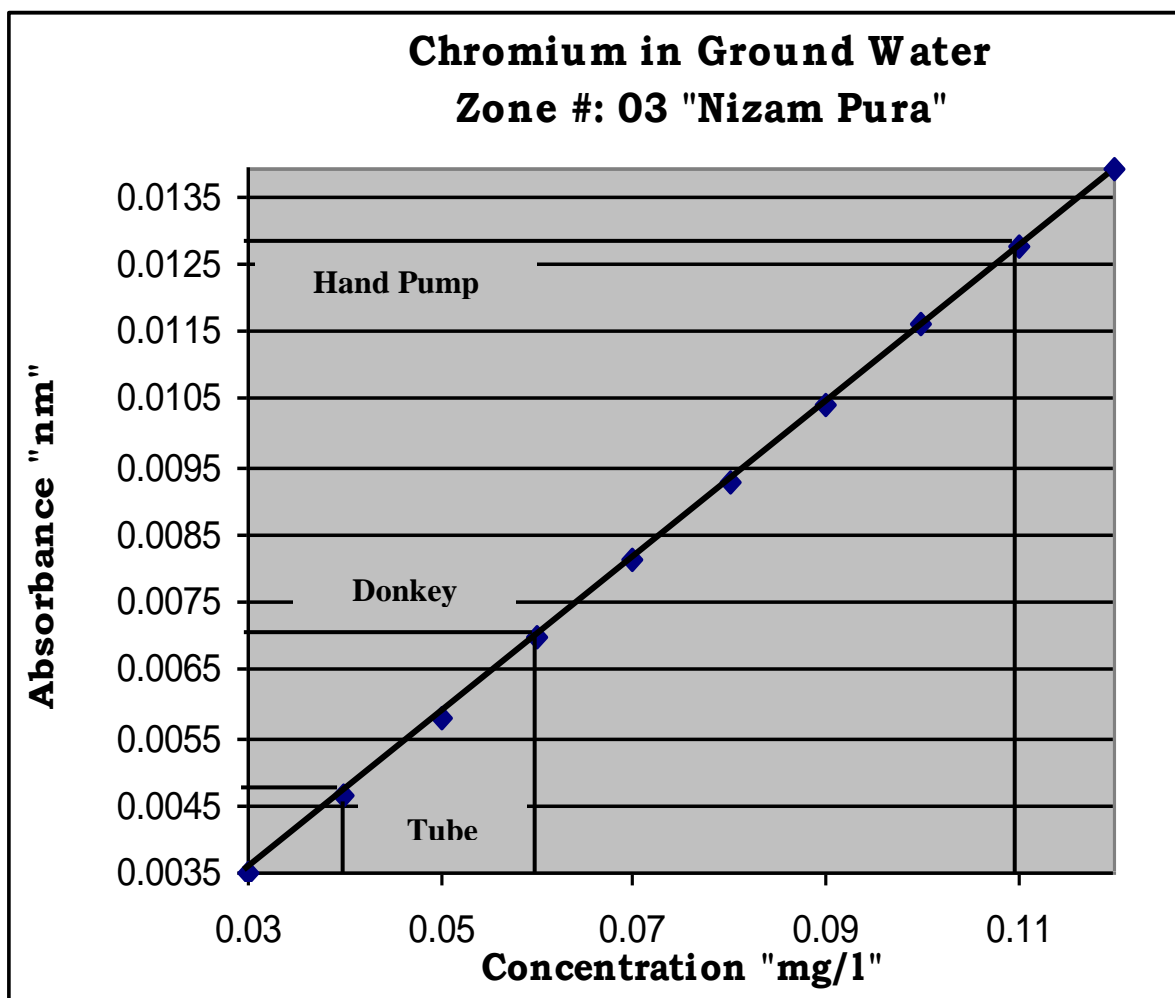
The Graph below shows the Concentration of Chromium (mg/l) in the Ground Water samples being collected from Zone # 3 "NizamPura" from all the three major sampling sites described in sampling, in the month of June along with their respective absorbance on atomic absorption spectrophotometer.



**Graph 4.9: Chromium Results for Summer in Groundwater "Zone # 3"**

#### 4.17 GRAPHICAL INTERPRETATION OF THE RESULTS OF GROUND WATER SAMPLES IN ZONE # 3 "NIZAM PURA" WINTER

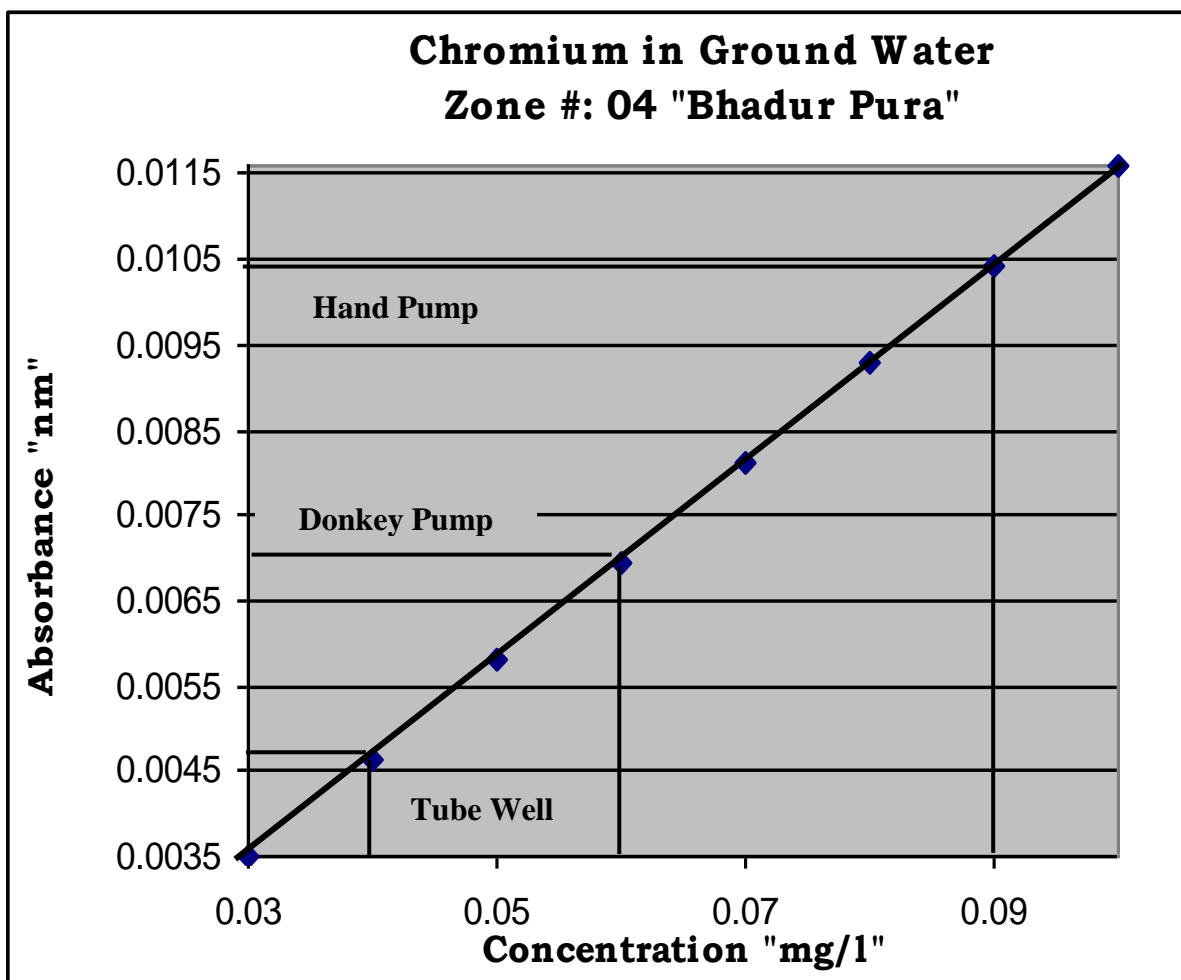
The Graph below shows the Concentration of Chromium (mg/l) in the Ground Water samples being collected from Zone # 3 "NizamPura" from all the three major sampling sites described in sampling, in the month of December along with their respective absorbance on atomic absorption spectrophotometer.



