

**ANALYSIS OF UNDERGROUND WATER CONTAMINATION
DUE TO SURFACE WATER POLLUTION OF
BUDDHA NULLAH, LUDHIANA**

A PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE

OF

**MASTER OF TECHNOLOGY
IN
ENVIRONMENT ENGINEERING**

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DECLARATION

I, hereby declare that the work being presented in the Project Report entitled “**ANALYSIS OF UNDERGROUND WATER CONTAMINATION DUE TO SURFACE WATER POLLUTION OF BUDDHA NULLAH , LUDHIANA**” is an original work and an authentic report carried out as a part of my major project. The contents of this report have not been previously formed the basis for the award of any degree, diploma or other similar title or recognition and is being utilized by me for the submission of my Major Project-2 Report to complete the requirements of Master’s Degree of Examination in Environment Engineering, as per Delhi Technological University curriculum.

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CHAPTER 1

INTRODUCTION

1.1 General

Water pollution is one of the few major problems faced by industrial world. It is caused due to introduction of harmful biological, physical and chemical substances to the water. These can be released either by industrial sources and domestic sources. Agricultural runoff is also one of a major source of water pollution discharge of untreated sewage water to review of a major reason of water pollution of major rivers.

Apart from this leaking of industrial waste like heavy metal, leaking from solid landfill sites is also responsible for groundwater pollution. Effect of water pollution is sewer. Apart from harmful effect on aquatic life, it has huge impact on human too. Drinking Polluted water causes disease like Typhoid, Cholera, heavy metal toxicity like Minamata diseases, Arsenic poisoning.

1.2 Ground water pollution

Ground water is the water located beneath the earth's surface in soil pores and in rock formation. The depth at which water is found in sufficient quantity is called water table. Ground water is recharged through surface water by infiltration of water from rivers, ponds, rainfall etc.

1.2.1 Ground water contamination

Ground water may get contaminated due to movement of polluted surface water. Sometime pollutions may get reached and reach directly to underground water. For example reaching of solid waste from landfill site sites. Pollutants flow along with ground water as per the topography of region. Thus as we move away from the source the concentration of ground water reduces. Speed of spread depends upon solubility, directly and topography of region.

Also ground water flows through fractures in rocks. Since it is difficult to locate and predict fractures in the rock thus spread of pollutants in ground water may be difficult to predict sometime. Also sometime pollutants may flow through rod systems, abandoned wells and other type of holes, making it difficult to predict the nature of spread of ground water pollution.

1.2.2 Factors affecting Ground water Pollutions

The main factors which affect Ground water Pollutions are:-

1. Rainfall pattern
2. Depth of water table
3. Distance from source
4. Soil properties

1.2.3 Effect of Ground water pollution

Contamination of underground water may result in decline in quality of water making it in-fact not suitable for human consumption. In areas where major source of drinking water is underground water it may lead to adverse effect on human health. Cost of treating water supply may increase and in some cases a new source of water supply need to be found.

There are several ways to treat underground water and control the spread of contamination. First and most commonly used method is to pump the water, treat it and return it to aquifer. This process is quite expensive process and time consuming process too. And probability of recontamination is high in this process too. Thus more effective strategy is to contain the migration of pollution of underground water either by not allowing industries to discharge their toxic waste or treat the toxic waste before dumping.

Also bio remediation process is a natural process to reduce contaminant by allowing their decomposition by bacteria. This is slow process and requires constant monitoring, most suitable strategy would depend upon local conditions like concentration of pollution, nature and time.

1.3 Heavy metal pollution

Amongst all the pollutants, heavy metal are most dangerous one as these are non-biodegradable and they remain in environment for a long time. These may enter food chain through bio-accumulation. Their concentration increases as we move up the food chain due to bio magnification process.

The term heavy metal refers to metallic compounds of higher density. Their density is usually greater than 5 gm/cm³. This includes Arsenic, Chromium, lead, Iron etc. These are quiet tonic even at very low concentration.

Some heavy metals are necessary for bio-metallic process but at very-very low concentration. Like zinc is necessary for synthesis of enzymes but as they crosses Household concentration, they become toxic to human body. Heavy metal poisoning may occur due to air emission like use of leaded petrol or drinking contaminated water or eating food with high concentration of heavy metals. As compared to organic pollutants, it is difficult to treat heavy metal pollution as they are non-bio-degradable so difficult to remove.

Table 1.1 : Common industrial units releasing heavy metals into water bodies.

Metal	Common sources
Chromium	Chrome plating, petroleum refining, electroplating industry, leather, tanning, textile manufacturing and pulp processing units. It exists in both hexavalent and trivalent forms.
Nickel	Galvanization, paint and powder, batteries processing units, metal refining and super phosphate fertilizers.
Lead	Petrol based materials, pesticides, leaded gasoline, and mobile batteries.
Copper	Electroplating industry, plastic industry, metal refining and industrial emissions.
Zinc	Rubber industries, paints, dyes, wood preservatives and ointments.
Cadmium	Batteries, electroplating industries, phosphate fertilizers, detergents, refined petroleum products, paint pigments, pesticides, galvanized pipes, plastics, polyvinyl and copper refineries.
Iron	From metal refining, engine parts.
Aluminium	Industries preparing insulated wiring, ceramics, automotive parts, aluminum phosphate and pesticides.
Arsenic	Automobile exhaust/industrial dust, wood preservatives and dyes.
Mercury	Electric/light bulb, wood preservatives, leather tanning, ointments, thermometers, adhesives and paints.

Source: www.pollutioninpeople.org

1.4 Soil Pollution

Soil pollution is defined as degradation of soil fertility and soil quality due to natural and anthropogenic reasons. Natural reasons may consist of soil erosion like wind erosion, gully erosion, splash erosion.

Anthropogenic reasons may consist of excessive use of harmful pesticide and insecticide or dumping of toxic waste from industry like dumping of fly ash from thermal power plants. Apart from this fuel leakage, leakage of sewage system, unhealthy waste management technique like unsanitary landfill cause soil pollution.

Unhealthy and harmful irrigation practices also cause soil pollution. Excessive use of pesticide and fertilizers cause imbalance in soil quality. Runoff of these nutrients to surrounding areas cause phenomena of Eutrophication, thus causing water pollution too.

The effects of pollution on soil are quite alarming and can cause huge disturbances in the ecological balance and health of living creatures on earth. Some of the most serious soil pollution effects are:

- Decrease in soil fertility and therefore decrease in the soil yield. How can one expect contaminated soil to produce healthy crops.
- Loss of soil and natural nutrients present in it. Plants also would not thrive in such soil, which would further result in soil erosion.
- Foul smell due to industrial chemicals and gases might result in headaches, fatigue, nausea, etc., in many people.

1.5 Objective of study

Ludhiana city is one of the most industrialized cities of Punjab. It is well known for small scale industries like smelting, wooden, industry, electroplating industry. But due to lack of planning and lack of enforcement of laws, major industries are dumping their industrial waste diversity to Buddha Nullah which flows through the heart of city. Its waste contains heavy metals like lead, chromium etc. This water leaches to underground aquifer contaminating it.

Apart from this agricultural runoff from maybe field also the water further increasing water pollution. The traces of heavy metal was also found in soil sample was the Buddha Naullah showing the extent of pollution level. This also shows the possibility of heavy metals entering food chain by bio-magnification.

In this dissertation, water quality of Buddha Naullah is being studied and correlation of surface water quality to underground water quality is being made.

The Main objective of study is:-

- 1) To analyse surface water quality of Buddha Naullah
- 2) To analyse heavy metal contamination of ground water
- 3) To analyse heavy metal contamination of soil.

1.5.1 Significance of the study:

There exists a direct relation of water quality and its impact on human health. Various physical, chemical and biological factors have been analyzed in this study to check the surface water quality and underground water quality. Through assessment of water quality we can suggest various remediation measures to reduce water pollution. This helps us to take necessary discussions

CHAPTER 2

LITERATURE REVIEW

This chapter deals with literature review of previous researches by various scholars.

Chattopadhyay *et al.*, 2005 Linkage between land use pattern and water quality is an emerging field of multidisciplinary research. Change in land use practices, particularly urbanization and intensive agriculture lead to water quality deterioration. The present study in Chalakudy river basin in Kerala based on an analysis of 27 water samples spread over five land use types and monitored during four seasons, substantiated this argument.

Samples under urban land use showed poor water quality throughout the year. Correlation analysis of various parameters indicated seasonality in physico-chemical characteristics of river water, which was linked to fluctuations of drainage discharge and changes in land use pattern

Mukherjee *at et.*, 2006 Industrial disposal of effluents on land and subsequent pollution of groundwater and soil of surrounding farmlands – is a relatively new area of research. Environmental and socio-economic aspects of industrial effluent irrigation have not been studied as extensively as domestic sewage based irrigation practices, at least for developing countries like India.

Disposal of treated and untreated industrial effluents on land has become a regular practice for some industries. Industries located in Mettupalayamtaluk, Tamilnadu dispose their effluents on land, and the farmers of the adjacent farmlands have complained that their shallow open wells get polluted and also the salt content of soil has started building up slowly.

This study attempts to capture the environmental and socioeconomic impacts of industrial effluent irrigation in different industrial locations at Mettupalayamtaluk through primary surveys and secondary information. This study found that continuous disposal of industrial effluents on land, which has limited capacity to assimilate the pollution load, has led to groundwater pollution.

Ground water quality of shallow open wells surrounding the industrial locations has deteriorated, and the application of polluted groundwater for irrigation has resulted in increased salt content of

soils. In some locations drinking water wells (deep bore wells) also have high concentration of salts. Since the farmers had already shifted their cropping pattern to salt tolerant crops (like jasmine, curry leaf, tobacco etc.) and substituted their irrigation source from shallow open wells to deep bore wells and/or river water, the impact of pollution on livelihood was minimized. It is observed that with the rise in concentration of electrical conductivity of groundwater samples, revenue from banana cultivation (in Rs. per acre) has gone down.

However blending open well water with the river water and/or water from deep bore wells has arrested the fall in revenue. For salt tolerant crop like jasmine, the rise in EC did not seem to have significant impact on productivity. Since the local administration is supplying drinking water to households the impact in the domestic sector has been minimized.

It has also been noticed that in some locations industries are supplying drinking water to the affected households. However, if the pollution continues unabated it could pose serious problems in the future.

Hossain (2006) observed that the 'As' concentrations of drinking water from deep wells in 64 districts in Bangladesh and found that 59 had concentrations $>10 \mu\text{g L}^{-1}$ and 43 had concentrations $>50 \mu\text{g L}^{-1}$. Contaminated groundwater is also used for irrigation of paddy rice, which is the main staple food for the population. This practice enhances the level of 'As' in the soils rendering them unsuitable for agriculture.

A few recent studies have reported that 85–95% of total 'As' in rice and a vegetable was inorganic. Arsenic concentration is higher in Bangladeshi soils, groundwater and plants (data based on 4% area of the country) than the permissible limits or normal range reported.

Sharma et al. (2007) did an assessment of the impact of wastewater irrigation on heavy metal contamination of Beta vulgaris (palak) which is highly nutritious leafy vegetable that is widely cultivated and consumed in urban India. The field study was conducted at three major sites that were irrigated by either treated or untreated wastewater in the suburban areas of Varanasi, India according to normal practice.

Samples of irrigation water, soil, and the edible portion of the palak were collected monthly during the summer and winter seasons and were analyzed for Cd, Cu, Zn, Pb, Cr, Mn, and Ni.

Heavy metals in irrigation water were below the internationally recommended (WHO) maximum permissible limits set for agricultural use for all heavy metals except Cd at all the sites.

Similarly, the mean heavy metal concentrations in soil were below the Indian standards for all heavy metals, but the maximum value of Cd recorded during January was higher than the standard. Also in the edible portion of *B. vulgaris*, the Cd concentration was higher than the permissible limits of the Indian standard during summer, whereas Pb and Ni concentrations were higher in both summer and winter seasons.

The study concluded that the use of treated and untreated wastewater for irrigation had increased the contamination of Cd, Pb, and Ni in edible portion of vegetables causing potential health risk in the long term.

Alamat *et al.*, 2007 Water samples have been collected from a part of Surma River along different points and analyzed for various water quality parameters during dry and monsoon periods. Effects of industrial wastes, municipal sewage, and agricultural runoff on river water quality have been investigated.

The study was conducted within the Chattak to Sunamganj portion of Surma River, which is significant due to the presence of two major industries-a paper mill and a cement factory. The other significant feature is the conveyors that travel from India to Chattak. This study involves determination of physical, biological and chemical parameters of surface water at different points.

The river was found to be highly turbid in the monsoon season. But BOD and fecal coliform concentration was found higher in the dry season. The water was found slightly acidic. The mean values of parameters were Conductivity 84-805 μ s; DO: dry- 5.52 mg/L, monsoon-5.72 mg/L; BOD: dry-1 mg/L, monsoon-0.878 mg/L; Total Solid: dry-149.4 mg/L, monsoon- 145.7 mg/L. A model study was also conducted and values of different model parameters were estimated.

Kumar *at et.*, 2008 the crucial role groundwater plays as a decentralized source of drinking water for millions rural and urban families cannot be overstated. According to some estimates, it accounts for nearly 80 per cent of the rural domestic water needs, and 50 per cent of the urban water needs in India.

Groundwater is generally less susceptible to contamination and pollution when compared to surface water bodies.

Also, the natural impurities in rainwater, which replenishes groundwater systems, get removed while infiltrating through soil strata. But, In India, where groundwater is used intensively for irrigation and industrial purposes, a variety of land and water-based human activities are causing pollution of this precious resource.

Its over-exploitation is causing aquifer contamination in certain instances; while in certain others its unscientific development with insufficient knowledge of groundwater flow dynamic and geo-hydro chemical processes has led to its mineralization.

Nangare et al. (2008) studied the impact of textile industry on ground water quality of the industrial estate area of Ichalkaranji. The results showed that the pH value ranged from 6.5 to 9.0, but within the permissible limit and only two samples showed the pH 9.0.

The value of turbidity was also within range of permissible limits for all samples except only one sample which showed the more turbidity because of this sample totally consisted of effluents or waste water coming from the industries, and collected from sewer nallahs.

Siddiqui and Sharma (2009) carried their work in the Okhla industrial area phase-II, New Delhi, India in the year 2007. The result showed that discharge of untreated effluents by the industries was leading to contamination of groundwater of the surrounding areas. Lead, mercury, fluoride, TDS, sulphate was above the desirable limit in effluent water (ISI standard for effluent water discharge).

Subsequent analysis of groundwater of nearby areas was rated as unacceptable for drinking because of presence of fluoride in all the samples above the desirable limit. Lead, mercury, cadmium, chloride was also detected in many samples

Gupta at el., 2009 Ground water samples were collected from different locations in the radius of 25 km. of Kaithal city, Haryana (India). These water samples from 20 sampling points of Kaithal were analyzed for their physicochemical characteristics. Laboratory tests were performed for the analysis of samples for pH, Color, Odor, Hardness, Chloride, Alkalinity, TDS etc.

On comparing the results against drinking water quality standards laid by Indian Council of Medical Research (ICMR) and World Health Organization (WHO), it is found that some of the water samples are non-potable for human being due to high concentration of one or the other parameter. The usefulness of these parameters in predicting ground water quality characteristics were discussed. Thus an attempt has been made to find the quality of ground water in and around Kaithal City town, suitable for drinking purposes or not.

Rajamanickamat *et al.*, 2010 Amaravathi river basin at the downstream of Karur Town is severely polluted due to discharge of partially treated effluent by the textile bleaching and dyeing units. There are 487 units and they treat the effluent either in individual effluent treatment plant (IETP) or common effluent treatment plant (CETP). Daily about 14600m³ of coloured effluent with 10,000 mg/l is let into river Amaravathi. A study has been conducted using Visual MODFLOW 2.8.1 version.

The study area is limited to 320 sq.km. This 320 sq.km is divided into 4572 cells with grid size of 350m x 200m with two layers. The groundwater monitoring data, lithology, hydro geological parameters, topography, rain fall data obtained from PWD, CGWB, Survey of India, India Metrological Department are used in the model. The MODFLOW and MT3D models are calibrated and validated.

The validated model is used for simulation of the ground water (i) if the present system with 10,000 mg/L TDS discharge into river continues, (ii) if the CETPs meet the TDS discharge standards of 2100 mg/L and discharge the effluent into river, (iii) if the quantum of discharge is doubled with TDS level of 2100 mg/L, (iv) if the dyeing units go for reverse osmosis plant and recycle the entire effluent and achieve zero discharge, (v) 1.5 time groundwater recharge and zero discharge by the units.

The simulation results show there is no improvement in groundwater quality even the effluent meet the discharge standards for the next ten years. When the units go for zero discharge then there will be an improvement in the quality of groundwater over a period of few years.

Ndibalat *et al.*, 2010 Beneficial reuse as an alternative to disposal is increasingly being considered in management of contaminated sediments dredged from harbors. The risk of metal leaching into groundwater in reuse of phosphate and thermal treated sediments was assessed with sequential

extraction, synthetic precipitation leaching procedure _SPLP_, and leaching as a function of pH and liquid to solid ratio _L/S_.

