WATER QUALITY STATUS AND GEOSPATIAL MAPPING OF DAHARABI DAM

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Sohail Anjum

Sehar Gul

DEDICATED TO

THE PROJECT IS DEDICATED TO OUR LOVING PARENTS WHO'S EFFORTS ENABLED TO DO THIS PROJECT SPECIAL THANKS AND GRATITUDE TO ALL TEACHERS WHO HAD BEEN A SOURCE OF GUIDANCE AND INSPIRATION TO US.

Abstract

Water is essential for life but this resource is becoming scarce due to overexploitation of the resources on account of competing land use patterns, degradation of forest cover and lack of conservation in its use. Water use would be beneficial when managed properly amongst the competing interests. Spatial information systems commonly referred to as Geographic Information Systems (GIS), have emerged as a potent investigative tool in securing a layered analysis of the earth resources, land and water included. A study was carried out to evaluate the surface-water quality in Dharabi dam with the help of GIS and remote sensing techniques. To monitor the water quality of the dam in terms of various physiochemical parameters. The results of the study demonstrated that physicochemical quality of water was satisfactory where as the Biological quality of water was unsatisfactory, while 50 to 87.5% of the samples contained bacteriological contamination before monsoon. This percentage rose to 98.5% after the monsoon. Lack of proper management practices for dam and control of sewage and agricultural discharge into the surrounding locality is also linked with the deterioration of water quality. It is recommended to carry out Mitigation measures to control the quality of water.

Abbreviations

• EC	Electric conductivity
• TSS	Total Suspended Solids
• TDS	Total dissolve solids
• US- EPA	United States Environmental Protection Agency
• PPM	Part Per Million
• NEQS	National Environmental Quality Standards
• WHO	World Health Organization
• GIS	Geographical Information System
• GPS	Global Positioning System
• RS	Remote Sensing
• DSS	Decision Support System
• H/WQ	Hydrologic Water Quality
• BDL	Below Detection Limit
• NTU	Nephlometric turbidity unit
• SAR	Sodium adsorption ratio
• RSC	Residual sodium carbonate

Table of Contents

List of Figures

List of tables

CHAPTER – 1

INTRODUCTION

INTRODUCTION

"We have made every living thing out of water.

"(Surah 21 The Prophets, ayah 30)