Graph 4.10: Chromium Results for Winter in Groundwater "Zone # 3"

#### 4.18 GRAPHICAL INTERPRETATION OF THE RESULTS OF GROUND WATER SAMPLES IN ZONE # 4 “BHADUR PURA” SUMMER

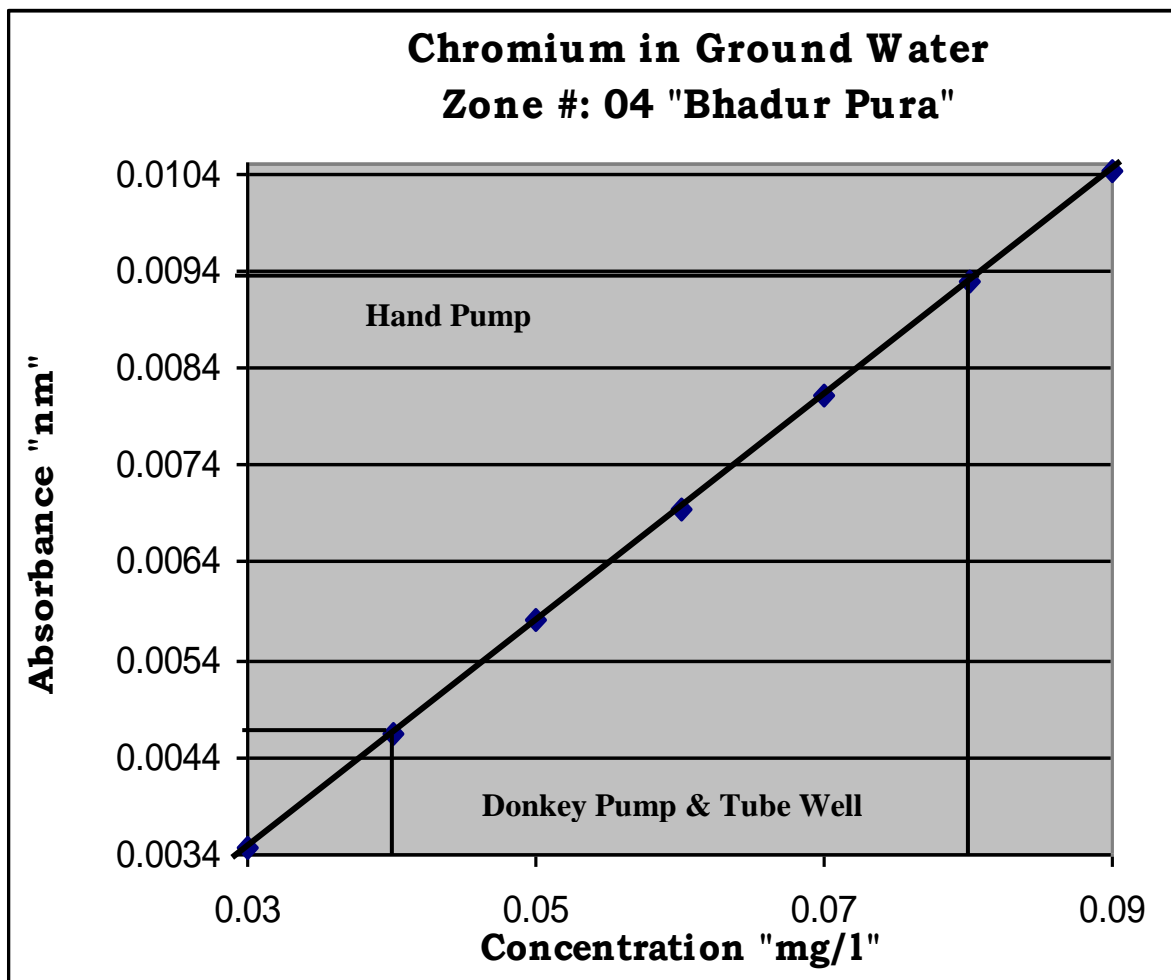
The Graph below shows the Concentration of Chromium (mg/l) in the Ground Water samples being collected from Zone # 4 “BhadurPura” from all the three major sampling sites described in sampling, in the month of June along with their respective absorbance on atomic absorption spectrophotometer.