Sequential extraction revealed that phosphate addition at 5% by dry weight, followed by calcination at 700°C reduced metal association with exchangeable/carbonate and organic phases and increased that with sparingly soluble residuals. Over the pH range 4 to 9, metal leachability varied by two to four orders of magnitude while varying L/S over 5 to 100 showed little difference.

The SPLP revealed that risk to groundwater criteria based on applying a dilution attenuation factor _DAF_ of 13 _New Jersey_ to groundwater quality levels were achieved. Risk criteria based on a DAF of 1 _Florida and Wisconsin_ were exceeded for Pb, Cd, and Mn; thermodynamic analysis demonstrates that the criteria cannot be satisfied should dissolution control pore water concentrations.

Ministry of Water Resources (2010) studies about ground water quality in Bathinda, Mansa and Patiala districts of Punjab with prime objective to study the geo-genic contamination of ground water by the various major and minor elements including arsenic and fluoride by Central Ground Water Board, Ministry of Water Resources.

The ground water of the district is alkaline in nature with pH values ranging from 7.45 to 8.24 and a mean pH value of 7.90. Well waters in the area are generally medium to highly saline. However, pockets of fresh water are also found. EC of waters show wide variations, it ranges from 395 μ S/cm at DerraTappa to 4850 μ S/cm at 25°C at Dadde and average EC value is 2199 μ S/cm.

The ground water is moderately hard in nature with total hardness expressed as CaCO₃ ranging from 119 to 654mg/l with a mean value of 375mg/l. Among cations, the concentration of calcium ranges from 20mg/l at DialpurMirza, Lahri&Jhanduke to 117mg/l at Ablu whereas magnesium concentration ranges between 1.2mg/l at Ablu and 118mg/l at Ghuda. Calcium content is within the permissible limit of 200mg/l (BIS) and an average concentration of 61mg/l is observed in the area. Likewise, magnesium, in most of the waters, is below 100mg/l and an average concentration of 54mg/l of Mg is found.

Sodium concentration varies widely from 15 mg/l at DeraTappa to 878mg/l at Dadde with an average of 331mg/l, whereas potassium concentration ranges from 6.0mg/l at Jhanduke to 342mg/l at Kaila Bhandar with an average of 84mg/l. In majority of the samples, the potassium content is less than 100 mg/l.

CHAPTER 3

MATERIAL AND METHODOLOGY

3.1 Description of study area

3.1.1 Ludhiana City

Ludhiana city is located in Indian state of Punjab at 30.0 N 75.85°E at an average elevation of 244 m. It has a population of 3,487,882 roughly as per 2011 census making it 84th largest city in India. It has an area of 310 km² giving it a population density of 975 person per square km. The city stands at the west bank of Sutlej river and is a major industrial city of Northern India.

3.1.2 Ground Water Scenario

As per the Central Ground Water Authority of India, most of the blocks of Ludhiana district are under over-exploited category. Ludhiana city has a reputation of being the most polluted city of the state. It has 250 large scale industries and 45,000 small scale industries. Electroplating, cycle manufacturing, machine parts, chemical industries are the major industries located in the city. These units spread all over the city are basically concentrated in Industrial area A, Industrial area B, GT Road, etc,

3.1.3 Major water bodies around Ludhiana City

River Sutlej

Sutlej river originated in Tibet and after flowing through Himachal Pradesh enters the plains at Roopnagar and enters Ludhiana district at Samrala Tehsil. It flows west and is joined by the river Beas at Harike. Bhakra – Nangal dam is constructed across the Sutlej river and is a major source of electricity and irrigation water.

Buddha Nullah.

It is a tributary of the river Sutlej and flows parallel to the south in Ludhiana district. It ultimately joins the Sutlej at Gursikhar. Ludhiana city and Machhiwara city are situated across Buddha Nullah. With industrialization and dumping of industrial waste, Buddha Nullah has become a carrier of industrial effluent to the river Sutlej.



Figure 3.1: River bodies of Ludhiana city

The water of the stream becomes polluted after it enters Ludhiana City. With the industrialization/ urbanization of the area, Buddha Nullah has become the sullage/ sewage as well as industrial effluent carrier for the Ludhiana city leading to River Sutlej

TABLE 3.1: Number of existing industries in Ludhiana city

S.No	Type of industry	No. of industries
1	Dyeing	268
2	Hosiery/washing /printing	66
3	Electroplating	482
4	Galvanizing	9
5	Wire drawing/pickling	111
6	Engineering goods	12
7	Milk plant	3
10	Used oil refining units	6
11	Rubber industry/tyre/tube	22
12	Pesticide formulation industry	1
13	Brewery	1
14	miscellaneous	73
	TOTAL	1060

SOURCE: http://www.ppcb.gov.in/river_satluj.php

3.2 Location of sample source

Surface water samples are collected from Buddha Nullah for its analysis. Underground water samples, are taken from various sources like tube well, hand pump etc.

Total of 12 samples were taken out of which 5 re surface water sample, and rest are ground water sample. These are taken at various distances from Buddha Nullah to find the effect of surface water pollution on ground water and its relation with distance.

TABLE 3.2: Site details of water quality sampling stations

Sample no.	SOURCE	LOCATION	Distance from Budha nullah (m) approx.	SAMPLE TYPE
1.	BUDHA NULLAH	NEW VIJAY NAGAR	-	SURFACE WATER
2.	BUDHA NULLAH	GAUSHALA ROAD	-	SURFACE WATER
3.	BUDHA NULLAH	KIRPAL NAGAR	-	SURFACE WATER
4.	BUDHA NULLAH	HERO CYCLE(ADJ.PETROL PUMP)	-	SURFACE WATER
5.	BUDHA NULLAH	DASHMESH NAGAR	-	SURFACE WATER
6.	HANDPUMP	NEAR TAJPUR ROAD	10-20	GROUND WATER
7.	TUBEWELL	RESIDENTIAL AREA NEAR TAJPUR ROAD	20-30	GROUND WATER
8.	HANDPUMP	GURU ARJANDEV NAGAR	100-110	GROUND WATER
9.	TUBEWELL	HARBANSPURA GAUSHALA ROAD	180-200	GROUND WATER
10.	TUBEWELL	GURU NANAKDEV NAGAR	100-120	GROUND WATER
11.	HANDPUMP	NEAR SHIVPURI	250-300	GROUND WATER
12.	TUBEWELL	CLOCK TOWER ROAD	600-700	GROUND WATER

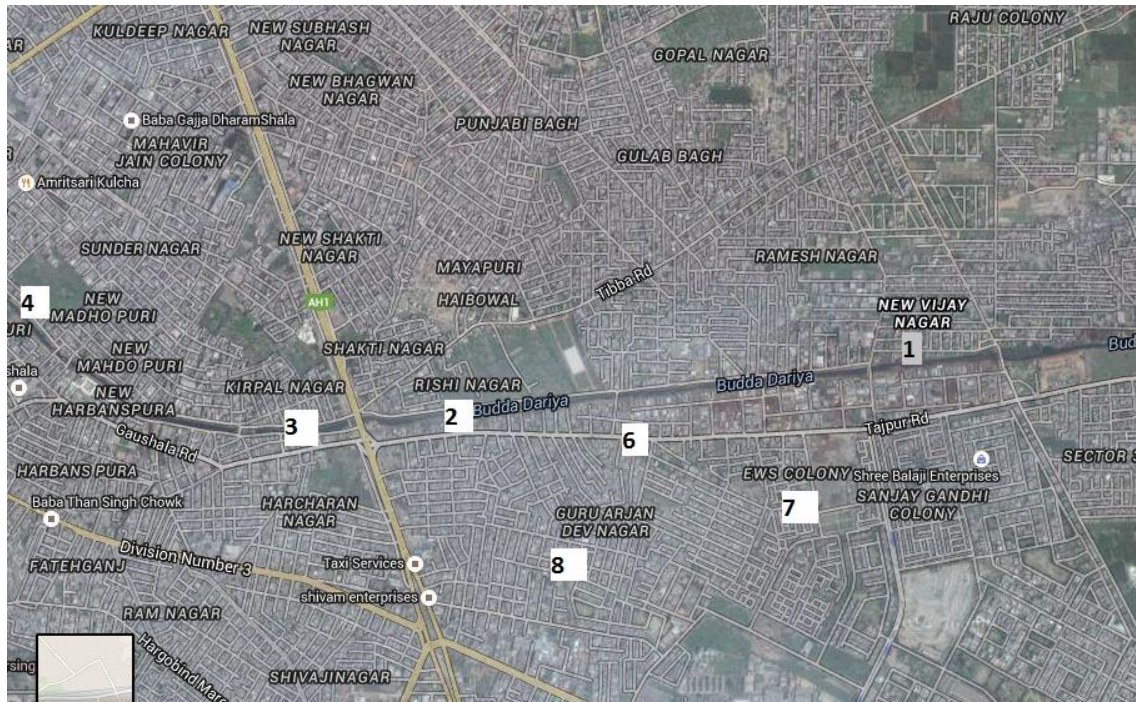


Figure 3.2: Site Locations on Map



Figure 3.3: Site Locations of sample source on Map

3.3 Pollution Parameters Analyzed

Water may be contaminated by various physical, biological and chemical contaminants. These are broadly classified into 3 categories.

1) Physical and chemical parameter

This include pH, Total hardness as CaCO_3 , chloride, total dissolved solids TDS, Alkanity and COD

2) Biological parameter

This include Biochemical Oxygen demand (BOD)

3) Heavy metal testing

The heavy metals analyzed are zinc, arsenic, Iron lead, Potassium, Sodium, Chromium and nickel

3.4 METHODOLOGY

1) pH

pH is the negative logarithm of the concentration of hydronium ion

$$\text{pH} = -\log_{10} [\text{H}^+]$$

pH scale vary from 0 to 14. pH7 represent neutrality and pH greater than 7 means that water is basic. Acidic conditions make it difficult for organisms to survive; Acidic condition also favors dissolutions of metals and heavy metals, further increasing the tonicity of water

Major reason for increasing acidity is human activity like discharge of industrial effluent to river directly. Apart from this increasing level of CO_2 in air and acid rain also increases the acidity of water.

Electrometric method was adopted for the determination.

TABLE 3.3: Analytical methods and equipment used in the study

S. No	Parameter	Method	Instrument/Equipment
1	pH	Electrometric	pH meter
2	Total hardness as CaCO ₃	EDTA titrimetry method	Titrimetry
3	Chlorides	Argentometric method	Titrimetry
4	Total Dissolved Solids	Gravimetry method	Oven
5	Alkalinity	Potentiometric titration	Titrimetry
6	Chemical Oxygen Demand	Digestion followed by titration	COD digester
7	Biochemical Oxygen Demand	5 days incubation followed by titration	BOD incubator
8	Arsenic	Inductively Coupled Plasma	ICAP-AES
9	Cadmium	Inductively Coupled Plasma	ICAP-AES
10	Chromium	Inductively Coupled Plasma method	ICAP-AES
11	Copper	Inductively Coupled Plasma method	ICAP-AES
12	Iron	Inductively Coupled Plasma method	ICAP-AES
13	Nickel	Inductively Coupled Plasma method	ICAP-AES
14	Zinc	Inductively Coupled Plasma method	ICAP-AES

Standardize the pH meter by immersing the electrode in a buffer solution of known pH, normally 4 and 9. Read the pH and calibrate, till it indicates the correct value for pH of buffer solution. Rinse the electrode in distilled water and immerse them in sample. Read the pH value.\

2) Total dissolved solids

It represents the solids including organic and inorganic dissolved in the water. Definition includes that solid which can pass filter up to 2 micrometer pore size.

General limit of amount of TDS in drinking water is that it should not exceed 500 mg/l. But higher concentration may be allowed as it has better physiological effects. But too much high level of TDS may be injurious to health and can hamper tastes too.

Method

Place the sample after measuring the weight in a curable. Heat it at temperature of 103⁰c and weigh the remaining weight. Deduct the weight of crucible from it.

Total solid mg/L= $A-B$ *1000/ml of sampl

A=weight of china dish dried residues

B=weight of empty dishes

3) Alkalinity

Alkalinity of water is the capacity of water to neutralize an acid of known pH. Alkalinity is usually due to presence of carbonate, bi-carbonate and hydroxide of calcium, magnesium and sodium. Silicate, Borate and potassium also contribute to alkalinity.

Method Take 100ml of sample in conical flask and add few drops of phenolphalein indicator. As sample, turns pink, titrate the sample with N/50 $\frac{1}{2}$ 50u acid solution. Titrate till pink color disappears. Now add 1 ml of methyl orange and again titrate with N/50 H₂ SO₄ until yellow colour changes to red orange.

Phenolphthalein alkalinity = $p \times 100 / 1 \text{ ml sample}$

Total Alkalinity = $T \times 1000 / \text{ml sample (CoCo}_3)$

4) Chloride

Chloride is found naturally in water upto varying concentration. In small concentration, they may not cause problem but after they cross a particular these hold value, they may cause problem.

Method:

Take 100 ml of sample in conical flask. Add 1ml of Potassium chromate indicator. Titrate with standard $N/35.5 \text{ AgNO}_3$ solution till the color changes from yellow to brick red. Note the amount of titrant used

5) Biochemical oxygen demand (BOD)

This is defined as amount of oxygen required by microbes to decompose bio-degradable substances. A high level of BOD suggests that the waste water high level of organic pollution. The rate of BOD depends upon temperature, sewage characteristics and bacterial pollution. Organic waste may consist of fat, hydrates, oils and protein. Drinking water should have zero BOD value as it should be free from organic pollution.

BOD is similar to COD to some extent but COD consist of both biodegradable and non-biodegradable matter. Thus COD value is always greater than BOD value.

Method

To 1 liter of distilled water add 1 ml of phosphate buffer, magnesium sulphate solution and ferric chloride solution. To this add 2ml of sewage sample. Determine the exact volume of 3 sample bottles. Now, take a undiluted sample and dissolved oxygen D_o of this sample.

Prepare the amount of percent mixture required by you by adding samples in the dilution water. Fill up one bottle with the mixture prepared by you and the other one with dilution water blank. Incubate at a fix temperature for 5 days at 20°C . Find out DO in both bottles after incubation and designate mixture as DO_i , blank as DO_b .

$$\text{BOD (mg/L)} = [(\text{DO}_b - \text{DO}_i) \text{D.F}]$$

Where,

DO_b = dissolved oxygen of blank solution (dilution water)

DO_i = dissolved oxygen of incubated diluted sample

$\text{D.F} = (\text{Total vol. of sample} + \text{Blank}) / \text{ml of Sample} = \text{dilution factor}$

6) Chemical oxygen demand (COD)

Both BOD and COD are the measure of pollution level of water. BOD measures only biodegradable matter but COD measures both biodegradable and non-biodegradable matter in sewage. BOD is usually measured for period of 5 days. As BOD varies exponentially so it is vary time consuming so we take BOD up to 5 days level only.

Method

Take 50 ml of sample and add 1gm of Hg So_4 , and 5 ml of H_2SO_4 . To this add 25 ml of N/4 $\text{K}_2\text{Cr}_2\text{O}_7$ solution and min again. Dilute the mixture of 300 ml and titrate excess of dichromate with standard ferrous ammonium sulphate using ferroin indicator. The colour changes from yellow to green blue. Record the amount of ml of titrates used.

$$\text{COD} = \frac{(\text{A}-\text{B})\text{C} * 8 * 1000}{\text{ml Sample}}$$

where A = ml of Ferrous ammonium sulphate used for blank.

B = ml of Ferrous ammonium sulphate used for sample.

C = normality of ferrous ammonium sulphate solution.

3.5 Heavy metal

Inducting coupled plasma methods

Principle and method:

An ICP source consists of flowing stream of Argon gas ionized by an applied radio frequency field typically oscillating at 27.1MHz. this field is inductively coupled to the ionized gas by a water cooled coil surrounding a quartz torch that supports and confines the plasma. A sample aerosol is generated in an appropriate nebulizer and spray chamber and is carried into the plasma through an injector tube located within the torch.

The sample aerosol is injected directly into the ICP, subjecting the constituent's atoms to temperature of about 6000 to 8000 °K. Because this results in almost complete dissociation of molecules, significant reduction in chemical interference is achieved. This high temperature of the plasma excites atomic emission efficiently. Ionization of high percentage of atoms produce ionic emission spectra. The ICP provide an optically thin source that is not subject to self absorption except at a very high concentration.

The efficient excitation provided by the ICP results in low detection limits for many elements. This coupled with the extended dynamic range, permits effective multielement determination of metals. The light emitted from the ICP is focused onto the entrance slit of either monochromator or a polychromator that effects dispersion.

A precisely aligned exit slit is used to isolate a portion of the emission spectrum for intensity measurement using photomultiplier tube. The monochromator uses a single exit slit/ photomultiplier and may use a computer controlled scanning mechanism to examine emission wavelength sequentially. The polychromator uses multiple fixed exit slits and corresponding photomultiplier tubes, it simultaneously monitors all configured wavelengths using a computer controlled readout system.

Arsenic

Arsenic is found in deep geological rocks and finds it way through dissolution of underground rocks with ground water. Also due to human activities like mining, smelting, coal combustion at find its way in water supply.

Arsenic contamination is a world wide problem. It is very much prevalent in Ganga delta region of Bihar and West Bengal. Arsenic poisoning can lead to serious health problem like cancer, pigmentation of skin, ulcers, lung diseases, hypertension and heart diseases.