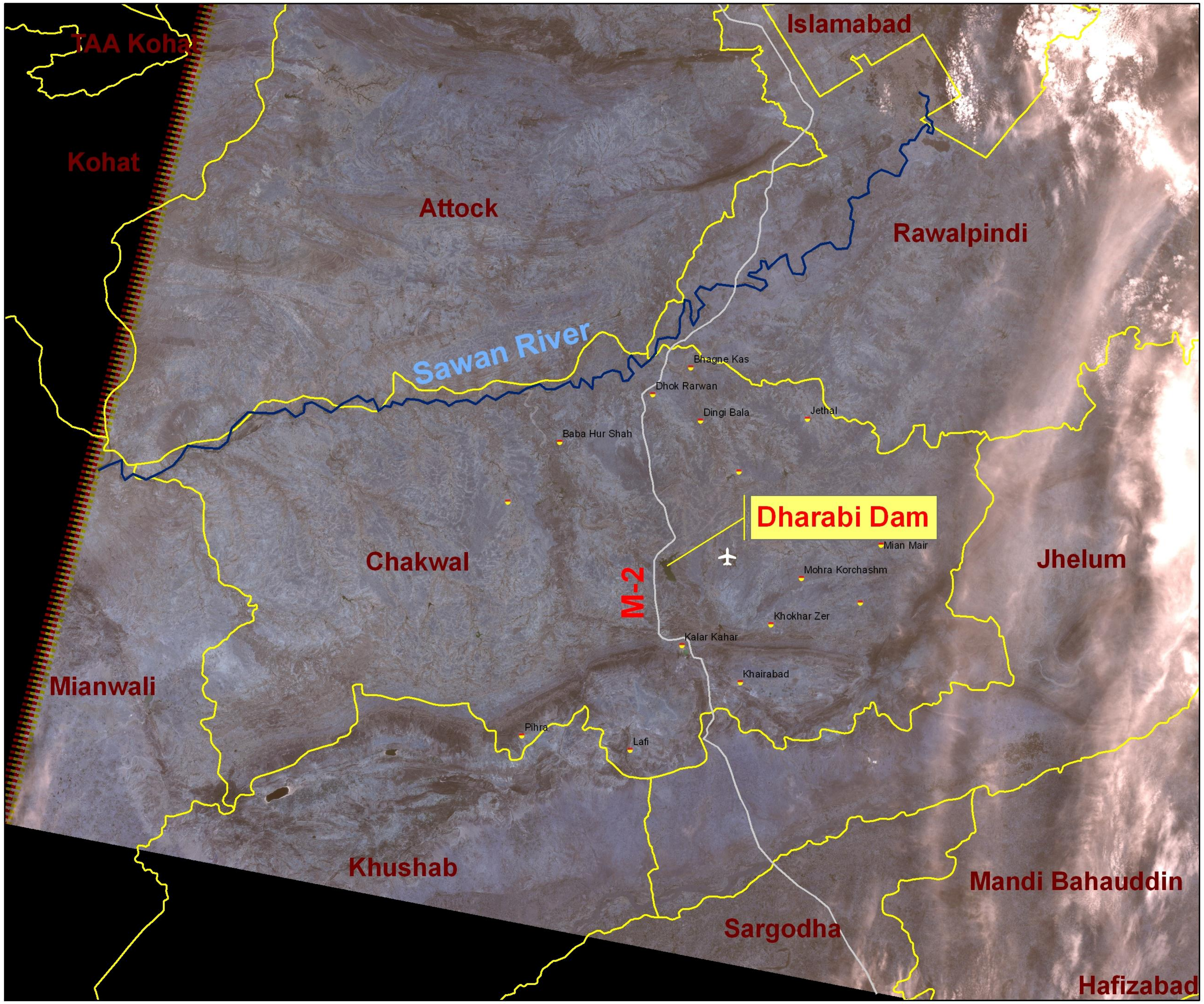
The above verse from holy Quran clearly mentions the importance of water. . Nowadays, everyone understands the essential and undeniable role that water has played in the emergence, development and maintenance of life on Earth. Water is by far the major constituent of the mass of living organisms, be they animals or plants. A recent report suggests that by 2030, in some developing regions of the world, water demand will exceed supply by 50%, so no one can deny the possible war that might fight between nations in order to control water resources of a region, like one is already started. (November 2009 UNO)

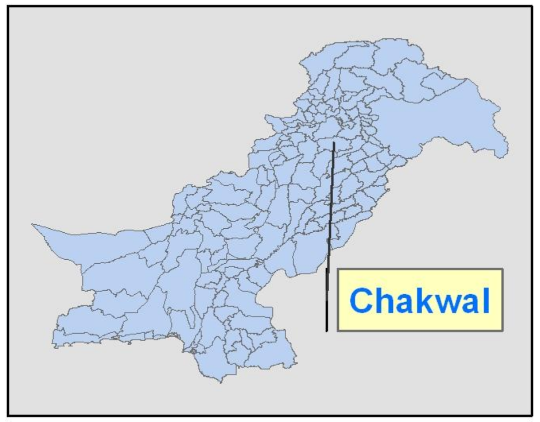
If there is magic on this planet, it is contained in water. (LORAN EISELY, The Immense Journey, 1957)

1.1 Study Area

Daharabi Dam is located near village Balkassar in district and tehsil Chakwal (Coordinates: 32° 54' 39.89" N 72° 39' 43.61" E). Daharabi Dam is located on the Daharab River. It is clearly visible on the left side after crossing the Balkassar interchange coming from Islamabad on the Motorway. Geographically placed in the Salt Range and the Potohar plateau, the physical features of Chakwal are typical of the region. The south and southeast is mountainous and rocky, covered with scrub forest, interspaced with flat lying plains; the north and northeast consist of softly undulating plains, with patches of rocky areas known as Khuddhar in the local dialect ravines and gorges and some desert areas. Chakwal is mainly a Barani area. There are no irrigation canals or rivers.

Geographical Location of the Dharabi Dam





Dharabi Dam is located near village Balkassar in Tehsil and district Chakwal (Coordinates: 32° 54' 39.89" N 72° 39' 43.61" E) Dharabi Dam is located on the Dharabi River. It is clearly visible on the left side after crossing the Balkassar Interchange coming from Islamabad on the M2 Motorway.