Graph 4.11: Chromium Results for Summer in Groundwater “Zone # 4”

**4.19 GRAPHICAL INTERPRETATION OF THE RESULTS OF GROUND WATER SAMPLES IN ZONE # 4 “BHADUR PURA” WINTER**

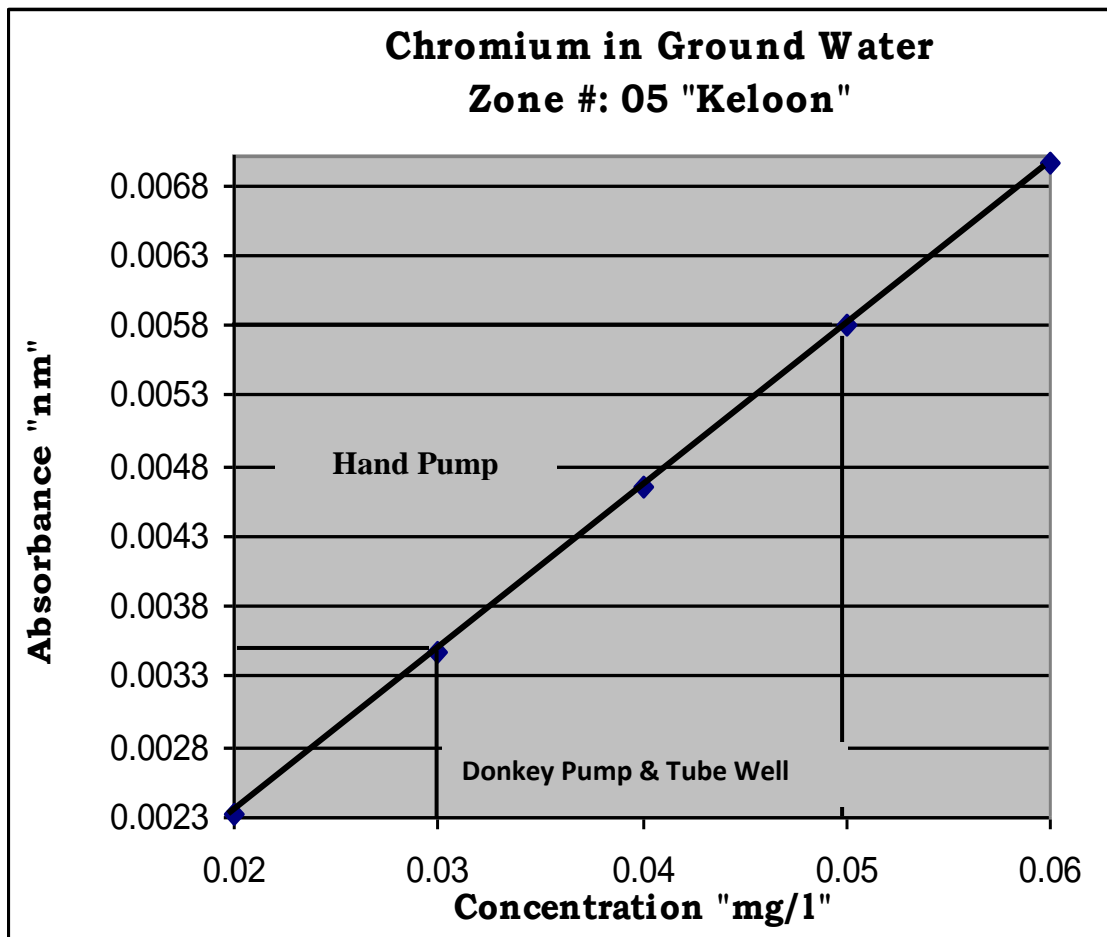
The Graph below shows the Concentration of Chromium (mg/l) in the Ground Water samples being collected from Zone # 4 “BhadurPura” from all the three major sampling sites described in sampling, in the month of December along with their respective absorbance on atomic absorption spectrophotometer.



**Graph 4.12: Chromium Results for Winter in Groundwater “Zone # 4”**

#### 4.20 GRAPHICAL INTERPRETATION OF THE RESULTS OF GROUND WATER SAMPLES IN ZONE # 5 “KELOON” SUMMER

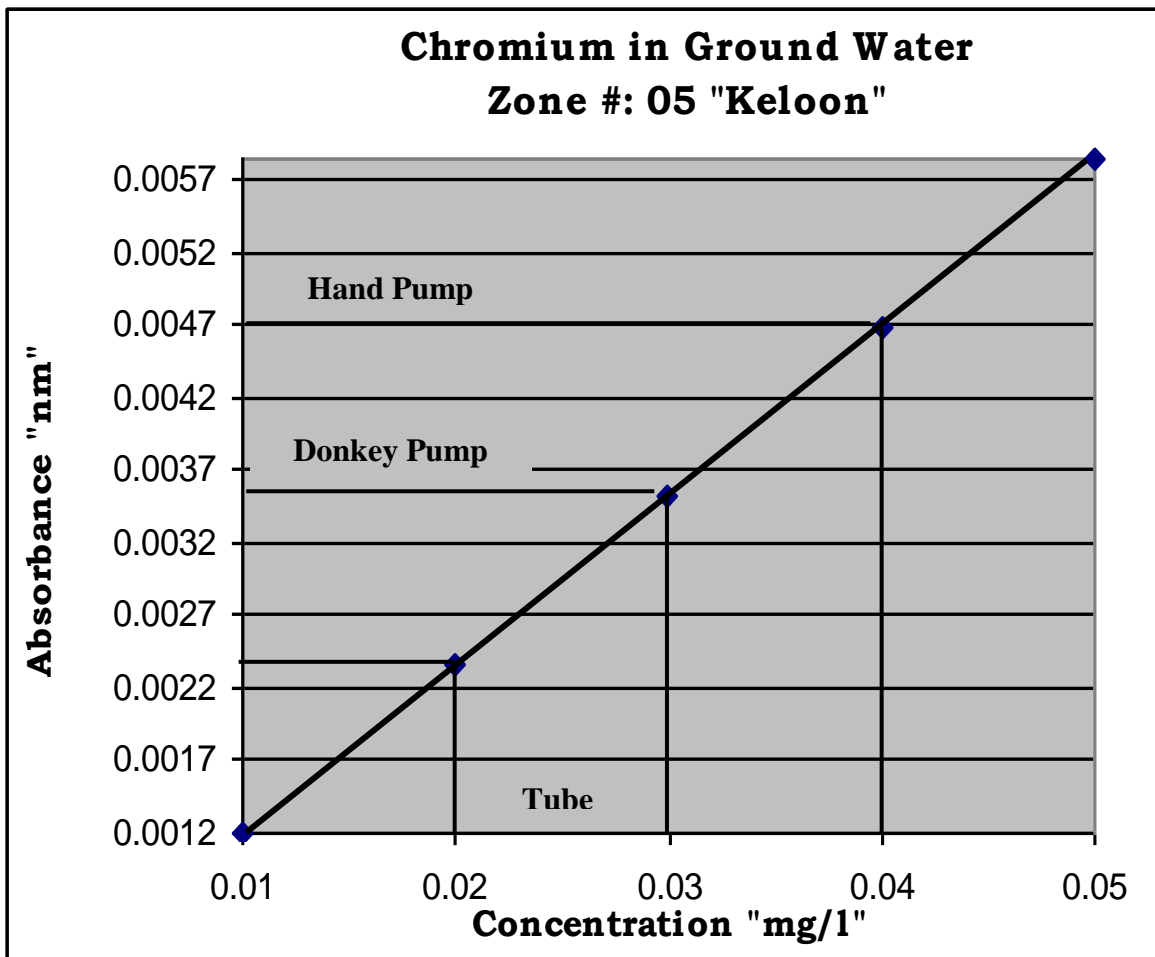
The Graph below shows the Concentration of Chromium (mg/l) in the Ground Water samples being collected from Zone # 5 “Keloan” from all the three major sampling sites described in sampling, in the month of June along with their respective absorbance on atomic absorption spectrophotometer.