Cadmium

The average concentration of cadmium in earth's crust is .16 ppm and it is found in ground water in concentration of 1-10ug/l. Major source of contamination is industrial pollution from industrial, like chemical industry, smelting industry, and electroplating industry.

The liquid waste discharged may percolate down to underground water and also increases the soils cadmium content.

Cadmium pollution is responsible for Itai-Itai disease. This was first found in Toyama city of Japan. The term 'Itai-Itai' refers to pain in joint felt by victims. It may also cause swelling of bone marrow and can cause kidney failure too. Itai-Itai is one of the major pollution diseases of Japan.

Chromium

Chromium is found in earth's crust at concentration of 122 ppm and in ground water at concentration of 100 ug/l. It is used in electroplating industry, Iron and steel industry and in making alloys.

Hexavalent compound is carcinogenic by its nature and is toxic to tissue. But at very low concentration it is an essential trace element for humans.

Iron

Iron is the most abundant metal found on earth and it is found in earth's crust at an average abundance of 6.2%. It is found in groundwater at an average concentration of 1-10 ug/l.

Iron is essential for human metabolism and growth. It is essential for the formation of red blood cells and the transport of oxygen throughout the body. It is one of the less toxic pollutants and its deficiency may cause anemia in humans. But very high concentration is a health issue and is reportedly found in high concentration throughout the country.

LEAD:

The average abundance of Pb in the earth's crust is 13 ppm; in soil it is 2.6 to 25 ppm; in streams it is 3 µg/L and in groundwater it is generally < 0.1 mg/L. Lead is obtained chiefly from galena

(PbS). The discharge of effluents to natural water and on the land Leads to localized in the groundwater near to the points of discharge, owing to low solubility of compound that are formed on contact with soil and water.

Lead is having high affinity for adsorption and it rapidly adsorbs on soil and bottom sediments due to high capacity of organic matter to bind Lead firmly. Lead is highly bioaccumulative metal and its presence in water due to natural reasons is small. However, the water contaminated due to industrial discharge, mining, smelting refining and Lead emissions from manufacturing of Lead and automobile exhaust contribute Lead to the environment.

Later the adsorbed Lead may be leached to underline groundwater aquifers. Salts of Lead are used as anti-knocking compounds in fuel for gasoline engines. Lead is also released to the atmosphere by smelting operations which on adsorbing by the soil may further leaches to the groundwater system. Some other sources of Lead are from the impurities in fertilizers, insecticides, effluent of industries such as paints, storage batteries and printing etc.

The Lead is a systematic toxicant, bioaccumulate in body tissue and interferes with haemic synthesis Leading to hematological damage. At higher level of Lead exposure, symptoms of anemia may appear due to deficiency of hemoglobin and may cause kidney dysfunction and finally brain damage. Lead is cumulative poison and accumulates in the skeletal structure of human being causing adverse affects on the central nervous system, blood cells, and kidneys and may even cause brain damage.

Nickel

Its main anthropogenic sources in the environment are electroplating, Ni-Cd batteries, steel production and in alloys manufacture etc. high Nickel alloys are used in chemical, marine, electrical, nuclear, aerospace application. Nickel is also used as catalyst in oil refining and other industrial process. Nickel is more abundant in the environment than other common metals such as Copper, tin or Lead and it enters the environment through natural process like withering of minerals and rocks, geothermal emission.

The various man made activities release significant amount of Nickel to the environment. Among these most common are discharge of industrial effluent containing Nickel, storm water

runoff, sewage and sludge generation, transportation and deposition of dust, fly ash from coal burning, power plant, automobiles, smelter process etc. Nickel concentration may be increased in soil strata with application of sewage sludge.

It is established that Nickel in general is relatively non toxic, through oral route, due to its limited intestinal absorption, but the excessive exposure with Nickel salt like Nickel sulphides and Nickel oxide can cause lung cancer and cancer of nasal sinus.

Zinc

This metal is found in abundance concentration in earth's crust especially in form of natural sediment, soils etc. In ground water, it is found mainly from natural sources as well as due to surface discharge from industries like metal and chemical industry. Another source of zinc contamination is industrial and domestic sewage .

Upto certain concentration, zinc is essential for human body. Zinc is one of micronutrient and is essential for enzyme formation and metabolic process. Above 5 mg/l concentration. it may cause bitter taste. Through dissolution of galvanized pipes, zincs may enter the household water supply.

3.6 SOIL QUALITY ANALYSES

3.6.1. Location of Sample

To analyze soil, samples were taken from area in vicinity to Buddha Nullah. Some samples were taken at distance greater than 500 m and some were taken near to Buddha Nullah.

TABLE 3.4: Site details of soil sampling stations

Sample no.	Location	Distance from Budha Nullah (m) approx.
1.	RESIDENTIAL AREA NEAR TAJPUR ROAD	500-550
2.	NEW VIJAY NAGAR	5-10
3.	GAUSHALA ROAD	40-50
4.	HARBANSPURA GAUSHALA ROAD	100-150
5.	NEAR SHIVPURI	600-650

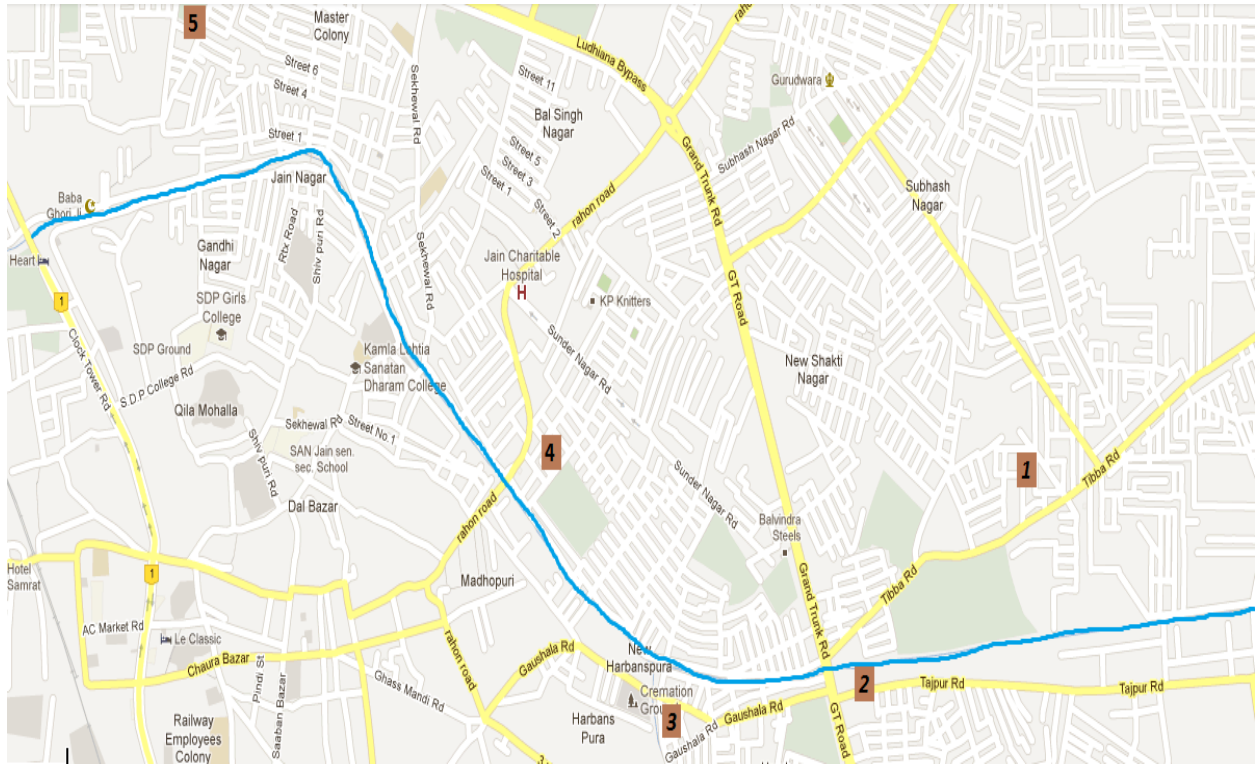


Figure 3.4: Site location on map

3.6 POLLUTION PARAMETERS ANALYZED

The heavy metals analyzed are zinc, arsenic, Iron lead, Potassium, Sodium, Chromium and nickel

Initially soil was digested for extracting the solution by:

Add 1.87 g of DTPA (Diethylene Triamine Penta Acetic acid) to 800 ml of distilled-de ionized water taken in 1 litre beaker. Add approximately 2 ml of 1:1 NH_4OH to facilitate dissolution and to prevent effervescence. Shake until most of the DPTA is dissolved. Then add 79.06 g of NH_4HCO_3 and stir gently until dissolved. Adjust the pH with $\text{NH}_4\text{OH}/\text{HCl}$ to 7.6. Dilute the solution to 1 liter with distilled and de ionized water. This solution is unstable with regard to pH. It is preferable to use a fresh solution each day.

Procedure:- Weigh 10 g of soil into 125ml conical flask. Add 20 ml of AB-DTPA solution. Shake on a reciprocal shaker for 15 min with flask kept open. Filter the extracts through Whatman no.42 filter paper or its equivalent. Add conc HNO_3 @ 0.25ml per 2ml of the filtrate and shake for about 10 min to get rid of carbonate-bicarbonate matrix to prevent clogging of the

capillary tip in the nebulizer. This solution is ready for simultaneous multielement determination on ICAP

3.6.1 Sodium Absorption ratio (SAR)

Excess salts, particularly high level of sodium is detrimental to plants. Soil with high level of salt is characterized by poor growth of plant and low permeability. Salinity and alkalinity is a major reason for decreasing of soils fertility. Sodium Absorption ratio (SAR) is an important quantifiable characteristics of soil affected soil. It indicates relative concentration of Na^+ , Ca^{2+} , Mg^{2+} in soil solution. The equation used to find SAR is :

$$\text{SAR} = \frac{[\text{Na}^+]}{\sqrt{\frac{1}{2}[\text{Ca}^{2+}] + \frac{1}{2}[\text{Mg}^{2+}]}}$$

Where $[\text{Na}^+]$, $[\text{Mg}^{2+}]$, $[\text{Ca}^{2+}]$ are the concentration of sodium, magnesium and calcium ions in soil solution. This is determined by first dissolving soil in a solution and then find concentration of various ions in the solution.

Through the equation, it can be seen that adverse effect of $[\text{Na}^+]$ is neutralized or compensated by $[\text{Ca}^{2+}]$ and $[\text{Mg}^{2+}]$ ions. High value of SAR upto 12 to 15 indicate low level of soil fertility and low permeability. Growth of plants would be less and plants would have difficulty absorbing water. SAR value should be less than 10.

CHAPTER 4 RESULT AND DISCUSSION

4.1 Variation of parameters along various locations.

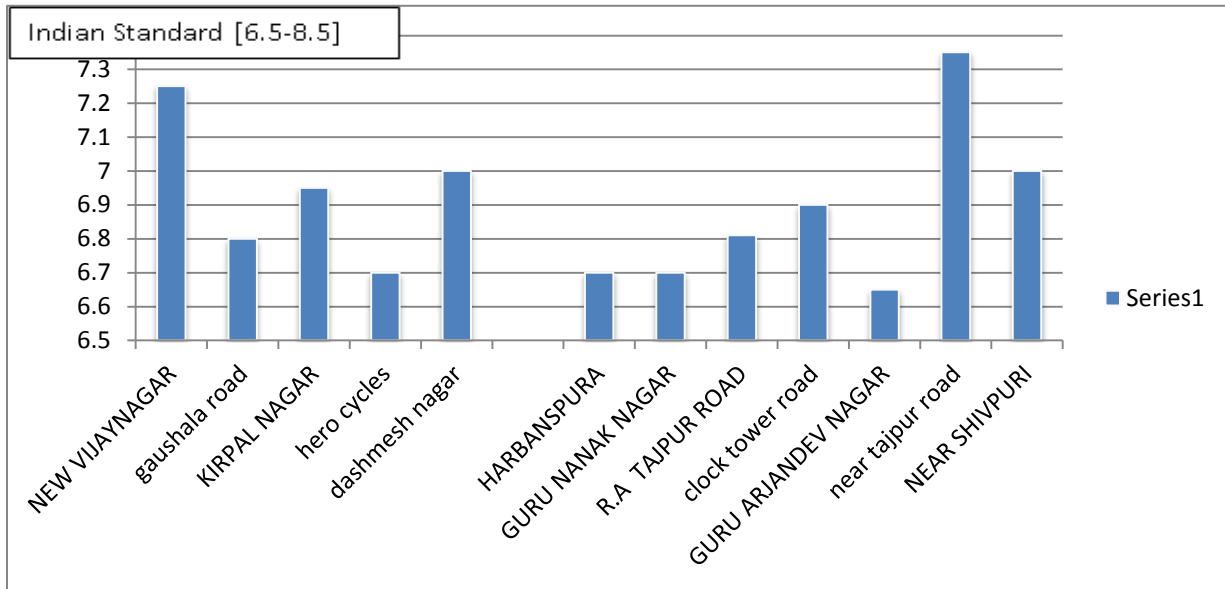


Figure 4.1 Variation of ph along various locations

pH is the negative logarithm of the concentration of hydronium ion. Solutions having pH greater than 7 are considered alkaline solutions while less than 7 are considered to be acidic.

The pH values of the water from hand pump are 6.65, 7, 7.35 and that of tube well are 6.7, 6.7, 6.81, 6.9 which are within the permissible limit of 6.5-8.5 according to WHO and BIS and can be used for drinking.

The values of pH of samples from Buddha Nullah are. 7.25, 6.8, 6.95, 6.7, 7 pH range for water for irrigation should lie between 5.5 to 8.5 and all samples lie in between this range.

The test results show that the pH values comply with the WHO and BIS standards, the standard value of pH for potable water is within the range of 6.5 – 8.5.

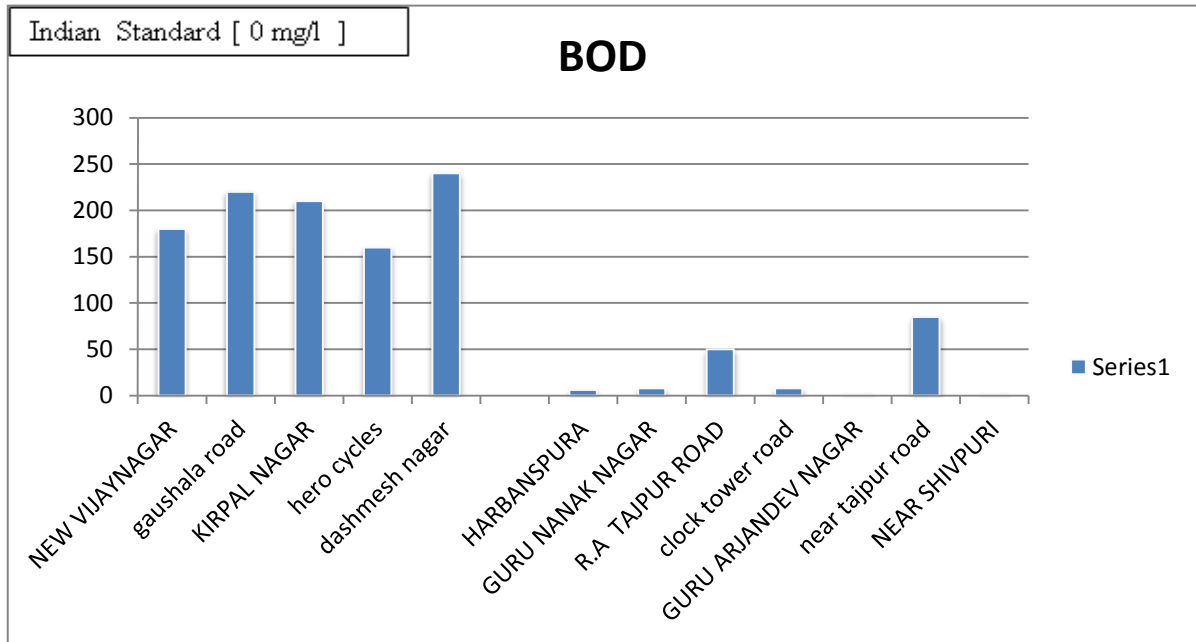


Figure 4.2 Variation of BOD along various locations

In case of drinking water BOD is desired to be absent in the water but a tolerance of 2 mg/l is there.

The BOD for most of the samples of groundwater is in the range of 2-8 mg/l but two sample of tube well which is only 5-10m away from Buddha Nullah has BOD as high as 85 mg/l and 50 mg/l which is possible due to seepage of surface water from Buddha Nullah to underground water. The general trend seen in groundwater samples is that BOD of samples which are near the Buddha Nullah have higher BOD values than the points which are away from Budha Nullah which can be due to seepage of stream water into nearby groundwater.

The BOD of the samples of Buddha Nullah is in range of 160-240 mg/l

Most of the ground water samples have high BOD than permissible limit so it is unfit for drinking. According to IS 10500, General Standards for Discharge of Environmental Pollutants, limit of BOD (3 days at 27°C), mg/l, max for inland surface water, public sewer and land of irrigation is 30 mg/l, 350 mg/l and 100 mg/l respv. So most of the samples of Budha nullah are not even fit for irrigation.