Legend

- Settellments
- Water Boddies
- District

The only major rivulets and seasonal channels that run through Chakwal are the Soan, and the Soj Nullah. A number of small dams have been constructed in the district through which some irrigation takes place. There are some storm water channels, which are mostly active during rainy season. The plains of the district are being cultivated, even those which lie in the hilly regions, and a considerable area is covered by forests.

1.2 Objective of the Research

The objective of this project is to characterize surface-water quality in Dharabi dam with the help of GIS and remote sensing techniques.

The main objectives of this study are as follows.

A. To analyze the water quality of the dam in terms of various physiochemical parameters.

B. The ultimate goal is to help protect Dharabi surface-water bodies, which are ecological resources used as a habitat by wildlife and communities near it.

C. Awareness of the public health officials and related agencies about the quality of the water.

D. To suggest the appropriate remedial measures if the water is contaminated.

E. Development of different thematic maps of the area with the help of GIS and remote sensing techniques

F. On the basis of the results achieved during this study, it would be possible to compare the quality of the water with international standards.

1.3 Available Data

Weather and Climate

Chakwal lies in the subtropical region and its climate is typical of the area, with the exception that it varies a little on the cooler side owing to its elevation from central Punjab. Winter temperatures normally range between –4° C and 25° C and summer temperatures average between 15° C and 40° C and may go upto a maximum of 15° C.

1.3.1 Rain fall

Chakwal lies within the monsoon range and apart from occasional rainfall there are two rainy seasons: the first caused by the monsoon winds originating from the Bay of Bengal begins from 15th of July and continues up to around the 15th of September; the second caused by Mediterranean winds lies in the last two weeks of December and the first two weeks of January. The average rainfall is 22 to 25 inches. Choa Saidan Shah Subdivision has the maximum rainfall in the district.

1.3.2 RAINFALL IN (mm)

Months	1999	2000
January	112.06	54.00
February	16.00	46.00
March	24.00	03.00
April	06.00	-
May	39.00	42.00
June	45.00	80.00
July	140.00	116.00
August	199.00	101.00
September	78.00	100.00
October	04.00	-
November	09.00	-
December	**-**	06.00

1.3.3Soil Types

Most of the soils in District Chakwal range from silt loam to loam with Ph ranging from 7-9

1.3.4Flora and Fauna

The forests which exist naturally since Chakwal lies in the subtropical semiarid zone are dry deciduous scrub, consisting of the plant varieties which are typical of these kinds of forests- keeker, kau, phulai, sanatha, wild beri, gurgura and potaki.

The underbush mainly consists of saryala, khawi, mesquite and karir. In the plantations that have been carried out by the forest department and private farmers, apart from the naturally occurring species of trees, the sheesham, sufaida and to some extent the poplar trees have also been planted.

The species which exist in various areas of Chakwal district are:

A. **Grey partridge**- found all over the district especially in areas which are sparsely populated.

B. **Black partridge**- found along the seasonal channels and water holes in the bellas throughout the district.

C. **Chakore**- found in dry rocky areas in the district especially in the Choa Saidan Shah area.

D. **See See partridge-** found at a number places in the district in the dry rocky area especially in the Kallar Kahar mountain belt leading into subdivision Talaga

1.3.5 Agriculture

Farming is the main occupation of the people of Chakwal. With the exception of a few large landholders in subdivision Talagang holdings are small in the district and farming is conventional. The total area of the district is 1652443 acres and the total cultivated area is 786212 acres. The main crops of the district are:

Wheat, Groundnut, Oil seeds, Grams, Lentils- Masoor, Moong, Mash, Maize, Millets, Jawar, Vegetables, Fruit orchards, especially of citrus have also been planted by farmers but only on small areas owing to shortage of water. Fair sized Loquat orchards exist in Kallar Kahar and Choa Saidan Shah.

CHAPTER – 2

LITERATURE REVIEW

Literature Review

Water quality of small reservoirs such as rivers and small dams is a very basic aspect of assessment of water for many purposes like conservation, irrigation and for intake on daily basis. Around the world various ways and parameters and methods are used for assessing the water quality. Many parts of the world are prone to drought making water a scarce and precious raw material for trade purpose in other some parts of the world it appears in raging torrents consequently causing loss of life and property. Because of the shortage of clean water financial restrictions and the water sources variability, rural communities resort to using untreated water directly from the water sources such as boreholes, reservoirs and rivers(Pirages, 2005).