Graph 4.13: Chromium Results for Summer in Groundwater “Zone # 5”

#### 4.21 GRAPHICAL INTERPRETATION OF THE RESULTS OF GROUND WATER SAMPLES IN ZONE # 5 “KELOON” WINTER

The Graph below shows the Concentration of Chromium (mg/l) in the Ground Water samples being collected from Zone # 5 “Keloan” from all the three major sampling sites described in sampling, in the month of December along with their respective absorbance on atomic absorption spectrophotometer.



Graph 4.14: Chromium Results for Winter in Groundwater “Zone # 5”

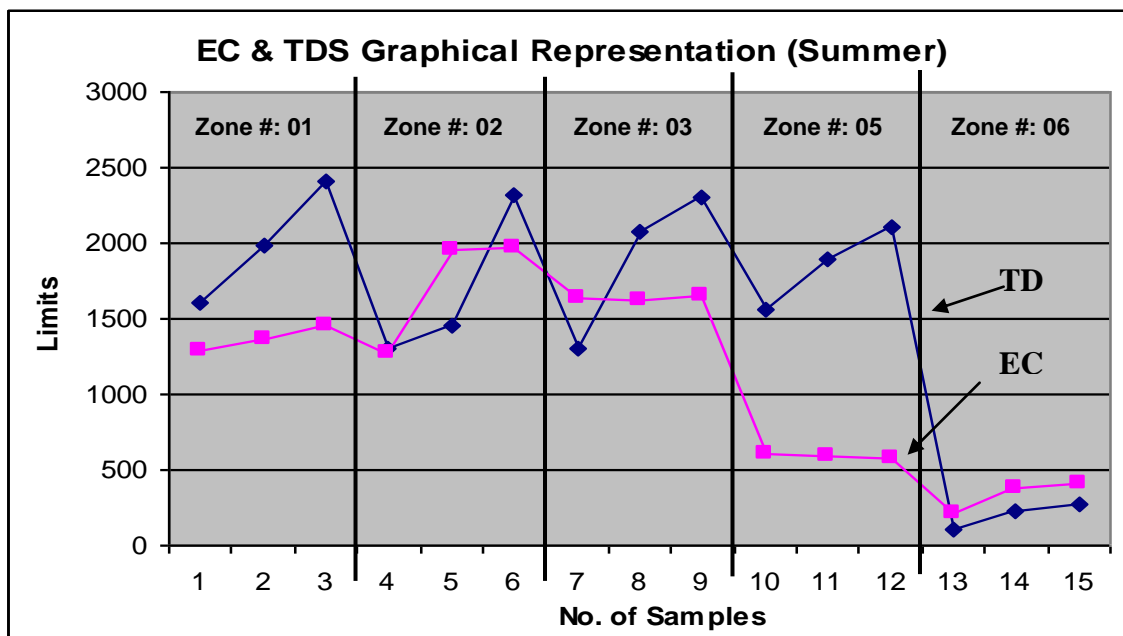
# CHAPTER 5

## RESULTS AND DISCUSSION

The pollution of water by the addition of pollutants constitutes a major threat to the environment all over the world. But now-a-days pollution of ground waters has become one of the most serious problems. It needs attention and action by individuals, civic groups, cities, states and national sanitary and health departments and by industries.

The data collected for pH, Electrical Conductivity and TDS of all the water samples in Summer and Winter seasons is reported in Table # 04-01 and Table 4.2. From this data it is clear that the results for Electrical Conductivity and TDS indicated a wide variation in the results, where the pH values remain there with little variation.

The Results of groundwater samples for Physical Parameters (EC and TDS) for summer season are shown in the graph 5.1 below;

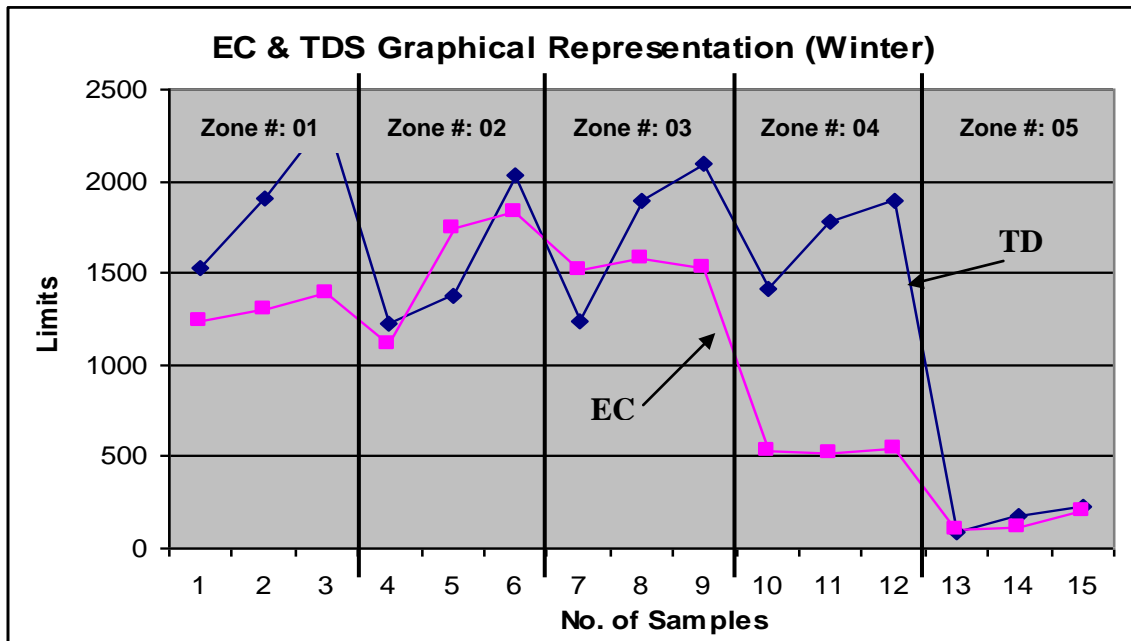


**Graph 5.1: EC & TDS Ground Water Results Graphical Representation for Summer**

The above graph shows the variation in results for Physical Parameters (EC, pH and TDS) in groundwater not only zone wise, but also in the sources there is very wide variation for “TUBE WELL” samples with that of the

“DONKEY PUMP” and “HAND PUMP” samples for the Summer season. EC values varies from 1604 to 2407, 1296 to 2319, 1301 to 2307, 1568 to 2101 & 110 to 270, whereas values for TDS varies from 1292 to 1457, 1280 to 1969, 1615 to 1653, 578 to 609 & 212 to 409 in the respective zones.