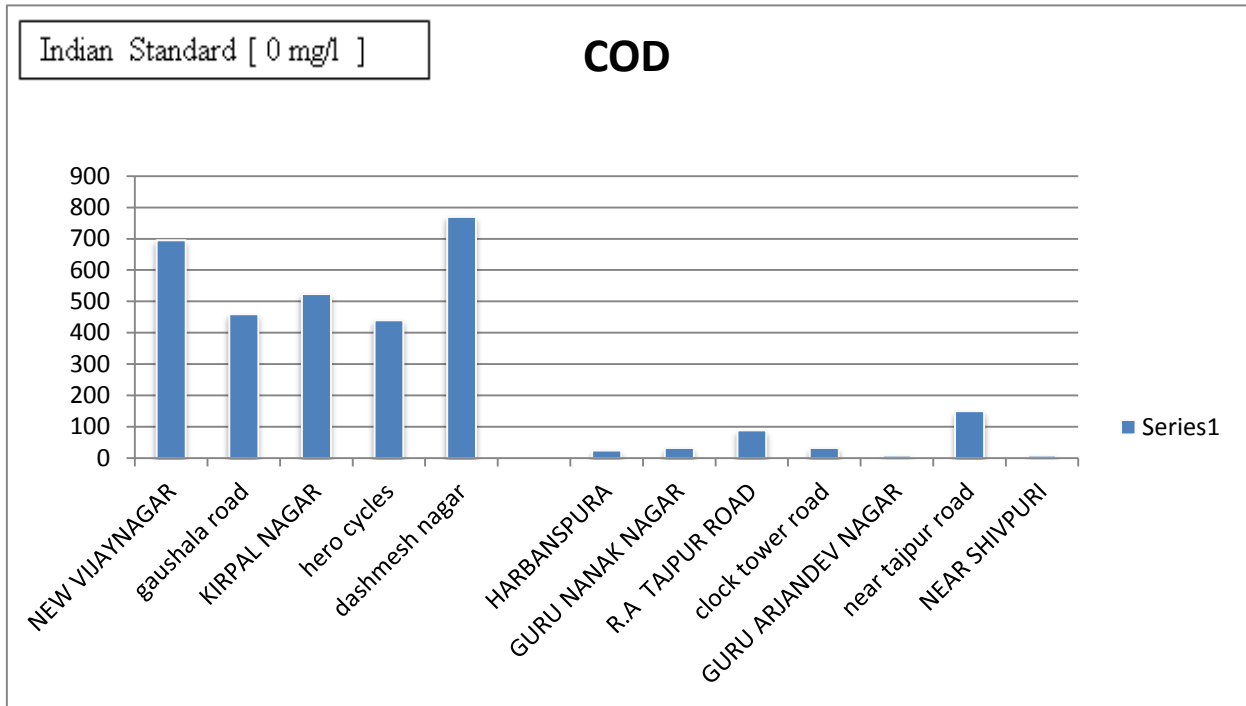


Figure 4.3 Variation of COD along various locations

The COD of the ground water samples ranges from 8 mg/l to 32 mg/l whereas one sample of groundwater which is at 5-10 m distance from Budha Nullah has COD of 150 mg/l, which is considered very high for ground water sample. This can be due to the mixing of Budha Nullah water with ground water due to its proximity of tubewell to the Nullah. COD of the sample taken at clock tower road which is at 800 m distance from Budha Nullah is 20 mg/l which is close to the values found in other ground water samples.

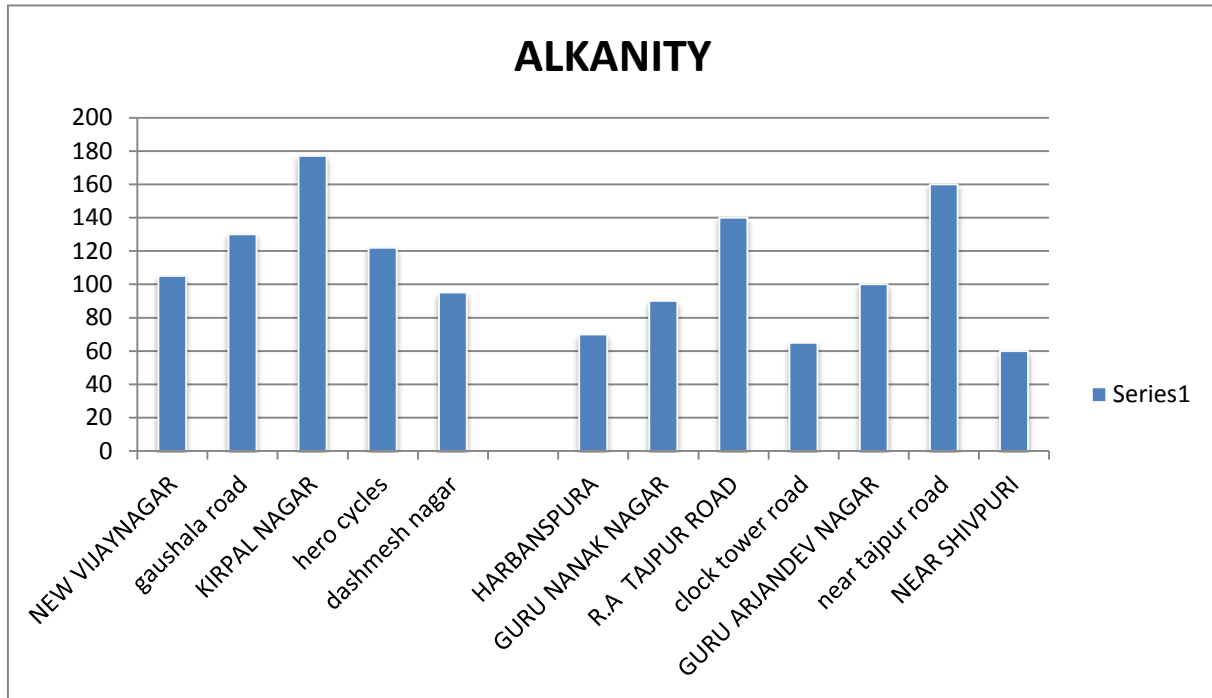


Figure 4.4 Variation of alkalinity along various locations

Alkalinity of water is the capacity of water to neutralize an acid of known pH. Alkalinity is usually due to presence of carbonate, bi-carbonate and hydroxide of calcium, magnesium and sodium. Silicate, Borate and potassium also contribute to Alkalinity.

As per the WHO and BIS standard, the limit of alkalinity in drinking water is 200 mg/l while the maximum limit is up to 600 mg/l.

The alkalinity found in the groundwater samples is in the range 65-160 mg/l. Therefore all the values are within the permissible limit and the water is fit for human consumption. High alkalinity of water causes the corrosion in distribution networks.

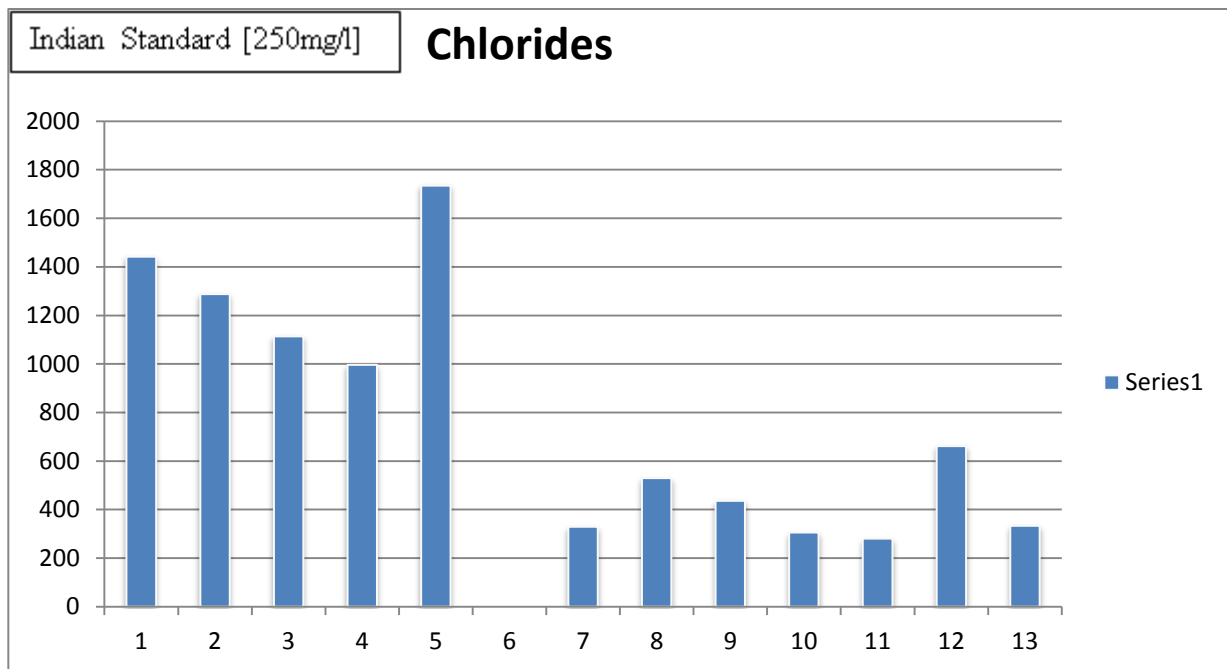


Figure 4.5 Variation of **Chlorides** along various locations

As per the WHO and BIS standard prescribed for the Chlorides is 250 mg/l and extendable up to 1000mg/l in drinking water. The maximum value of chloride in groundwater is found is 700 mg/l which is more than limit of 250 mg/l and it is found to be 280mg/l in tubewell water at clock tower road.

Concentration of chloride in samples of budha nullah is found in range of 1000-1700 mg/l .

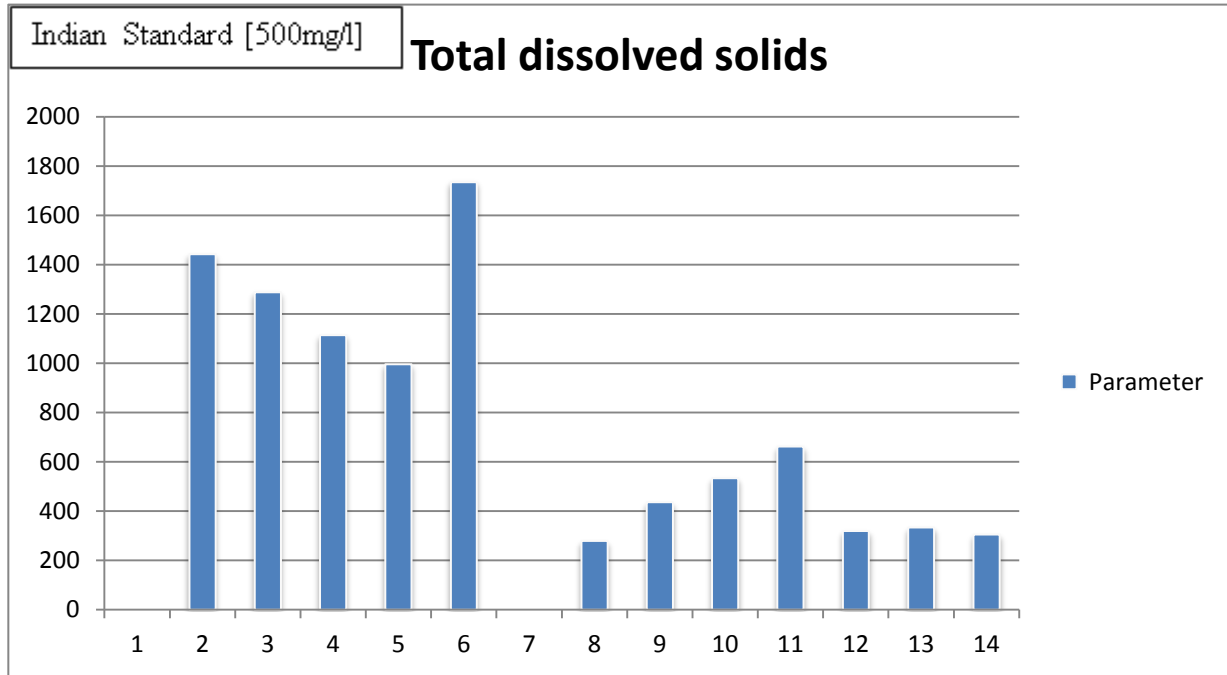


Figure 4.6 Variation of Total dissolved solids along various locations

As per WHO and BIS prescribed permissible limit for the TDS is 500mg/l and extendable up to 2000mg/l for drinking water. All the groundwater samples have TDS within limits except hand pump sample which has TDS of 662 mg/L AND 530 mg/l but in absence of any other alternative this water can also be used for drinking as limits are extendable upto 2000 mg/l if no alternate is present.

TDS values of Budha Nullah samples lie in range of 996-1735 mg/l. Excess of TDS can lead to organoleptic implications.

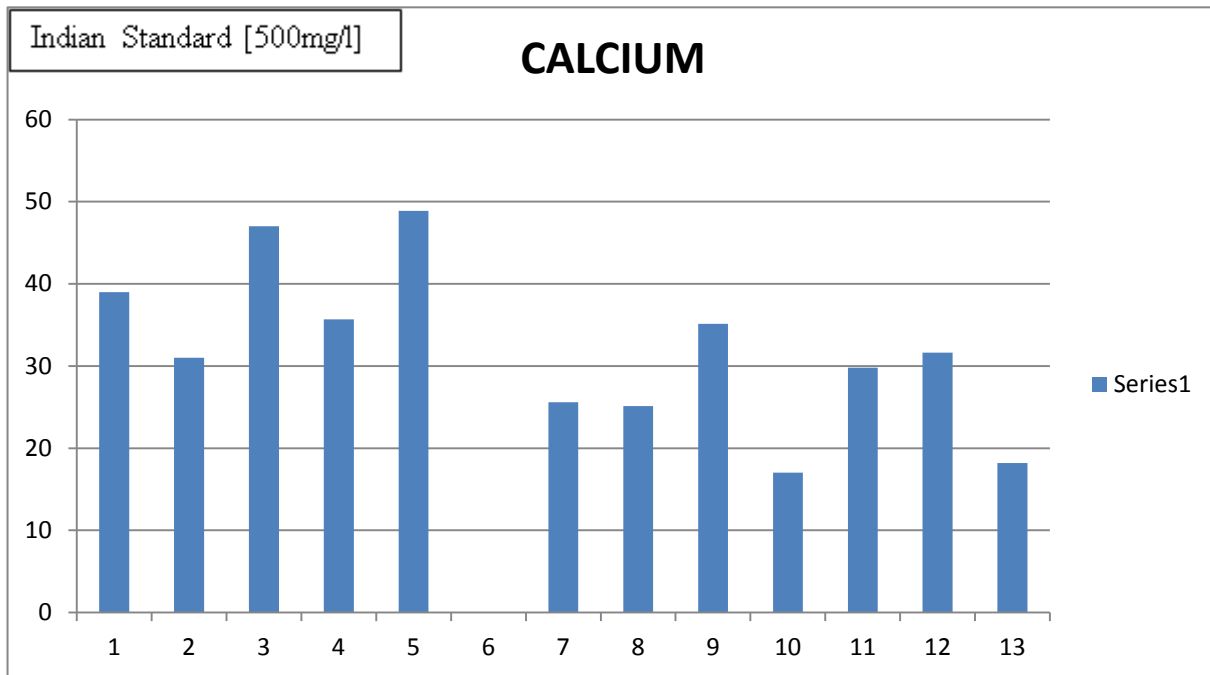


Figure 4.7 Variation of **CALCIUM** along various locations

In case of drinking water, value of Calcium is desired to be 75 mg/l and can be exceeded to 200 mg/l. Value of calcium in all the groundwater samples is within the desirable limit.

Value of calcium in case of Budha Nullah ranges from 31-47mg/l which is under desirable limit. In case of Budha nullah all values are less 75 mg/l.

Value of calcium in soil samples is found to be in range of 385.4-522 mg/kg. This value is considered normal for soils. Calcium is essential for many plant functions.