Globally speaking, small reservoirs are storage structures used for storage and capturing runoff water; however categorization of a reservoir as being large or small varies widely across the world. In the arid and semi arid areas with water scarcity small reservoirs serve as a source of drinking water, irrigation and livestock-watering. International estimates suggest that approximately 1.5 billion people are deprived of safe drinking water and that at least 5 million deaths per year can be attributed to waterborne diseases. To improve the ability to access of humans to safe water and to properly track progress toward decreasing impacts on reservoir water quality and depends on the availability of baseline data that includes temporal and spatial trends. It is therefore necessary to regularly monitor the reservoir water quality in order to reduce negative impacts on human health, irrigation and livestock quality. In water scarce arid and semi arid regions small reservoirs serve as a drinking water, irrigation and livestock-watering source. Global estimates show that nearly 5 million cases of death per year can be attributed to waterborne diseases (Scheelbeek, 2005).

Zimbabwe in early 1990's experienced severe droughts and the semi-arid Matabeleland South province was at a great risk. As a result more reservoirs were formed in Zimbabwe. Developing small reservoirs in Zimbabwe has the objective to mitigate the drought effects by providing sources of water for domestic uses, formation of new irrigated lands and groundwater recharge (Chimowa and Nugent, 1993).

A study in Albania showed that irrigated agriculture is one of the most essential sectors of this region which in the prevailing situation considers more than 50 percent of GDP and employment. Due to the importance of this sector and the need for irrigation the irrigation water quality plays an important role in this sector (Cabej et al. 1999).

A study was done in the two areas of South Africa namely Western Cape (winter rainfall, temperate, south-western coast) and Mpumalanga (summer rainfall, tropical, eastern coast). Multivariate analyses found that the changes in macro invertebrate indices and the stream's physico-chemistry were more strongly correlated with the density of small dams in the catchment (as a measure of cumulative impact potential) relative to the storage capacity of large dams. Regional differences were apparent in the results for discharge reductions and the macro invertebrate index. The results suggest that the cumulative effect of a high number of small dams is impacting the quality and quantity of waters in South African rivers and that these impacts need to be systematically incorporated into the monitoring protocol of the environmental water requirements (Mantel, Sukhmani K, 2010).

Many small reservoirs are found all over the semi-arid areas but efficient management and the planning of further dam development is hindered by a lack of basic information. Reliable, up-to-date information on the number, location and storage volumes of existing reservoirs is hardly ever available from official sources as their planning and construction is oftentimes neither coordinated nor inventoried. In the Upper East Region of Ghana we have shown that the evaluation of satellite images is a useful tool in making region wide and up-to-date reservoir inventories. Even reservoir storage volumes can be determined as a function of reservoir surface areas using regional area-volume relations. Such relations can be derived from few bathymetric surveys of reservoir basins (Liebe et al., 2005).

Rural populations in some areas are dependent on small reservoirs for their water supply and are concerned about the quality of this water for direct consumption and other uses. Such concerns can be raised by what appears to be water pollution or by disease symptoms perceived to be water related. In these cases chemical and biological water quality measurements can be taken to ascertain the suitability of water for different uses. Water "suitability" of course depends on the use for which it is intended. Brick making, livestock watering, fisheries or irrigation have different water quality requirements. These activities, in turn can affect water quality Reservoir users can assess water quality through simple methods such as observing its color, transparency, taste and smell. These methods require no financial resources and are within the reach of even the very poor (WHO Guidelines for drinking water, 2004).

Nearly all waters contain dissolved salts and trace elements many of which result from the natural weathering of the earth's surface. Drainage waters from irrigated

Lands and effluent from sewage city and industrial waste water can affect water quality. In irrigated areas, the basic water quality relevant is level of salinity, since salts can affect both the soil structure and crop yield. However, a number of trace elements are found in water which can limit its use for irrigation. Generally, “salt” is thought of as ordinary table salt (sodium chloride). But, several types of salts are present in waters. Most salinity problems in agriculture result directly from the salts carried in the irrigation water. Salts as well as other dissolved substances begin to accumulate as water evaporates from the surface and as crops withdraw water (Richards, 1954).