The Results of *GROUNDWATER* samples for Physical Parameters (EC and TDS) for Winter season are shown in the graph below;



**Graph 5.2: EC & TDS Groundwater Results Graphical Representation for Winter**

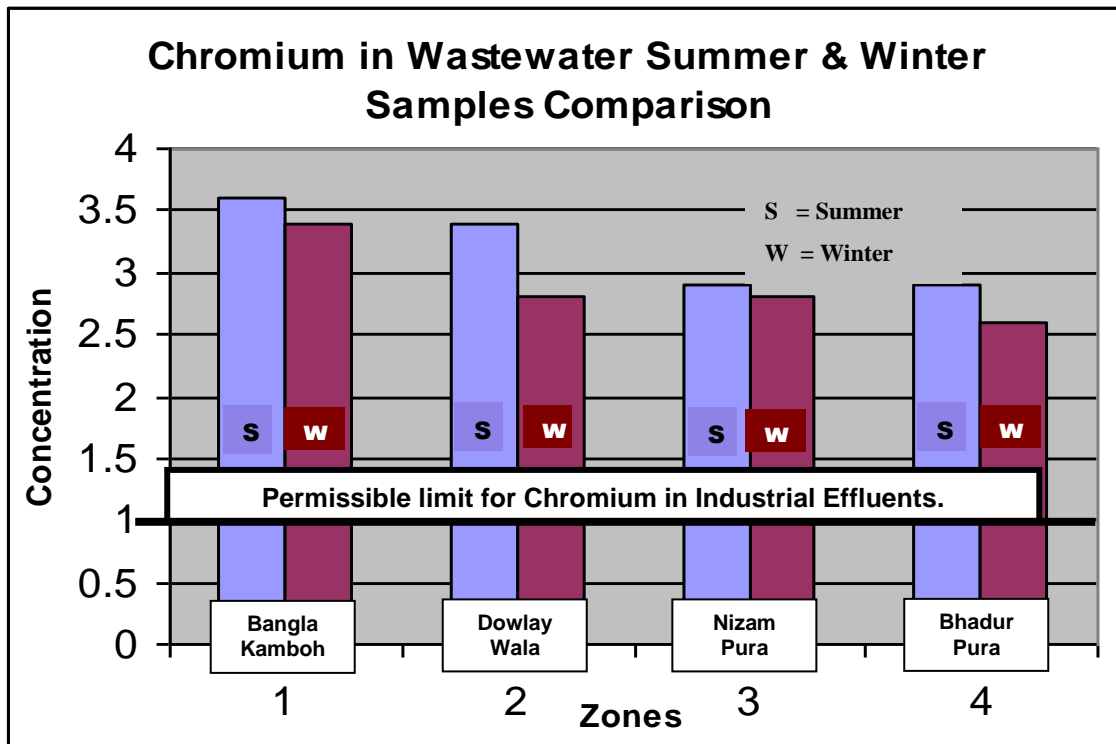
The above graph shows the variation in Physical Parameters (EC and TDS) for *GROUND WATER*, results not only in zone wise, but also in the sources there is very wide variation for “*TUBE WELL*” samples with that of the “*DONKEY PUMP*” and “*HAND PUMP*” samples for the “Winter” season. EC values varies from 1524 to 2339, 1219 to 2028, 1239 to 2100, 1419 to 1900 & 93 to 213, whereas values for TDS varies from 1243 to 1394, 1107 to 1829, 1519 to 1576, 519 to 537 & 101 to 207 in the respective zones.

On average samples for EC and TDS values range from 110 to 2407 & 212 to 1969 for summer & 93 to 2339 & 101 to 1829 for winter. The samples from Zone # 01 to Zone # 04 are found very high where the values for Zone # 05 are considerably very low, the principal reason for it is this that this Zone is not prone to the contamination of the waste water of KLDP.

The results for Chromium in *WASTEWATER* in all the five Zones under consideration in both the seasons are given in the Table 4.5 & Table 4.6

respectively. The graph below will give comprehensive look into the results for CHROMIUM in WASTEWATER for both seasons.

The results for CHROMIUM in “WASTEWATER” in SUMMER vary from 2.9 to 3.6, where for WINTER these are 2.6 to 3.4 mg/ml. It is clear that these values are very high as the limit for Chromium in the Sewage and Industrial Effluents is set at 1.00 mg/l by Government of Pakistan (EPD, Memo # 124/LABS/EPD).