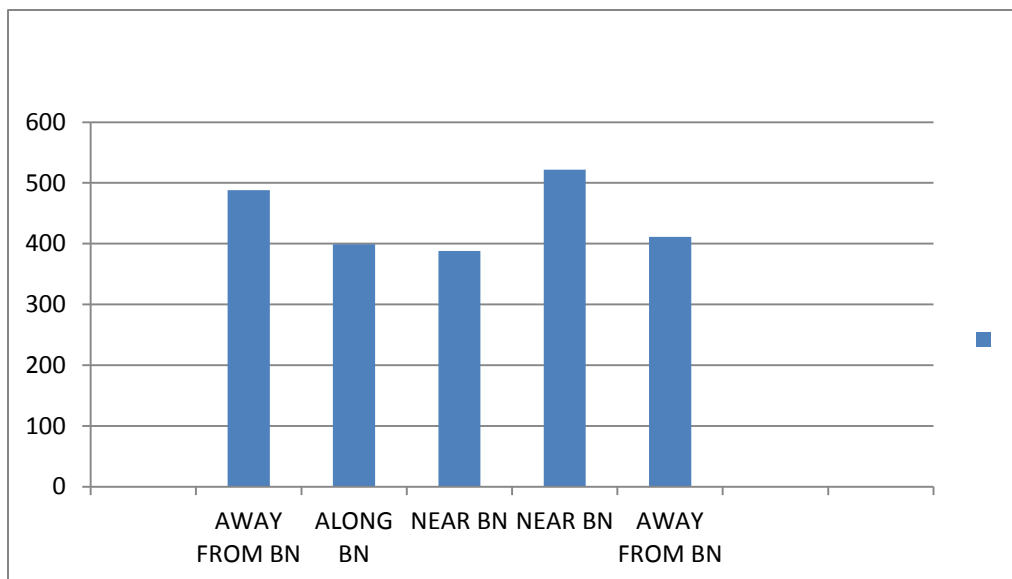


Figure 4.8 Variation of **CALCIUM** in soil sample along various locations

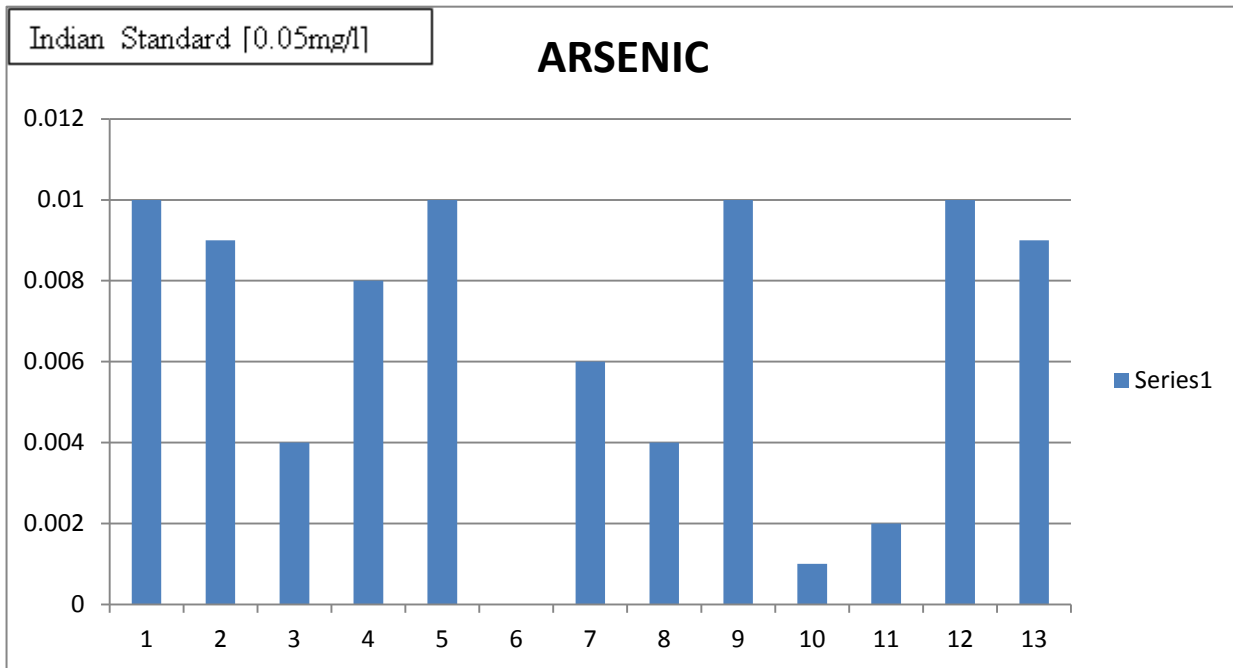


Figure 4.9 Variation of **ARSENIC** along various locations

The desirable limit for arsenic in water is 0.05 mg/l and there is no relaxation for this. Beyond this limit, water becomes poisonous. Value of arsenic in samples is in range of .0081 mg/l -.01 mg/l. So all the values are within permissible limit.

The value of arsenic in soil ranges from 0.0019 mg/l to 0.02 mg/l. Value of arsenic does not changes and shows no direct co relation with the distance from the Budha Nullah. The arsenic found in water could have been due to leaching from the soil.

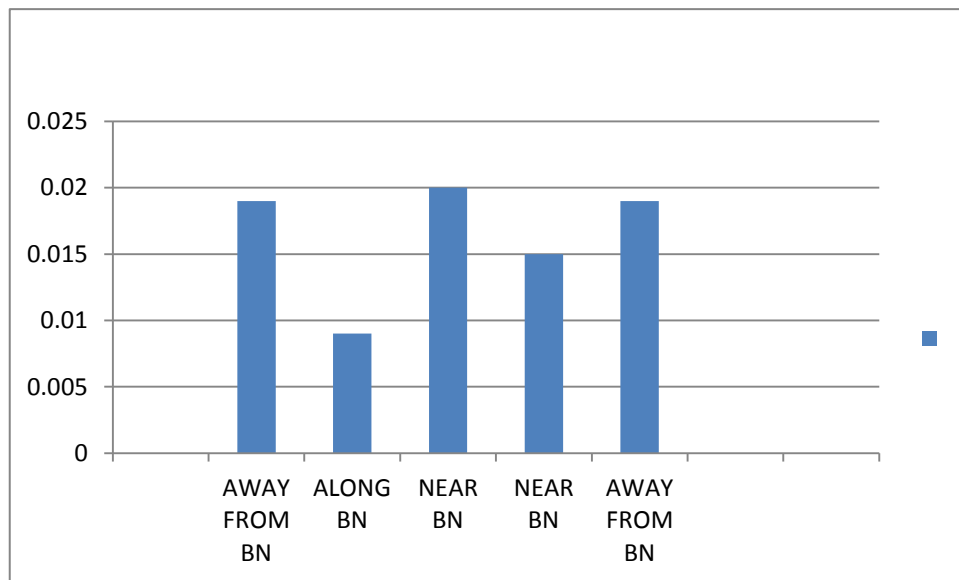


Figure 4.10 Variation of **ARSENIC** in soil sample along various locations

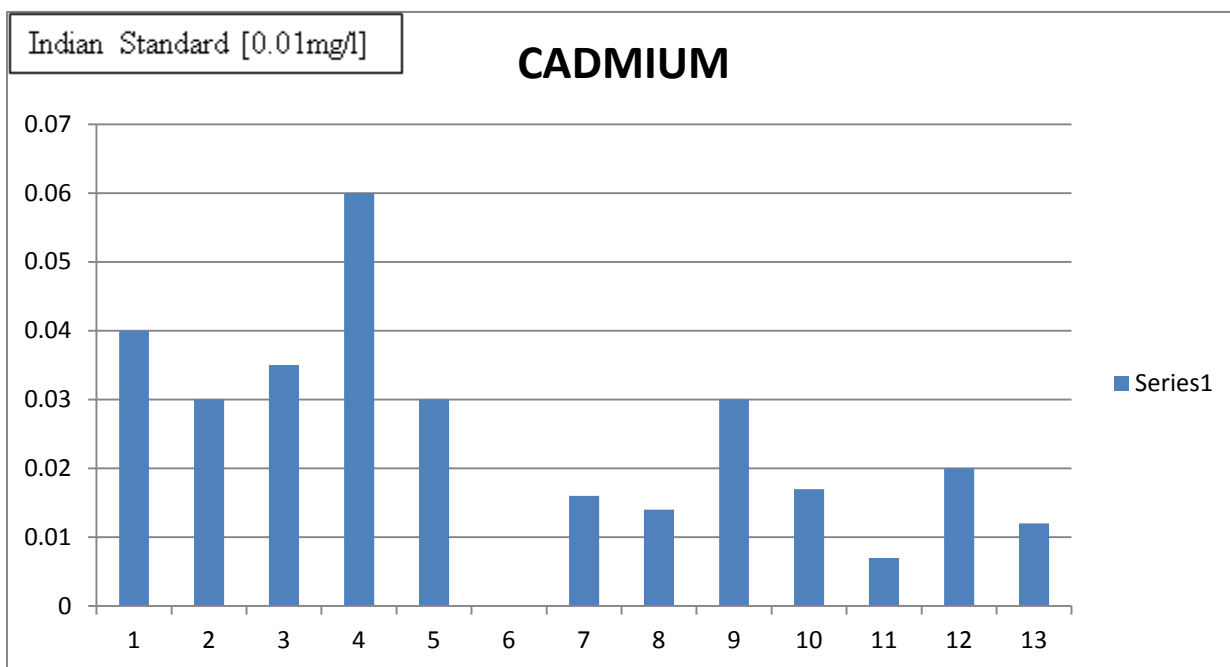


Figure 4.10 Variation of **CADMIUM** along various locations

BIS standards for Cadmium is 0.01 mg/l. Cadmium found in all the samples of ground water as well as Budha Nullah is within permissible limit . So groundwater samples are safe for drinking in case of cadmium.

Cadmium in small quantities cause adverse changes in the arteries of human kidneys, it is therefore a priority pollutant, has been reported to be carcinogenic and may produce cancer to various parts of the body

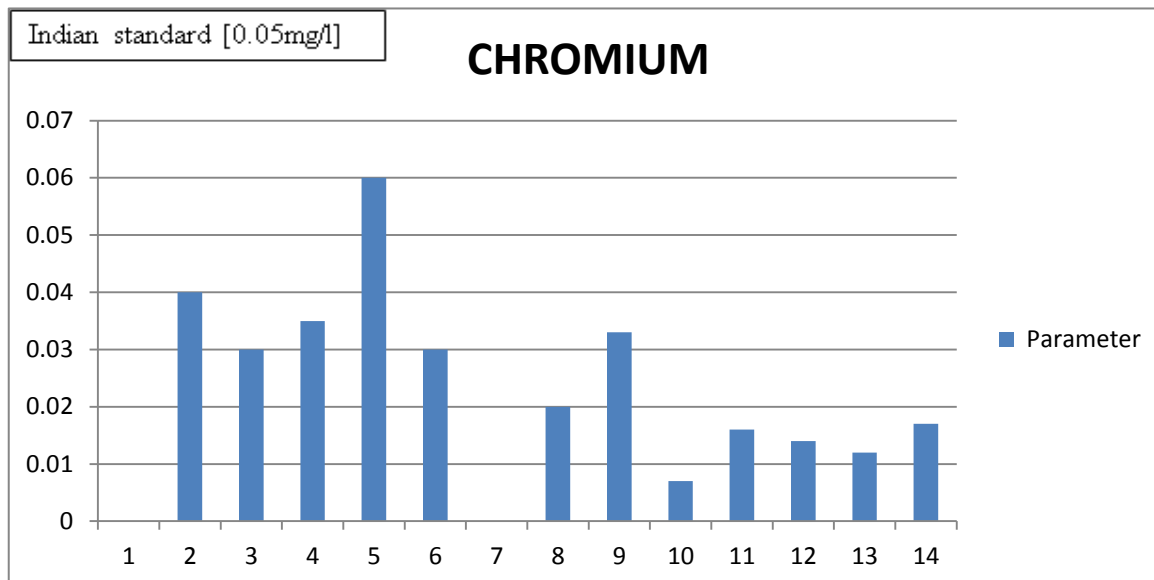


Figure 4.11 Variation of **CHROMIUM** along various locations

As per WHO and BIS standard prescribed for the Chromium is 0.05 mg/l. The concentrations of chromium in all ground water samples surface were considerably lower than the maximum desirable limit.

Concentration of chromium in samples of Budha nullah is also within permissible limit. Concentration of chromium found in the samples shown below is maximum (0.02mg/kg) in soil near the Budha nullah whereas it is least as we tend to increase distance from the Budha Nullah. Value of 0.009mg/kg is least in the soil sample which was taken at 600-700m away from budha Nullah..

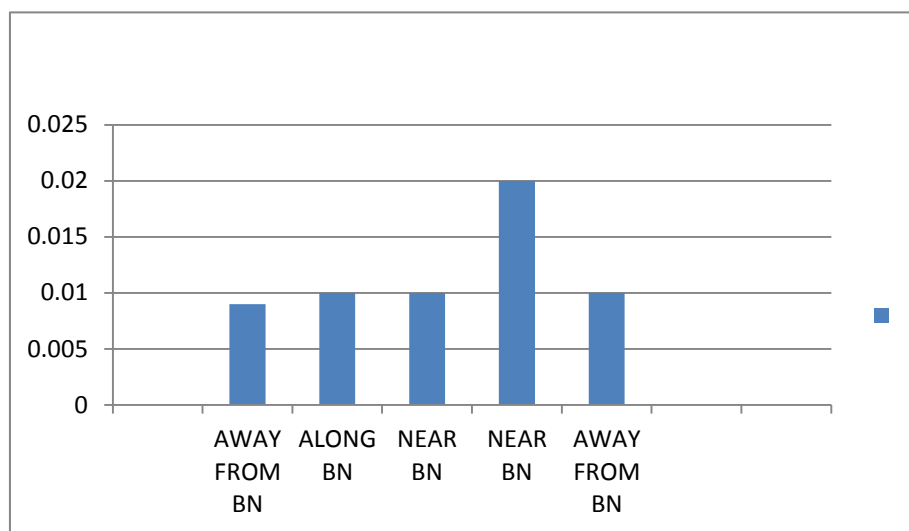


Figure 4.12 Variation of **CHROMIUM** in soil sample along various locations

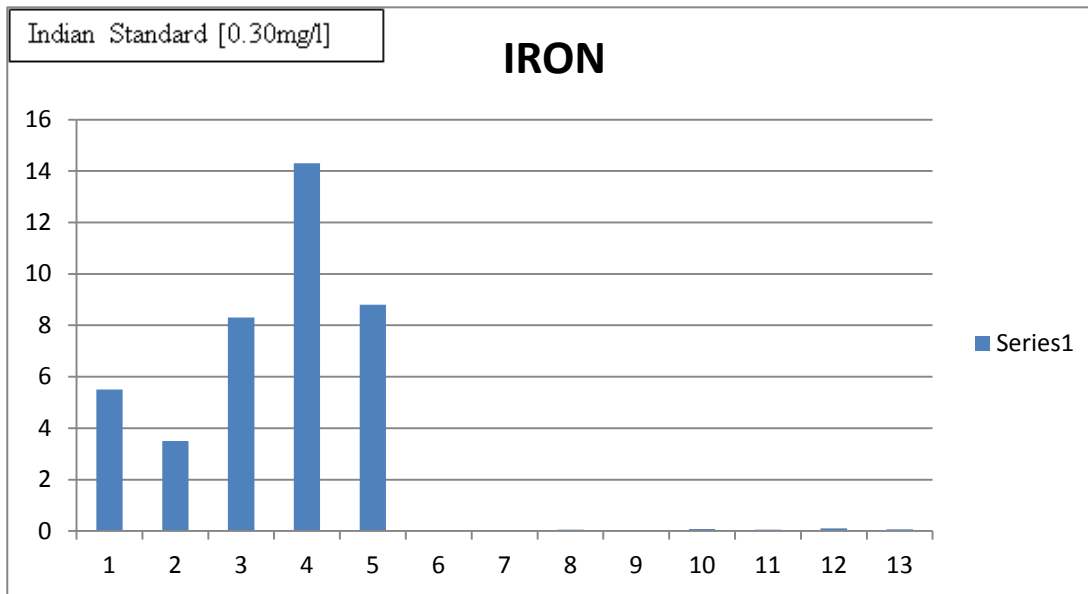


Figure 4.13 Variation of **IRON** along various locations

As per BIS standards permissible limit for iron is 0.3 mg/l. The value of iron in samples of groundwater varies in range 0.023-0.1 mg/l . Though the concentration has surpassed the limit of 0.3 mg/l but still it can used for drinking purpose as there is a acceptance limit of 1 mg/l according to BIS standards in case there is no alternate source available. So groundwater from all areas can be used for drinking purpose.

Iron in Budha nullah water samples lies between 3.5 mg/l and 14.3 mg/l Concentration of iron in samples of soil lies between 8.46 mg/l and 22.6 mg/kg. It can inferred that high iron concentration in groundwater samples can be due to leaching from the soil as the concentration of iron is found to be high in samples of soils.