The most harmful impact of poor-quality water used in irrigation is excessive deposition of soluble salts and/or sodium in soil. These highly soluble salts in the soil make soil moisture more difficult for plants to extract, and crops become stressed. Clay and humus. Particles accumulate due to accumulation of excessive sodium to float into and plug up large soil pores. This action decreases water movement into and through the soil, thus crop roots do not get enough water even though water may be standing on the soil surface. These two aspects of irrigation water (total salts and percent sodium) are grouped in relation to the levels present and their effects on crops and soils. This classification system is based on research conducted in Oklahoma, other states, and by the USDA Salinity Laboratory at Riverside, California in year 2010.

More sophisticated technical methods can be used by water managers to monitor changes in reservoir water quality. These include analysis of biomedical (e.g. fecal streptococci, total coliforms, fecal coliforms, Cryptosporidium, Giardia); biological (e.g. chlorophyll as indicator of eutrophication); and physio-chemical (e.g. EC, pH, hardness, nitrate, chloride, phosphorus) parameters. It also helps to identify sources of pollutants and their loading. Changes in plankton diversity and abundance can be used as an indirect assessment of water quality, to ascertain how various land and water uses impact water quality(Fernando, 2002)

Advances in the field of data interpretation and analysis have necessitated the use of powerful tools within the computer environment. The set of tools applicable to the geographical data constitutes the Geographic Information System (GIS). GIS is a software and hardware tool applied to geographical data for integration of collection, storing, retrieving, transforming and displaying spatial data for solving complex planning and management problems. This tool (software and hardware) has made the data handling and analysis much easier with meaningful research outcomes. GIS has the advantage of handling attribute data in conjunction with spatial features, which was totally impossible with manual cartographic analysis. It stores both spatial and non spatial data layer by layer either in raster or vector format. The linking of modeling concepts with the GIS domain is proved useful in development of a Decision Support System (DSS) and expert system based on heuristic logic. This tool makes the data handling job easier and meaningful. It is more versatile for analyzing a large data base and large areal extent. GIS facilitates repetitive model application with considerable ease and accuracy (Grayson et al. 1997).

Traditional catchment-scale water quality assessments are based on monitoring chemical and biological indicators at selected sites to observe long-term trends and develop causal relationships with land-use practices. Due to the spatial distribution of non-point sources, locating the precise origin and triggering of water quality exceedance events is difficult from historical measurements at a few sparse sites. For this reason, Grayson et al. (1997) and Eyre & Pepperell (1999) advocate the use of short-duration, spatially extensive water quality sampling campaigns during steady-state conditions.

This sampling methodology provides an instantaneous view of the spatial variation of water quality under stable, low flow conditions. However, during storm events when water quality exceedances are typical (Nolan et al. 1995), the steady-state "snapshot" sampling strategy is not appropriate for discerning water quality variations within a large regional watershed (Grayson et al. 1997). Diagnosing the spatial distribution of water quantity and quality during storm events requires incorporating field measurements into watershed simulation models. Although water quality modeling studies abound (e.g. Tim et al. 1992; Laroche et al. 1996; Leo´ n et al. 2001; Engelmann et al. 2002), typical applications do not consider spatial variability of point or non-point source pollutants due to the lack of appropriate field data. The conjunctive use of field sampling and hydrologic and water quality (H/WQ) modeling has the potential for providing continuous, spatially distributed predictions under most hydro meteorological conditions, including flooding events. In addition, a distributed H/WQ simulation tool could be used for predicting water quality variations at spatial and temporal scales beyond the field monitoring extent.

To improve H/WQ studies in large regional basins, an efficient means is sought for monitoring and simulating the spatial and temporal variations in hydrologic and water quality parameters. The integrated use of GIS-based sampling and modeling during a H/WQ study is a means for (1) efficiently gathering field data at sites critical to the model application, (2) merging field data with historical records at selected model-specific sites, (3) corroborating existing maps through field verification for model input,