**Graph 5.3: Chromium in Wastewater Results in Summer & Winter Comparison**

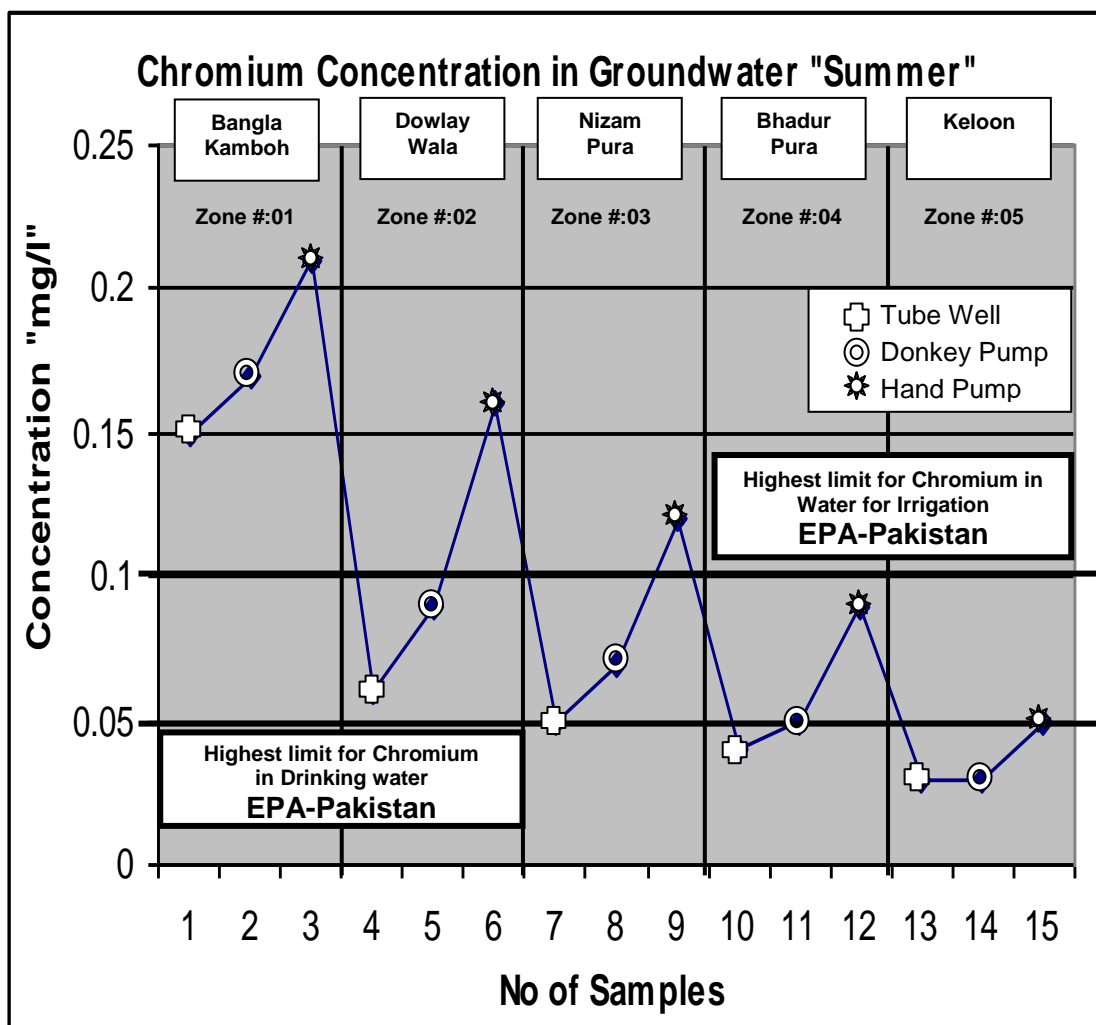
This very high amount of Chromium in WASTEWATER is directly becoming the part of the sewage water which is passing through the KLDP, and which is been used for Irrigation purposes very frequently in the associated areas. Irrigation of the lands by this water has resulted an increase in the level of Chromium in the GROUNDWATER of the adjacent areas, which is the sole source for drinking purposes in these areas.

The results for Chromium in GROUNDWATER samples being collected in the month of June (SUMMER) are given in Table # 04-09. These results varies from 0.03 to 0.17 mg/l, these values shows that the samples from Zone # 05 have the values which comes in limits where the values for Chromium concentration are very high from the limits set by EPD “i.e. 0.05 mg/l” for

drinking water standards in other four Zones. Graph 5.4 can provide a comprehensive picture of the results;

It is clear from the graph below that in Zone # 01 the values (0.15 to 0.21mg/l) from all the three sources are out of limit, so it is neither fit for irrigation nor for drinking purposes, since in this zone “Bangla Kamboh” the results shows that this area is at high risk to the toxicity of Chromium.

In Zone # 02 the values are in the range (0.06 to 0.16 mg/l). Where the results shows that groundwater from Tube Well and Donkey Pump is fit for irrigation but not for human use, Chromium concentration in the sample from Hand Pump is high, showing that this water is not fit for drinking as well as irrigation purposes.



**Graph 5.4: Chromium conc. in Groundwater Results in Summer**

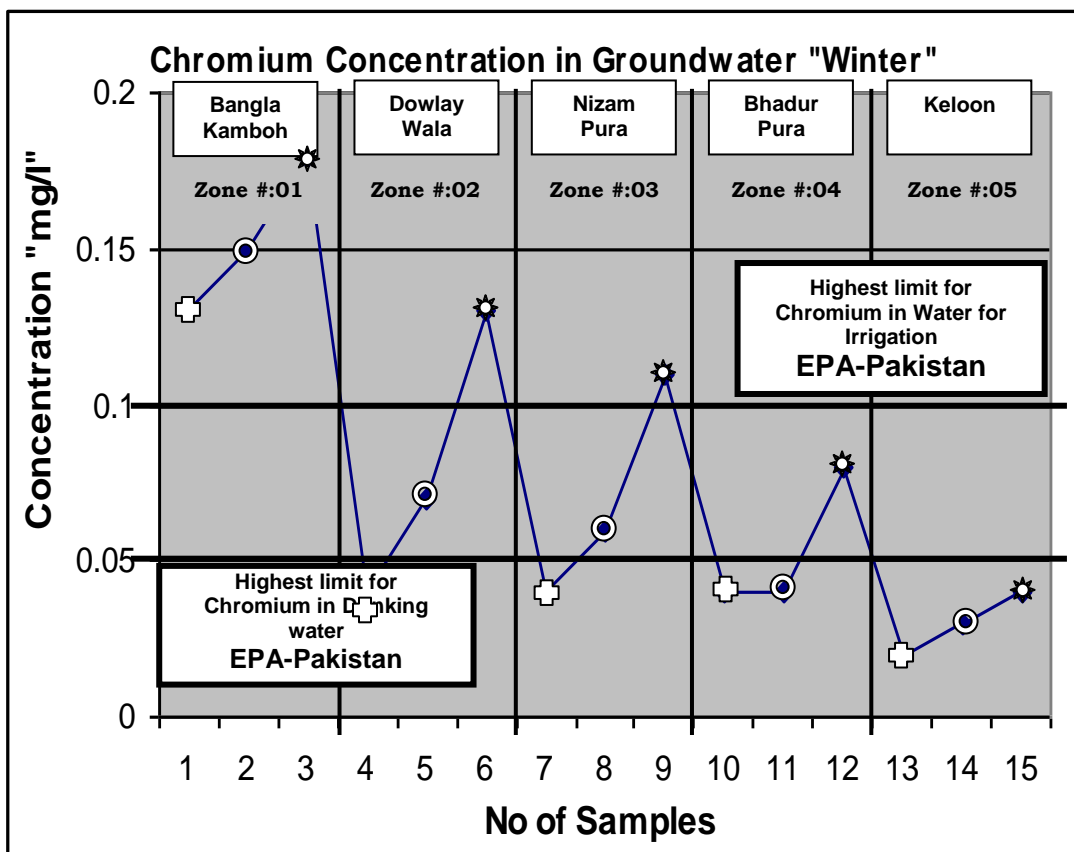
Tube Well water is considerably complying the drinking water limits, Donkey Pump water sample complies the limits for irrigation and the water

from Hand Pump is not even fit for Drinking as well as for Irrigation purposes in Zone # 03 i.e. “NizamPura”.

Water samples from “*Tube Well*” as well as from “*Donky Pump*” are complying the limits of drinking water, where the water sample from “*Hand Pump*” is in the good limits of Irrigation in the Zone : 04 i.e. “BhadurPura”.