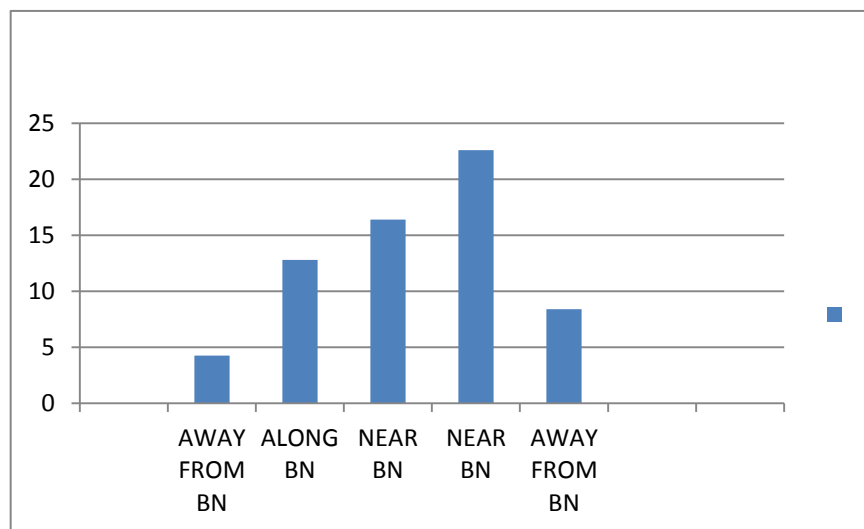


Figure 4.14 Variation of **IRON** in soil sample along

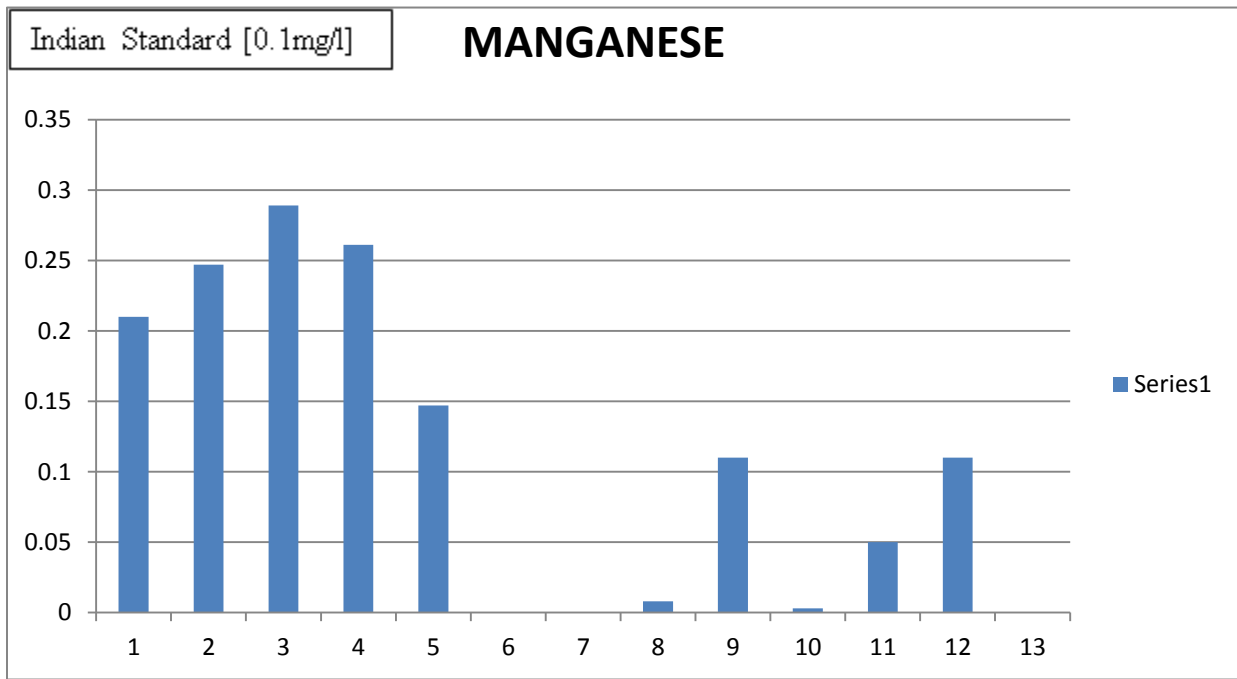


Figure 4.15 Variation of **MANGANESE** along various locations

As per the BIS standard the limit prescribed for the manganese is 0.10 mg/l and it can be extendable up to 0.30 mg/l.

The samples of groundwater lies within prescribed limit for manganese except two value of 0.111 mg/l which is slightly greater than 0.1 mg/l. Otherwise groundwater is safe for drinking purpose. Concentration of manganese in samples of budha nullah lies in range of .147 mg/l -.247 mg/l.

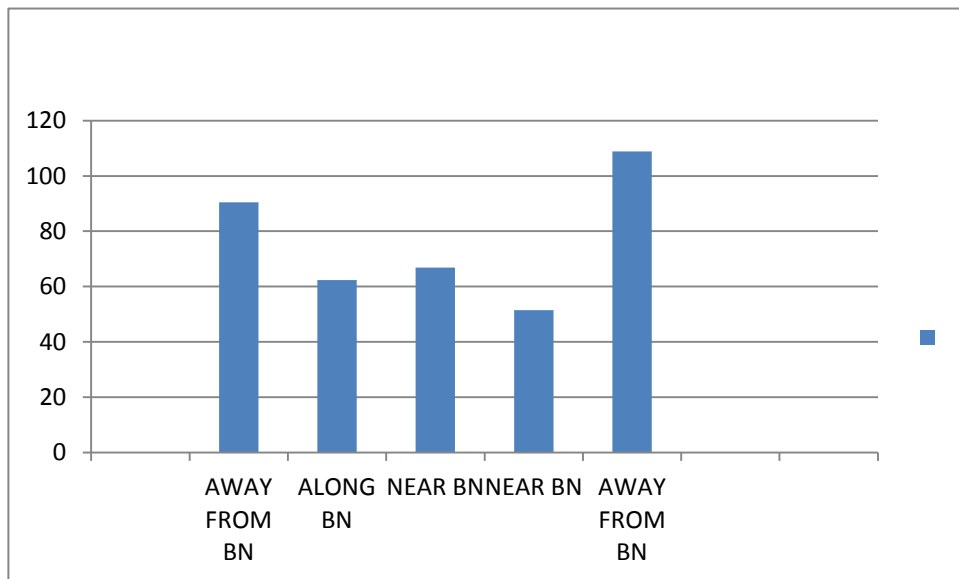


Figure 4.16 Variation of **MANGANESE** in soil sample along various locations

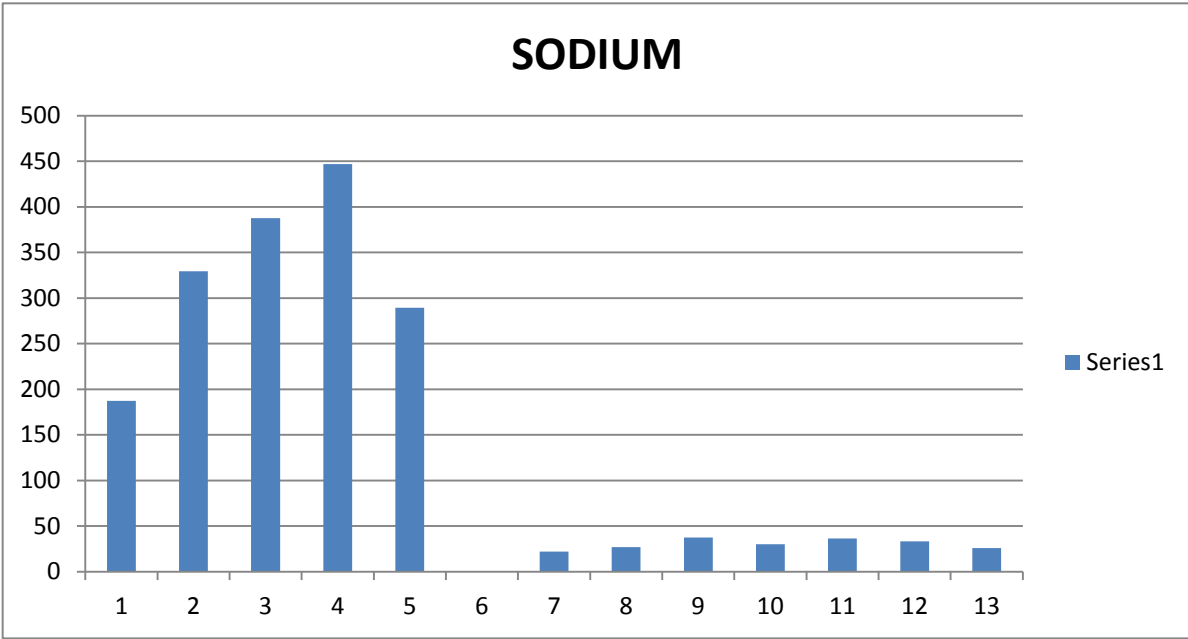


Figure 4.17 Variation of **SODIUM** along various locations

Concentration of sodium found in groundwater samples is lowest (22mg/l) at harbanspura whereas it is highest (36.3 mg/l) guru arjandev nagar.

The soil is also rich in sodium and concentration ranges between 66.4 to 111.4 mg/kg. The three main problems caused by sodium are reduced infiltration, reduced hydraulic conductivity, and surface crusting.

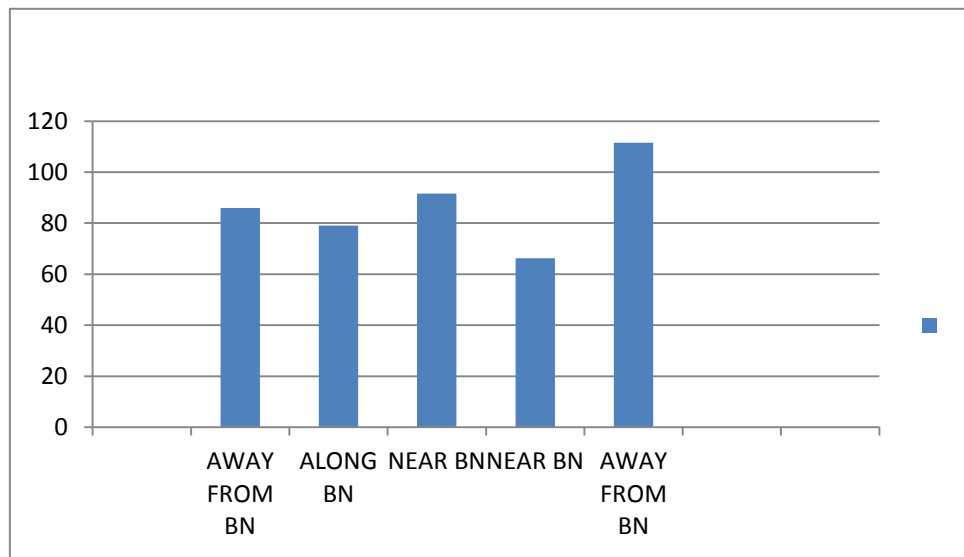


Figure 4.18 Variation of **SODIUM** in soil sample along various locations

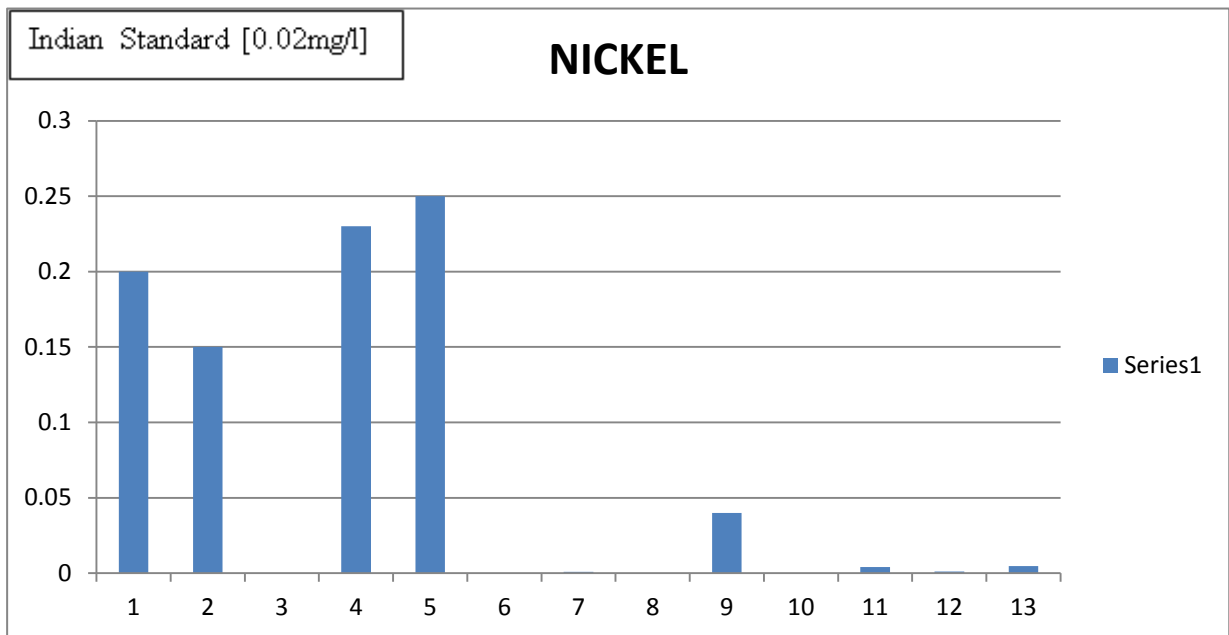


Figure 4.19 Variation of **NICKEL** along various locations

As per the BIS standard the limit prescribed for the nickel in drinking water is 0.02 mg/l. The samples of groundwater lies within prescribed limit for nickel except one handpump water sample taken from NEAR SHIVPURI, which is found to be 0.0462 mg/l.

In case of soil samples the maximum concentration reaches 1.8 mg/kg, still it will not affect soil fertility as concentration of more than 100 mg/kg starts affecting soil fertility. The nickel content in soil can be as low as 0.2 mg/kg or as high as 450 mg/kg in some clay and loamy soils.

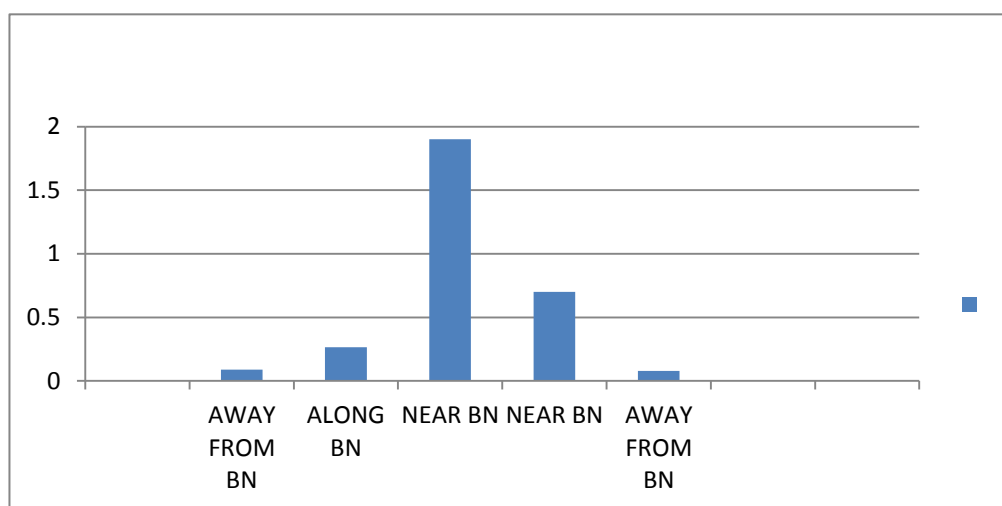


Figure 4.20 Variation of **NICKEL** in soil sample along various locations

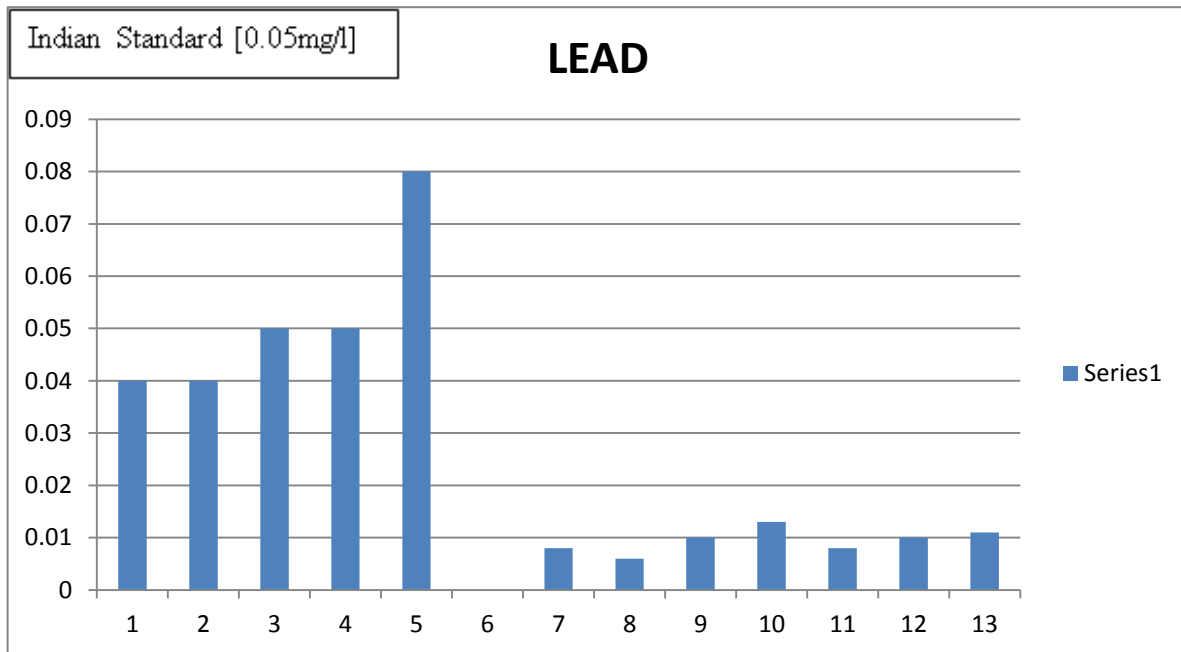


Figure 4.21 Variation of **LEAD** along various locations

Lead is found naturally in soil at very low concentration of 15-20ppm. But if lead levels cross some household value, it become tonic especially to children and pragnent women. Lead poisoning can lead to headache, mental retardation and kidney failure.