(4) enhancing the geospatial details of the model application via field observations and (5) conducting continuous and spatial simulations during and beyond the sampling period. The proper integration of the GIS-based sampling and modeling technologies would allow the field experimentalist and the computer modeler to better understand the watershed system under study (e.g. Siebert & McDonnell 2002). While the tight coupling between the GIS-based field sampling and modeling is desirable, a reasonable first step towards this goal is to utilize the two technologies in a loosely coupled fashion. Since the data collection and simulation efforts are conducted within a GIS system, a seamless integration is possible of the geospatial coverage, field observations and data, historical records, model forcing and model output Loose coupling between the two GIS-based technologies is achieved via: (1) utilizing geospatial watershed data verified in the field to setup the H/WQ model, (2) developing a modeling domain based on sampling sites from historical and spatially extensive studies, (3) using geospatial data to force the continuous H/WQ model and (4) comparing spatial model output to the historical and field data at numerous sampling sites. Furthermore, the integrated use of GIS-based field data in the H/WQ model can lead to enhancements in both activities by exposing deficiencies in the sampling plan or in the model simulation. These deficiencies can be corrected through an iterative process of refinement of the field data collection and model application. For example, field data can be used for updating model parameters and the modeling results can be used to target sampling efforts.

CHAPTER - 3

MATERIAL, METHODS and PROCEDURES

3.1 Study Methodology

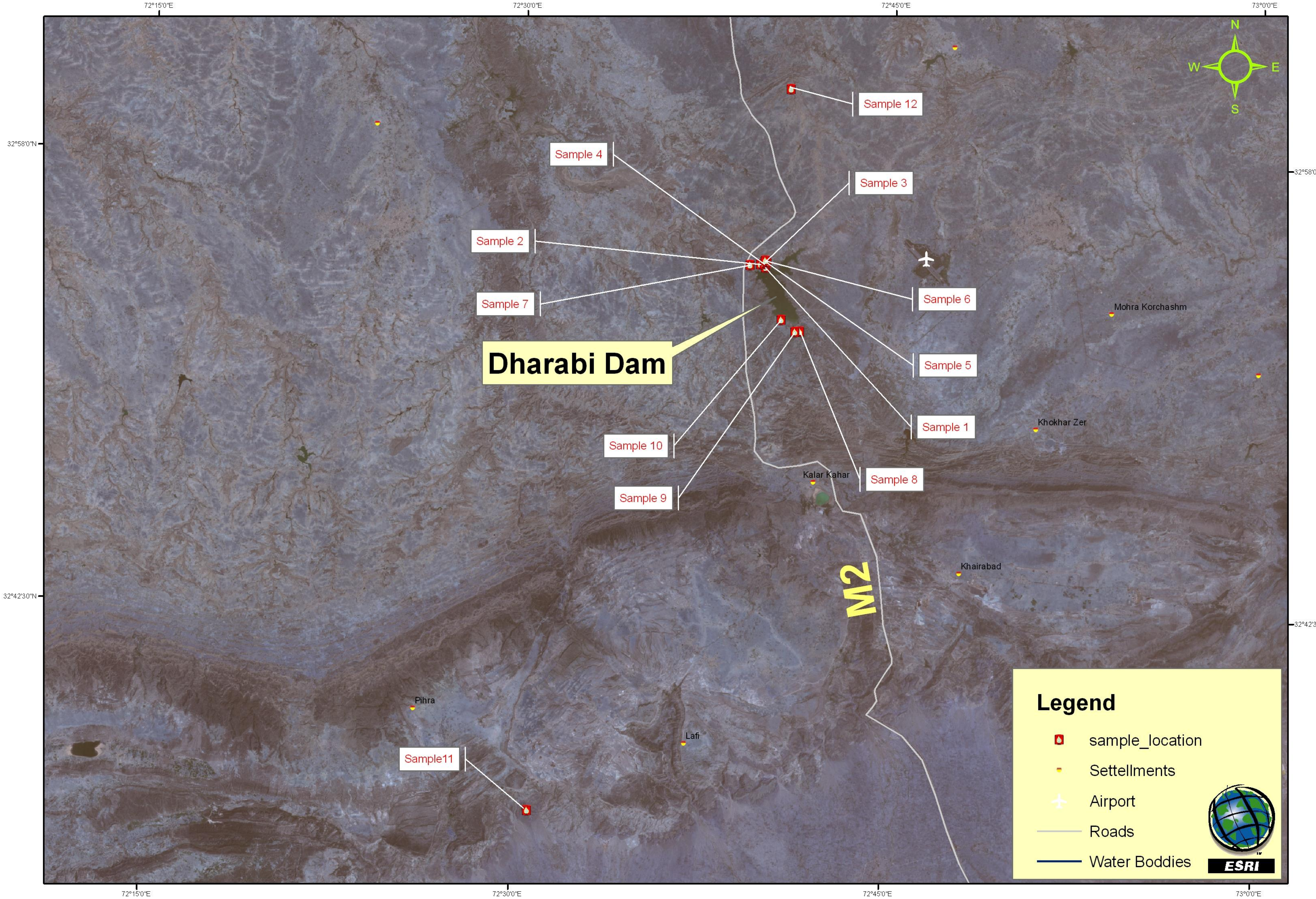
The methodology adopted for the sampling and analysis of water resources of the selected dam site is described below. Broadly the tasks undertaken included:

- Development of a sampling and spot testing plan for water quality for surface water.
- Identification of suitable sampling points and
- Implementation of quality control and assurance protocols during sampling, spot testing, sample handling, transportation and laboratory testing.

3.2 Identification of Sampling Locations

The water sampling locations were carefully selected in order to represent the exact picture of the study area. The idea of collecting the most representative samples was kept in mind while finalizing the locations.

Water Sample Location Map



Surface Water Quality Parameters (Parameters considered)

Sr. No	Parameters
1	Temperature
2	PH
3	Color
4	Turbidity
5	Calcium
6	Magnesium
7	Hardness
8	Alkalinity
9	Bicarbonates
10	Carbonates
11	Chlorine
12	Sodium
13	Flourine
14	Potassium
15	Nitrate
16	Sulphate
17	Coli form
18	Fecal coliform
19	TDS

3.3 Sampling Procedures

Standard sampling procedures were followed by the field analysts at each sampling location to ensure the integrity of the samples collected and validity of test results. The sampling procedures followed by the field analysts throughout the filed sampling and testing are given below:

a) Polyethylene bottles were used to collect the water samples. For microbiological ssampling, sterilized glass containers were used.

b) Manual sampling procedures were adopted for the collection of water samples. Extreme care was taken during the sampling and only trained persons were entrusted the task of sampling.

c) Sterilized bottles were kept at 4°C in an ice box.

d) Standard sample transfer procedures were followed to avoid confusion in sample identification, including labeling and safe transportation to the laboratory at Islamabad for further analysis.

e) Sample bottles were given identification numbers immediately after the samples were collected.

GIS, GPS and Image Processing

LandSat TM imagery was provided by Wetlands, The Ministry of Environment's Pakistan Wetlands Program. The Satellite Image was first rectified and geometrically (procedure that corrects spatial distortions in an image) corrected so that GPS data can be overlapped with the Satellite data. Hybrid method (It is the use of both classifications techniques i.e. unsupervised classification followed by supervised classification) was carried out. Unsupervised classification is a means by which pixels in an image are assigned to spectral classes without the user having foreknowledge of the existence or names of those classes. The analyst then identifies those classes afterwards by associating a sample of pixels in each class with available reference data, which could include maps and information from ground visits.