In the Zone # 05 “Keloon” the water samples from all the three sources is in limits of drinking water standards being set by Environment Protection Department Punjab.

The results of Ground water samples being collected in the month of December (WINTER) are given in Table # 04-10. These results varies from 0.02 to 0.18 mg/l, these values shows that the samples from Zone # 05 have the values which comes in limits where the values for Chromium concentration are very high from the limits set by EPD “i.e. 0.05 mg/l” for drinking water standards in other four Zones. Graph # 5.4 can provide a comprehensive picture of the results;



**Graph 5.5: Chromium conc. in Groundwater Results in Winter**

It is clear from the above graph that in Zone # 01 the values (0.13 to 0.18mg/l) from all the three sources are out of limit, so it is neither fit for

irrigation nor for drinking purposes, since in this zone “Bangla Kamboh” the results shows that this area is at high risk to the toxicity of Chromium.

In Zone # 02 the values are in the range (0.04 to 0.13 mg/l). Where the results shows that *GROUNDWATER* from Tube Well is fit for drinking purpose and that of Donky Pump is fit for irrigation but Chromium concentration in the sample from Hand Pump is high i.e. 0.13 mg/l, showing that this water is not fit for drinking as well as irrigation purposes.

“*Tube Well*” water is complying the drinking water limits, “*Donkey Pump*” water sample complies the limits for irrigation and the water from “*Hand Pump*” is not even fit for Drinking as well as for Irrigation purposes in Zone # 03 i.e. “NizamPura”.

Water samples from “*Tube Well*” as well as from “*Donky Pump*” are complying the limits of drinking water, where the water sample from “*Hand Pump*” is in the good limits of Irrigation in the Zone : 04 i.e. “BhadurPura”.

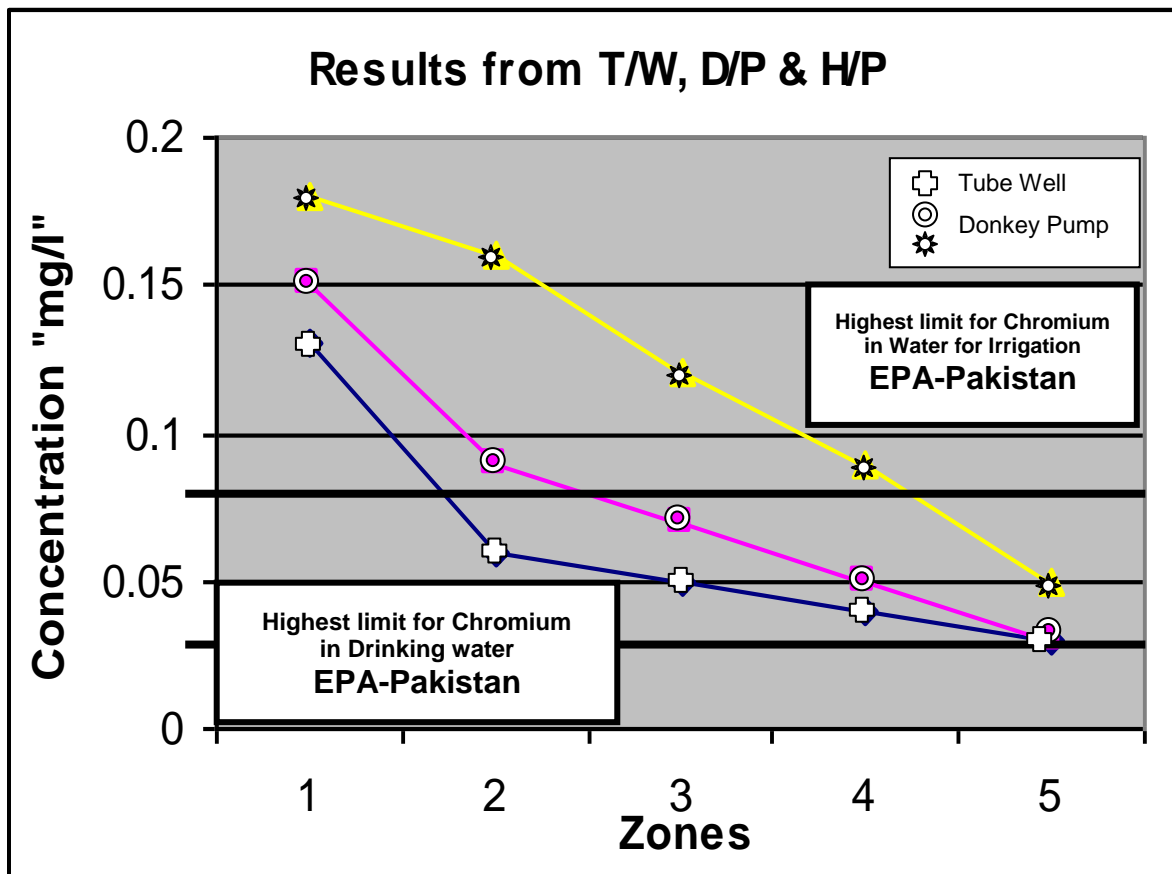
In the Zone # 05 “Keloon” the water samples from all the three sources is in limits of drinking water standards being set by Environment Protection Department Punjab.

Traditionally *GROUNDWATER* is a major source of water supply in Kasur and is used as domestic as well as for drinking purposes, but due to scarce supply for speedily growing population and associated industrial and urban expansion; it is becoming a substitute source for urban residents, either directly or indirectly. Individual users (homes or industries) extract the *GROUNDWATER* through surface suction pumps within their locations.

This substitute source is exaggerated due to the discharge of raw effluent from dyeing, printing, tannery, electroplating, textile and metallurgical industries directly into unlined drains. The inadequate management of raw effluents, large unlined transportation system used for irrigation, resulted in a very leaky distribution system that could contaminate the soils and *GROUNDWATER*. The raw effluents contain soluble salts, metals and other organic toxic substances that could have impact on the human health, due to consumption of polluted *GROUNDWATERS*.

As is clear from the above discussion that the concentration of *CHROMIUM* (a carcinogenic metal) is very high in the case of “*Hand Pumps*” but in the case of “*Donky Pumps*” and “*Tube Wells*” the concentration is considerably decreasing as we move down the stream of KasurPandoki Linkage Drain. The graph # 05-06 can depict the true picture.

It can be concluded from the graph below that the water from “*Hand Pumps*” and “*Donky Pumps*” cannot be used for drinking purposes, where the water from “*Tube Wells*” can be used for drinking / irrigation purposes with the exemption of some areas. Also it can be concluded from these results that use of raw effluent for raising vegetables which is the major agricultural business of the region, will not only make the soils slowly unproductive but will also adversely affect animal and human health through introducing higher amounts of Chromium into food chains.