The concentration of lead in ground water samples is way less than the permissible limitGroundwater samples are fit for drinking purpose. Samples of budha nullah also have concentration within permissible limit.

In case of soil samples value of lead is found to vary between 0.5 and 3.8 mg/kg

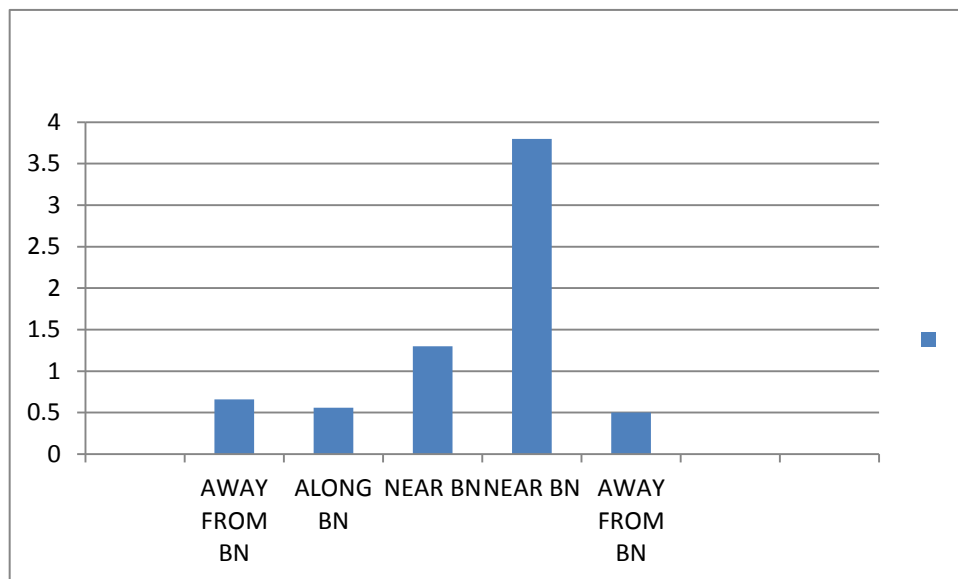


Figure 4.22 Variation of **LEAD** in soil sample along various locations

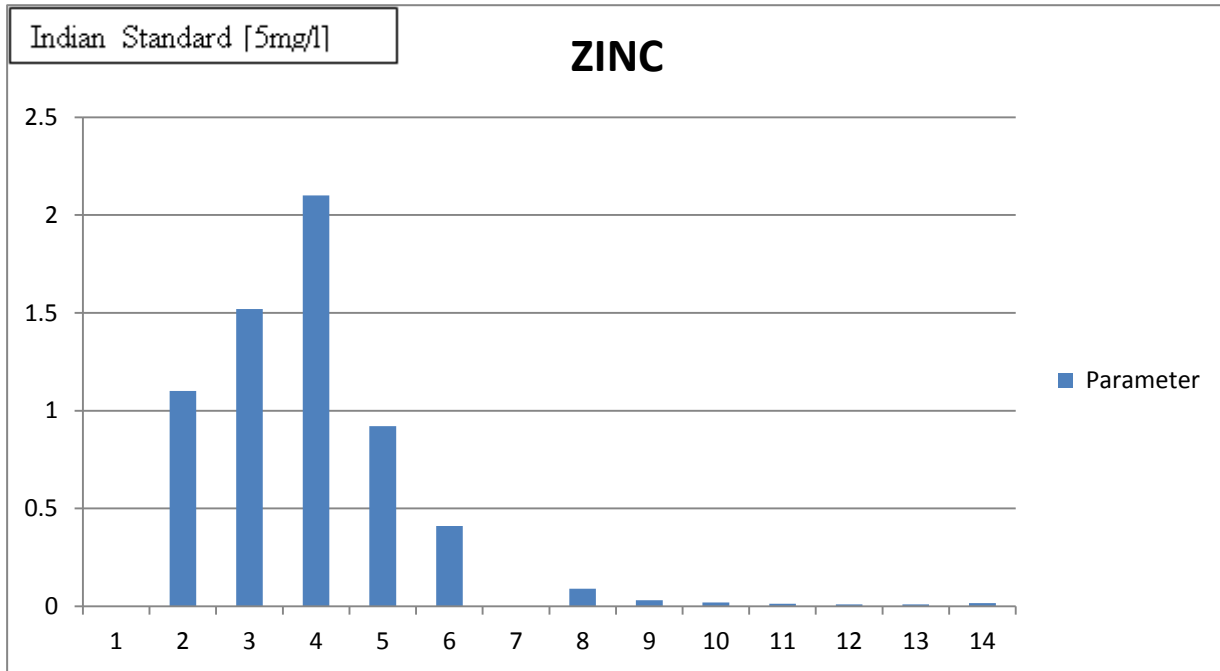


Figure 4.23 Variation of **ZINC** along various locations

Permissible limit of zinc is 5 mg/l. The value of zinc in groundwater sample lies between 0.009-0.03 mg/l..Highest value of zinc is found in a tubewell near Tajpur road, High concentration of zinc can cause skin irritation, Anemia, Stomach problem and can damage protein metabolism.

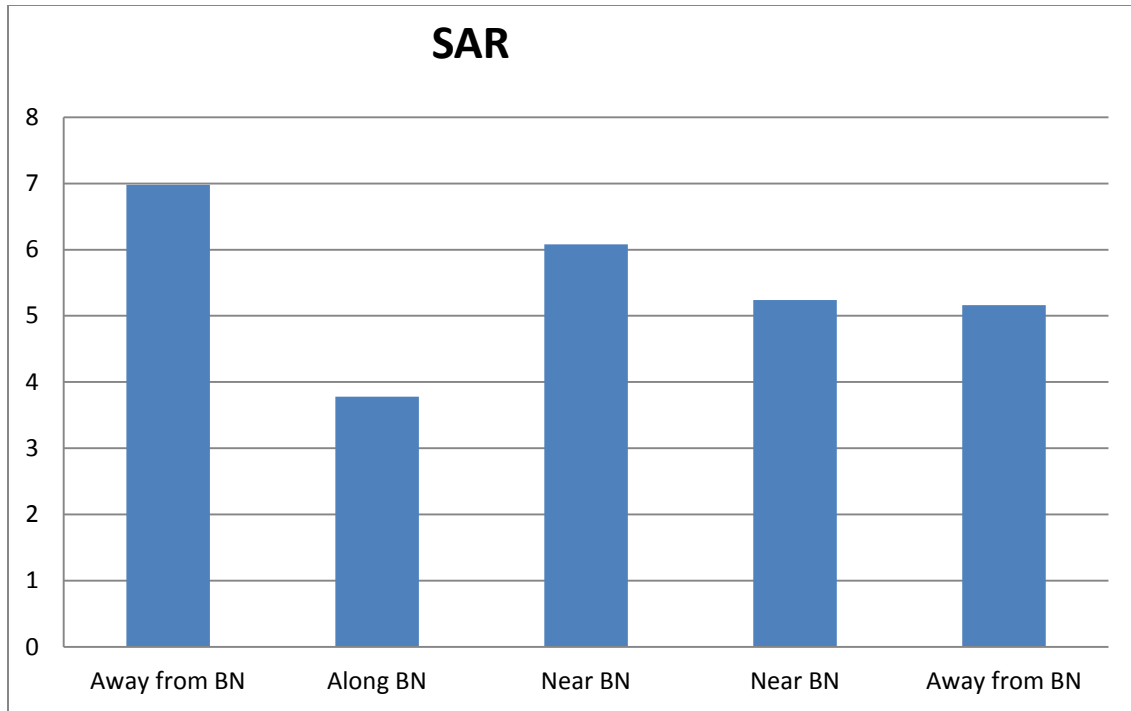


Figure 4.24 Variation of SAR along soil samples at various locations

Sodium adsorption ratio (SAR), along with pH, characterize salt-affected soils. SAR of soil ranges from 3.78 to 6.98 mg/kg, which is optimum value for soil, as soils with SAR value less than 10 mg/kg are considered good for leaching and water percolation.

When the SAR rises above 12 mg/kg to 15 mg/kg, serious physical soil problems arise and plants have difficulty absorbing water. SAR of the soil extract should be less than 10 mg/kg .

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSION:

Various conclusion regarding water quality and soil pollution can be drawn based on data obtained by analyzing various surface water and ground water samples

1) Quality of surface water of Buddha Nullah has degraded due to discharge of industrial waste apart from this domestic waste from settlements nearby also flows, directly to, further dumping the water quality. Analyses reveal very high value of TDS upto 1735 mg/l, COD value upto 524mg/l BOD value upto 160-240 mg/l and chloride value as high as 410 mg/l.

Also heavy metal contamination is found as Cr upto .041 mg/l., fe 14.3 mg/l As per CPCB, water, quality fall under E class which is not suitable for drinking irrigation on industrial cooling.

2) Most of heavy metal concentration in ground level is within permissible value concept magnesium, chromium, lead and nickel.

Thus quality of groundwater is unfit for drinking. Also high level of TDS makes underground water unfit for drinking.

3) Heavy metal concentration is highest near a vicinity of Buddha Nullah in ground water and this concentration decreases as we moves away from the Buddha Nullah. Very high concentration near vicinity of Buddha Nullah is mainly due to leaching of surface water of ground water aquifer.

4) Due to seepage of ground water, BOD value of ground water lies between 2 mg/l to 10 mg/l which it unfit for drinking but can be used for irrigation purpose.

5) SAR value of soil lies below to in range of 3.8 to 6.8 mg/kg. Soil. with SAR value less than 10 mg/kg is considered good for crops.

To water quality of Buddha Nullah has degraded largely in is affecting ground water too. Due to high tonicity, Buddha nullah is devoid of any aquatic life and has become a open drain rather

than a stream. This not only create public nuisance but also create health problems Due to dumping of sewage, water of Buddha Nullah has become stagnant. This hinders the self-purification process of water and is breeding ground of many disease like malaria, cholera, diarrhea. Due to this water quality lies in E class which is not suitable for drinking, human use, irrigation or industrial cooling .According to Punjab Pollution control board, it require treatment capacity of 680 MLD per day while present sewage treatment capacity is only 300 MLD.

5.3 RECOMMENDATION

1)Regular monitoring of water quality should be done and report should be placed in public domain.

2)Strict fines should be imposed as per environmental protection Act on those industries which dump their industrial waste directly to river body, for Thus transparent implementation mechanism is required.

3)Sewage treatment capacity should be increased. National Green Tribunal has ordered state government to install 20 sewage treatment plants by 2020. According to Punjab Pollution control board, it require treatment capacity of 680 MLD per day while present sewage treatment capacity is only 300 MLD.

4)Ministry of Environment and forestry has decided in 2011 to launch. In sites bio-remediation project' in Buddha Nullah. It should be launched immediately.

5) Educating the people, especially labour class that works in the industry about importance of clean environment. Regular monitoring of small scale industries which are also a major contributor for polluting the surface water and ultimately contaminates the ground water.

Proper awareness should be spread among the industrialists on how to decrease the pollution level in their respective factories. Each unit should self monitor its factory pollution and try to control it

5.4 SCOPE FOR FUTURE WORK

Based on the finding of the present investigation the following suggestions may be made for future studies.

- 1) All biological parameters of water can be studied to know the quality of water.
- 2) The study of air pollution can be studied. After that the effect of air pollution on quality of water can be studied
- 3)The modelling study can be extended for the other water quality parameters.
- 4) A study on groundwater quality movement can be carried out.
- 5)A detailed study on consumptive use of ground water can be carried ou

CHAPTER 6

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APPENDIX

Results of values of different parameters in Buddha nullah and ground water samples(appendix 1 to appendix 16)

APPENDIX 1 SAMPLE NO.: 1

LOCATION: NEW VIJAY NAGAR

S.No.	PARAMETERS	VALUE OF SAMPLES	IS10500:1991 DESIRABLE LIMIT
1.	pH	7.25	6.5 – 8.5
2.	Chlorides	350mg/L	250 mg/L
3.	Alkalinity	88mg/L	200 mg/L
4.	Biochemical Oxygen Demand (BOD)	180 mg/L	0 mg/L
5.	Chemical Oxygen Demand (COD)	695mg/L	0 mg/L
6.	Total dissolved solids	1442mg/L	500 mg/L
7.	Arsenic	0.002 mg/L	0.05 mg/L
8.	Calcium	39mg/L	75 mg/L
9.	Cadmium	0.0002mg/L	0.01 mg/L
10.	Chromium	0.04mg/L	0.05 mg/L
11.	Iron	5.5mg/l	0.30 mg/L
12.	Potassium	19.45 mg/L	-
13.	Manganese	0.21mg/L	0.1mg/L
14.	Sodium	187.2 mg/L	-
15.	Nickel	0.2 mg/L	0.02 mg/L
16.	Lead	0.02mg/L	0.05 mg/L
17.	Zinc	1.1mg/L	5mg/L

APPENDIX 2 SAMPLE NO.: 2

LOCATION: GAUSHALA road

S.No.	PARAMETERS	VALUE OF SAMPLES	IS10500:1991 DESIRABLE LIMIT
1.	pH	6.8	6.5 – 8.5
2.	Chlorides	300mg/L	250 mg/L
3.	Alkalinity	130 mg/L	200 mg/L
4.	Biochemical Oxygen Demand (BOD)	220mg/L	0 mg/L
5.	Chemical Oxygen Demand (COD)	459mg/L	0 mg/L
6.	Total dissolved solids	1288mg/L	500 mg/L
7.	Arsenic	2200+ per100ml	0.05 mg/L
8.	Calcium	0.002 mg/L	75 mg/L
9.	Cadmium	0.086 mg/L	0.01 mg/L
10.	Chromium	31mg/L	0.05 mg/L
11.	Iron	0.0004mg/L	0.30 mg/L
12.	Potassium	0.0001mg/L	-
13.	Manganese	0.03mg/L	0.1mg/L
14.	Sodium	0.094 mg/L	-
15.	Nickel	3.5 mg/L	0.02 mg/L
16.	Lead	7.61 mg/L	0.05 mg/L
17.	Zinc	21.75 mg/L	5mg/L

APPENDIX 3 SAMPLE NO.: 3

LOCATION: KIRPAL NAGAR

S.No.	PARAMETERS	VALUE OF SAMPLES	IS10500:1991 DESIRABLE LIMIT
1.	pH	6.95	6.5 – 8.5
2.	Chlorides	410 mg/L	250 mg/L
3.	Alkalinity	122 mg/L	200 mg/L
4.	Biochemical Oxygen Demand (BOD)	210mg/L	0 mg/L
5.	Chemical Oxygen Demand (COD)	524mg/L	0 mg/L
6.	Total dissolved solids	1114mg/L	500 mg/L
7.	Arsenic	0.004 mg/L	0.05 mg/L
8.	Calcium	47mg/L	75 mg/L
9.	Cadmium	0.0003mg/L	0.01 mg/L
10.	Chromium	0.035mg/L	0.05 mg/L
11.	Iron	8.3 mg/L	0.30 mg/L
12.	Potassium	25.77 mg/L	-
13.	Manganese	0.289mg/L	0.1mg/L
14.	Sodium	387.66 mg/L	-
15.	Nickel	0..2 mg/L	0.02 mg/L
16.	Lead	0.05mg/L	0.05 mg/L
17.	Zinc	2.1mg/L	5mg/L

APPENDIX 4 SAMPLE NO.: 4

LOCATION: HERO CYCLE(ADJ.PETROL PUMP)

S.No.	PARAMETERS	VALUE OF SAMPLES	IS10500:1991 DESIRABLE LIMIT
1)	pH	6.7	6.5 – 8.5
2)	Chlorides	350 mg/L	250 mg/L
3)	Alkalinity	122 mg/L	200 mg/L
4)	Biochemical Oxygen Demand (BOD)	160mg/L	0 mg/L
5)	Chemical Oxygen Demand (COD)	440mg/L	0 mg/L
6)	Total dissolved solids	996mg/L	500 mg/L
7)	Arsenic	.008mg/L	0.05 mg/L
8)	Calcium	35.7mg/L	75 mg/L
9)	Cadmium	.0002mg/L	0.01 mg/L
10)	Chromium	0.06mg/L	0.05 mg/L
11)	Iron	1 3mg/L	0.30 mg/L
12)	Potassium	16.44mg/L	-
13)	Manganese	0.261mg/L	0.1mg/L
14)	Sodium	446.99 mg/L	-
15)	Nickel	0.23 mg/L	0.02 mg/L
16)	Lead	0.01mg/L	0.05 mg/L
17)	Zinc	.92mg/L	5mg/L