**Graph 5.6: Chromium conc. in Groundwater Comparison among all the Three Sources**

For improvement, protection and maintenance a number of factors are to be addressed in order to improve, protect and maintain the quality of freshwater/groundwater resources in the country, these include:

### 5.1 GOVERNMENT PRIORITIES

Government is there with the treatment of sewage and industrial effluents on lower priority. According to reliable sources water treatment plant

is supposed to be installed but it still have not been installed showing the level of Government interest in the treatment of wastewater and towards improvement in the quality of freshwater/groundwater.

## **5.2 RULES AND REGULATIONS**

No Clear Guidelines are available till time for groundwater abstraction, which is the common cause of water depletion. Such rules and regulations have to be established at the earliest. In a recent case a bottled water company was halted by our courts from setting up their unit due to risk of extreme groundwater withdrawal near Karachi is to be respected. The apprehension is that rather than on-off debates such risks to excessive groundwater extraction need to be sheltered by legal rules and regulations.

## **5.3 WEAK LAW ENFORCEMENT & COMPLIANCE**

Enforcement of relevant laws like PEPA 1997, is exceptionally weak resulting in the low compliance particularly in the industrial and housing sector. There is a need to cultivate some sort of cohesive land use planning to legalize the housing sector. Non-operational environmental tribunals are enough to depict weak enforcement of law in the country, where strong law prosecution and compliance is obligatory for the safeguard of freshwater/ground water resources.

## **5.4 WATER POLICY**

Although relevant policies like National Environment Policy, National Water Policy, National Drinking Water Policy etc. are in place, there is no unblemished strategy formulated so far to implement them. Where their implementation is very highly required. In addition to the above, the provision of water and sanitation services in Pakistan is scarce, and highly ineffective. Public sector provided services remain fail to embed water quality standards and to provide adequate sanitation needs of massive population growth.

The major reasons why these service providers have failed to perform are:

1. Misperception of social, environmental, commercial, and political goals.

2. Poor management configurations operating without clear policy guidelines.
3. High capital investment needs with low or no rate of return.
4. Opposition in achieving full or even partial cost recovery.
5. Decentralized water agencies with service accountability but little assets.
6. Political intrusion at most levels of operation.
7. Non-existent regulator.
8. Lack of proper legal framework.
9. Deficiency of platforms for contribution by concerned citizens.

In conclusion, even though water is one of the most significant necessities for life and Pakistan is a semi-arid country, water use practices in the country fall far short of the required minimum for water conservation and water quality. In simple terms, Pakistan's water is drying up, and what little remains is heavily polluted. We need to make sure that our practices change if Pakistan is to survive the next few decades.

# CHAPTER 6

## CONCLUSIONS AND RECOMMENDATIONS

### 6.1 CONCLUSIONS

From the foregoing investigation following conclusions may be drawn:

- KasurPandoki Linkage Drain, the quality of water is polluted for various purposes like irrigation.
- KasurPandoki Linkage Drain, is polluted with massive amount of Chromium and toxic heavy metals due to the disposal of tannery, industrial and domestic sewage and solid waste.
- In both the season results, a wide variation was found in the quality of wastewater and groundwater.
- Concentrations were high in the first four regions as these sites are directly associated to the contamination of KasurPandoki Linkage Drain, which can cause problems if is been massively used for drinking and irrigation.

### 6.2 RECOMMENDATIONS

Followings are the recommendations on the basis of above discussion:

- Monitoring of the KasurPandoki Linkage Drain, should be done throughout the year by KTWAMA authorities, or the monitoring bodies.
- Wastewater contaminants like Chromium must be in the acceptable limits, before it is been disposed/thrown in the drain.
- Wastewater from KasurPandoki Linkage Drain, should not be used for irrigation purposes as it is containing high amounts of Chromium which is a carcinogenic metal.
- The people should be informed about the toxic effects of Chromium by means of community awareness programs.
- Water treatment plant should be installed to clear the water from all the toxic chemicals along with the existing solid waste collection plant.

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# APPENDIX I

## Guidelines of Water Quality for Irrigation [NEQS, EPA-Pakistan]

<b>Parameter</b>	<b>No Problem</b>	<b>Increasing Problem</b>	<b>Severe Problem</b>
Electrical Conductivity (µs/cm)	750	750-3000	>3000
SAR	<3	3-9	>9
RSC (m eq./L)	<1.25	1.25-5	>5
Chloride (mg/L)	<142	142-355	>355
Bicarbonate (mg/L)	<91	91-518	>518

## APPENDIX II

### Drinking Water Standards of EPA [NEQS]

S.No.	Contaminant	Limit
1	Chloride	250(mg/L)
2	Iron	0.3(mg/L)
3	pH	6.5-8.5
4	Copper	1(mg/L)
5	Sulfate	250(mg/L)
6	Total Dissolve Solids	500(mg/L)
7	Zinc	5(mg/L)
8	Cadmium	0.01(mg/L)
9	Chromium	0.05(mg/L)
10	Lead	0.05(mg/L)
11	Nitrate	10(mg/L)
12	Total Coliforms (Max. No. / 100mL)	5 /100mL

## APPENDIX III

### National Environmental Quality Standards for Sewage and Industrial Effluents

S.No.	Parameters	Standards
1	Temperature	40°C
2	pH value (acidity / basicity)	6-10 mg/L
3	Five day BOD at 20 0C	80 mg/L
4	COD	150 mg/L
5	TSS	150 mg/L
6	TDS	3500 mg/L
7	Grease and oil	10 mg/L
8	Phenolic compounds	0.1 mg/L
9	Chlorides	1000 mg/L
10	Fluorides	20 mg/L
11	Cyanide	2.0 mg/L
12	Anionic detergents	20 mg/L
13	Sulphate	600 mg/L
14	Ammonia	40 mg/L
15	Cadmium	0.1 mg/L
16	Chromium	1.0 mg/L
17	Copper	1.0 mg/L
18	Lead	0.5 mg/L
19	Total toxic metals	2.0 mg/L
20	Zinc	5.0 mg/L
21	Iron	2.0 mg/L
22	Boron	6.0 mg/L
23	Chlorine	1.0 mg/L
24	Pesticides, herbicides, insecticides	0.15 mg/L

## APPENDIX IV

### Sampling Sources and Number of Samples Collected

S.No.	Source	Depth Range	No. of Samples
1	Hand Pumps	35ft to 55ft	5 for 3 times/season
2	Donkey Pumps	40ft to 70ft	5 for 3 times/season
3	Tube Wells	70ft to 600ft	5 for 3 times/season
4	waste water sample from every zone except zone # 05		5 for 3 times/season