APPENDIX 5 SAMPLE NO.: 5

LOCATION: KALYAN NAGAR

S.No.	PARAMETERS	VALUE OF SAMPLES	IS10500:1991 DESIRABLE LIMIT
1.	pH	7	6.5 – 8.5
2.	Chlorides	380 mg/L	250 mg/L
3.	Alkalinity	95mg/L	200 mg/L
4.	Biochemical Oxygen Demand (BOD)	240mg/L	0 mg/L
5.	Chemical Oxygen Demand (COD)	770mg/L	0 mg/L
6.	Total dissolved solids	1735mg/L	500 mg/L
7.	Arsenic	.01mg/L	0.05 mg/L
8.	Calcium	48.9mg/L	75 mg/L
9.	Cadmium	.00045mg/L	0.01 mg/L
10.	Chromium	0.03mg/L	0.05 mg/L
11.	Iron	8.8 mg/L	0.30 mg/L
12.	Potassium	11.6 mg/L	-
13.	Manganese	0.147mg/L	0.1mg/L
14.	Sodium	289.4mg/L	-
15.	Nickel	0.25 mg/L	0.02 mg/L
16.	Lead	0.08mg/L	0.05 mg/L
17.	Zinc	0.41mg/L	5mg/L

APPENDIX 6 SAMPLE NO.: 6

LOCATION: Near tajpur road

S.No.	PARAMETERS	VALUE OF SAMPLES	IS10500:1991 DESIRABLE LIMIT
1.	pH	7.35	6.5 – 8.5
2.	Chlorides	300mg/L	250 mg/L
3.	Alkalinity	160mg/L	200 mg/L
4.	Biochemical Oxygen Demand (BOD)	85mg/L	0 mg/L
5.	Chemical Oxygen Demand (COD)	150mg/L	0 mg/L
6.	Total dissolved solids	662mg/L	500 mg/L
7.	Arsenic	0.01 mg/L	0.05 mg/L
8.	Calcium	31.63mg/L	75 mg/L
9.	Cadmium	0.001mg/L	0.01 mg/L
10.	Chromium	0.02 mg/L	0.05 mg/L
11.	Iron	0.107 mg/L	0.30 mg/L
12.	Potassium	6.42 mg/L	
13.	Manganese	0.011mg/L	0.1mg/L
14.	Sodium	33.36 mg/L	
15.	Nickel	0.001mg/L	0.02 mg/L
16.	Lead	0.01mg/L	0.05 mg/L
17.	Zinc	0.05mg/L	5mg/L

APPENDIX 7 SAMPLE NO.: 7

LOCATION: Residential area NEAR TAJPUR ROAD

S.No.	PARAMETERS	VALUE OF SAMPLES	IS10500:1991 DESIRABLE LIMIT
1.	pH	6.81	6.5 – 8.5
2.	Chlorides	280mg/L	250 mg/L
3.	Alkalinity	140mg/L	200 mg/L
4.	Biochemical Oxygen Demand (BOD)	50mg/L	0 mg/L
5.	Chemical Oxygen Demand (COD)	88mg/L	0 mg/L
6.	Total dissolved solids	436mg/L	500 mg/L
7.	Arsenic	0.01 mg/L	0.05 mg/L
8.	Calcium	35.22mg/L	75 mg/L
9.	Cadmium	0.001mg/L	0.01 mg/L
10.	Chromium	0.03mg/L	0.05 mg/L
11.	Iron	0.023 mg/L	0.30 mg/L
12.	Potassium	5.07 mg/L	
13.	Manganese	0.11mg/L	0.1mg/L
14.	Sodium	37.33 mg/L	
15.	Nickel	0.004 mg/L	0.02 mg/L
16.	Lead	0.001mg/L	0.05 mg/L
17.	Zinc	0.03mg/L	5mg/L

APPENDIX 8 SAMPLE NO.: 8

LOCATION: GURU ARJANDEV NAGAR

S.No.	PARAMETERS	VALUE OF SAMPLES	IS10500:1991 DESIRABLE LIMIT
1.	pH	6.65	6.5 – 8.5
2.	Chlorides	44mg/L	250 mg/L
3.	Alkalinity	100mg/L	200 mg/L
4.	Biochemical Oxygen Demand (BOD)	2mg/L	0 mg/L
5.	Chemical Oxygen Demand (COD)	8mg/L	0 mg/L
6.	Total dissolved solids	280mg/L	500 mg/L
7.	Arsenic	0.002 mg/L	0.05 mg/L
8.	Calcium	29.82mg/L	75 mg/L
9.	Cadmium	0.001mg/L	0.01 mg/L
10.	Chromium	0.007 mg/L	0.05 mg/L
11.	Iron	0.057 mg/L	0.30 mg/L
12.	Potassium	3.22 mg/L	
13.	Manganese	0.05mg/L	0.1mg/L
14.	Sodium	36.3mg/L	
15.	Nickel	0.004 mg/L	0.02 mg/L
16.	Lead	0.008mg/L	0.05 mg/L
17.	Zinc	0.019mg/L	5mg/L

APPENDIX 9 SAMPLE NO.: 9

LOCATION:HARBANSPURA GAUSHALA ROAD

S.No.	PARAMETERS	VALUE OF SAMPLES	IS10500:1991 DESIRABLE LIMIT
1.	pH	6.7	6.5 – 8.5
2.	Chlorides	52mg/L	250 mg/L
3.	Alkalinity	70mg/L	200 mg/L
4.	Biochemical Oxygen Demand (BOD)	6mg/L	0 mg/L
5.	Chemical Oxygen Demand (COD)	24mg/L	0 mg/L
6.	Total dissolved solids	330mg/L	500 mg/L
7.	Arsenic	0.006 mg/L	0.05 mg/L
8.	Calcium	25.13 mg/L	75 mg/L
9.	Cadmium	0.0008mg/L	0.01 mg/L
10.	Chromium	0.016mg/L	0.05 mg/L
11.	Iron	0.041mg/L	0.30 mg/L
12.	Potassium	3.48mg/L	
13.	Manganese	0.0mg/L	0.1mg/L
14.	Sodium	22mg/L	
15.	Nickel	0.0008mg/L	0.02 mg/L
16.	Lead	0.008mg/L	0.05 mg/L
17.	Zinc	0.012mg/L	5mg/L

APPENDIX 10 SAMPLE NO.: 10

LOCATION: GURU NANAKDEV NAGAR

S.No.	PARAMETERS	VALUE OF SAMPLES	IS10500:1991 DESIRABLE LIMIT
1.	pH	6.7	6.5 – 8.5
2.	Chlorides	34mg/L	250 mg/L
3.	Alkalinity	90mg/L	200 mg/L
4.	Biochemical Oxygen Demand (BOD)	8mg/L	0 mg/L
5.	Chemical Oxygen Demand (COD)	32mg/L	0 mg/L
6.	Total dissolved solids	530mg/L	500 mg/L
7.	Arsenic	0.004 mg/L	0.05 mg/L
8.	Calcium	25.13mg/L	75 mg/L
9.	Cadmium	0.0007mg/L	0.01 mg/L
10.	Chromium	0.014 mg/L	0.05 mg/L
11.	Iron	0.052 mg/L	0.30 mg/L
12.	Potassium	4mg/L	
13.	Manganese	0.008mg/L	0.1mg/L
14.	Sodium	27 mg/L	
15.	Nickel	0.0 mg/L	0.02 mg/L
16.	Lead	0.006mg/L	0.05 mg/L
17.	Zinc	0.009mg/L	5mg/L

APPENDIX 11 SAMPLE NO.: 11

LOCATION: NEAR SHIVPURI

S.No.	PARAMETERS	VALUE OF SAMPLES	IS10500:1991 DESIRABLE LIMIT
1.	pH	7	6.5 – 8.5
2.	Chlorides	64mg/L	250 mg/L
3.	Alkalinity	600mg/L	200 mg/L
4.	Biochemical Oxygen Demand (BOD)	2mg/L	0 mg/L
5.	Chemical Oxygen Demand (COD)	8mg/L	0 mg/L
6.	Total dissolved solids	334mg/L	500 mg/L
7.	Arsenic	0.009 mg/L	0.05 mg/L
8.	Calcium	18.2mg/L	75 mg/L
9.	Cadmium	0.0008mg/L	0.01 mg/L
10.	Chromium	0.012 mg/L	0.05 mg/L
11.	Iron	0.007 mg/L	0.30 mg/L
12.	Potassium	5 mg/L	
13.	Manganese	0.0mg/L	0.1mg/L
14.	Sodium	26mg/L	
15.	Nickel	0.004 mg/L	0.02 mg/L
16.	Lead	0.011mg/L	0.05 mg/L
17.	Zinc	0.009mg/L	5mg/L

APPENDIX 12 SAMPLE NO.: 12

LOCATION: clock tower road

S.No.	PARAMETERS	VALUE OF SAMPLES	IS10500:1991 DESIRABLE LIMIT
1.	pH	6.9	6.5 – 8.5
2.	Chlorides	46 mg/L	250 mg/L
3.	Alkalinity	65mg/L	200 mg/L
4.	Biochemical Oxygen Demand (BOD)	8mg/L	0 mg/L
5.	Chemical Oxygen Demand (COD)	32mg/L	0 mg/L
6.	Total dissolved solids	306mg/L	500 mg/L
7.	Arsenic	0.011 mg/L	0.05 mg/L
8.	Calcium	17.01 mg/L	75 mg/L
9.	Cadmium	0mg/L	0.01 mg/L
10.	Chromium	0.017mg/L	0.05 mg/L
11.	Iron	0.074 mg/L	0.30 mg/L
12.	Potassium	2.66mg/L	
13.	Manganese	0.003mg/L	0.1mg/L
14.	Sodium	30mg/L	
15.	Nickel	0.0 mg/L	0.02 mg/L
16.	Lead	0.013mg/L	0.05 mg/L
17.	Zinc	0.016mg/L	5mg/L

RESULTS OF VALUES OF DIFFERENT HEAVY METALS IN SOIL

SAMPLE NO.: 1 Appendix 13

SAMPLING STATION: Soil away from Budha Nullah

S.No.	PARAMETERS	VALUE OF SAMPLES
1.	Arsenic	0.019
2.	Calcium	488
3.	Chromium	0.009
4.	Copper	0.9
5.	Iron	4.254
6.	Magnesium	90.4
7.	Nickel	0.97
8.	Phosphorous	0.09
9.	Lead	0.66
10.	Sodium	86

SAMPLE NO.: 2 Appendix 4.14

SAMPLING STATION: Along Budha Nullah

S.No.	PARAMETERS	VALUE OF SAMPLES
1	Arsenic	0.009
2	Calcium	399
3	Chromium	0.01
4	Copper	0.5
5	Iron	12.8
6	Magnesium	62.3

7	Nickel	0.215
8	Phosphorous	0.266
9	Lead	0.56
10	Sodium	79

SAMPLE NO.: 3 Appendix 4.15

SAMPLING STATION: Soil near Budha Nullah

S.No.	PARAMETERS	VALUE OF SAMPLES
1	Arsenic	0.02
2	Calcium	388
3	Chromium	0.01
4	Copper	2.9
5	Iron	16.4
6	Magnesium	66.9
7	Nickel	0.766
8	Phosphorous	1.9
9	Lead	1.3
10	Sodium	91.6

SAMPLE NO.: 4 Appendix 16

SAMPLING STATION: Soil near Budha Nullah

S.No.	PARAMETERS	VALUE OF SAMPLES
1	Arsenic	0.015
2	Calcium	522
3	Chromium	0.02
4	Copper	12.5
5	Iron	22.6
6	Magnesium	51.5
7	Nickel	4.22
8	Phosphorous	0.7
9	Lead	3.8
10	Sodium	66.3

SAMPLE NO.: 5 Appendix 17

SAMPLING STATION: Soil away from Budha Nullah

S.No.	PARAMETERS	VALUE OF SAMPLES
1	Arsenic	0.019
2	Calcium	411
3	Chromium	0.01
4	Copper	0.85
5	Iron	8.4
6	Magnesium	108.9

7	Nickel	0.076
8	Phosphorous	0.08
9	Lead	0.5
10	Sodium	111.6

Appendix 18 SAR VALUES OF SOIL SAMPLES

SOIL SAMPLE	SAR VALUE
1.	6.98
2.	3.78
3.	6.03
4.	5.26
5.	5.12

Appendix 17 : WATER QUALITY STANDARDS

INDIAN STANDARD SPECIFICATIONS FOR DRINKING WATER IS: 10500 – 1991

S.No.	Substance or Characteristics	Requirement or Acceptable Limit	Undesirable Effect Outside the Desirable Limit	Permissible limit in the absence of alternate source
Essential Characteristics				
i)	pH Value	6.5 to 8.5	Beyond this range the water will affect the mucous membrane and/or water supply system.	No relaxation
ii)	Color (Hazen Units), Maximum	5	Above 5 consumer acceptance decreases	25
iii)	Odor	Agreeable	-	--
iv)	Taste	Agreeable	--	--
v)	Turbidity, NTU	5	Above 5, Consumer acceptance decreases	10
Following results are expressed in mg/l				
vi)	Total Hardness (as CaCO ₃) max	300	Encrustation in water supply structure and adverse effects on domestic use.	600
vii)	Iron (as Fe), max	0.3	Beyond this limit taste/appearance are affected & has adverse effect on domestic uses and water structures, and promotes Iron bacteria	1.0
viii)	Chloride as (Cl), max	250	Beyond this limit, taste, corrosion and palatability are affected	1000
ix)	Residual free chlorine Min	0.2		
Desirable Characteristics				
x)	Dissolved Solids, max	500	Beyond this palatability decreases and may cause gastro-intestinal irritation	2000
S.No.	Substance or Characteristics	Requirement or Acceptable Limit	Undesirable Effect Outside the Desirable Limit	Permissible limit in the absence of alternate source

xi)	Calcium (as Ca), max	75	Encrustation in water supply structure and adverse effects on domestic use.	200
xii)	Magnesium (as Mg), max	30	--	100
xiii)	Copper (as Cu), max	0.05	Astringent taste, discolouration and corrosion of pipes fittings and utensils will be caused beyond this	1.5
xiv)	Manganese (as Mn), max	0.1	Beyond this limit, taste/appearance is affected on domestic uses and water supply structure.	0.3
xv)	Sulphate (as SO ₄), max	200	Beyond this causes gastrointestinal irritation when Magnesium of Sodium is present.	400
xvi)	Nitrate (as NO ₃)	45	Beyond this methanemoglobinemia takes place.	100
xvii)	Fluoride (as F), max	1.0	Fluoride may be kept low as possible. High fluoride may cause fluorosis.	1.5
xviii)	Phenolic Compounds as C ₆ H ₅ OH, max	0.001	Beyond this it may cause objectionable taste and odour.	0.002
xix)	Mercury (as Hg) max	0.001	Beyond this the water becomes toxic.	No relaxation
xx)	Cadmium (as Cd), max	0.01	Beyond this the water becomes toxic.	No relaxation
xxi)	Selenium (as Se) max	0.01	Beyond this the water becomes toxic.	No relaxation
xxii)	Arsenic (as As) max	0.05	Beyond this the water becomes toxic.	No relaxation
xxiii)	Cyanide (as CN) max	0.05	Beyond this the water becomes toxic.	No relaxation
xxiv)	Lead (as Pb), max	0.05	Beyond this the water becomes toxic.	No relaxation
xxv)	Zinc (as Zn), max	5.0	Beyond this limit it can cause astringent taste and opalescence in water.	15

S.No.	Substance or Characteristics	Requirement Acceptable Limit	Undesirable Effect Outside the Desirable Limit	Permissible limit in the absence of alternate source
xxvi)	Anionic detergents (as MBAS), max	0.2	Beyond this limit it can cause a light froth in water.	1.0
xxvii)	Chromium (as Cr ⁺⁶) max	0.05	May be carcinogenic above this limit.	No relaxation
xxviii)	Polynuclear aromatic hydrocarbons as PAH, Max	--	May be carcinogenic	--
xxix)	Mineral Oil mg/L	0.01	Beyond this limit undesirable taste and odour after chlorination takes place.	0.03
xxx)	Pesticides,Max	Absent	Toxic	0.001
xxxi)	Radioactive materials Â emitters bq/l, max Â emitters pci/l, max	-- --	--	0.1 1
xxxii)	Alkalinity, Max	200	Beyond this limit, taste becomes unpleasant	600
xxxiii)	Aluminium (as Al) mg/L	0.03	Cumulative effect is reported to cause dementia.	0.2
xxxiv)	Nickel (as Ni) mg/L	0.02	--	--
xxxv)	Boron, max	1	--	5

Appendix 17:Water Quality Criteria

Designated-Best-Use	Class of water	Criteria
Drinking Water Source without conventional treatment but after disinfection	A	Total Coliforms Organism MPN/100ml shall be 50 or less pH between 6.5 and 8.5 Dissolved Oxygen 6mg/l or more Biochemical Oxygen Demand 5 days 20°C 2mg/l or less
Outdoor bathing (Organized)	B	Total Coliforms Organism MPN/100ml shall be 500 or less pH between 6.5 and 8.5 Dissolved Oxygen 5mg/l or more Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Drinking water source after conventional treatment and disinfection	C	Total Coliforms Organism MPN/100ml shall be 5000 or less pH between 6 to 9 Dissolved Oxygen 4mg/l or more Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
Propagation of Wild life and Fisheries	D	pH between 6.5 to 8.5 Dissolved Oxygen 4mg/l or more Free Ammonia (as N) 1.2 mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	pH between 6.0 to 8.5 Electrical Conductivity at 25°C micro mhos/cm Max.2250 Sodium absorption Ratio Max. 26 Boron Max. 2mg/l
	Below-E	Not Meeting A, B, C, D & E Criteria

Source: http://cpcb.nic.in/Water_Quality_Criteria.php