LandSat TM data was classified into seven classes

1. Water bodies
2. Vegetation
3. Rock
4. Urban and Bare soil
5. Shrubs

6. Non-Vegetated

7. Bare Land

3.4 GIS

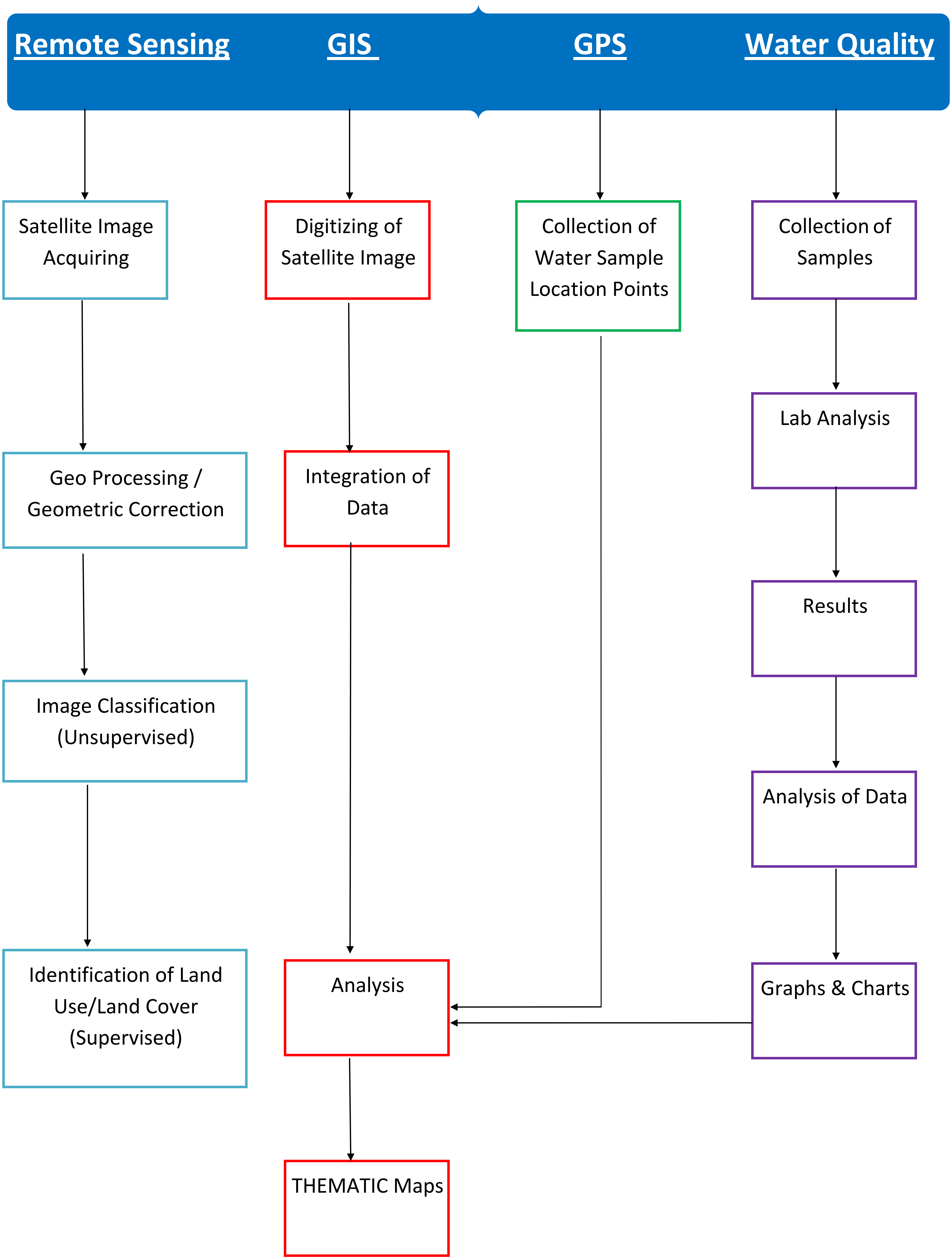
A geographical information system (GIS) was used to provide the spatial context for advancing the state-of-the-art in water quality sampling. Through the explicit representation of geographic location, GIS-enabled technologies capture the spatial variability inherent in sampled environmental parameters. Although various studies have integrated H/WQ models and GIS (e.g. Vieux 1991; Sui and Maggio 1999), the use of GIS for water quality assessment has not been addressed previously.

3.5 Global Positioning Systems

Handheld GPS Garmin Map 76 was used to collect the location of the water sampling for quality analysis. Then GPS data was added with the map for visualization. This was done because water sampling should be done at the same location every time. Site maps often do not have water sampling locations included on the map and a GPS is useful for direction. GPS coordinates can be stored to quickly identify locations without the confusion that maps often cause in locating a site specific area.

3.6 Tools used:

1. ArcGIS 9.2
2. ERDAS Imagine 8.6
3. GPS Garmin Map 76 having accuracy 5 meter


Remote Sensing
GIS
GPS
Water Quality
Satellite Image Acquiring
Digitizing of Satellite Image
Collection of Water Sample Location Points
Collection of Samples
Lab Analysis
Geo Processing / Geometric Correction
Integration of Data
Results
Image Classification (Unsupervised)
Analysis of Data
Identification of Land Use/Land Cover (Supervised)
Analysis
Graphs & Charts
THEMATIC Maps

Chapter – 4

Results

4.1 OBJECTIVES

The main objective of this study is to characterize surface-water quality of Dharabi dam with respect to various physio-chemical and biological parameters. Also the development of different types of thematic maps of the area with the help of GIS and remote sensing techniques for the visual representation.

4.2 Surface Water Quality Analysis

The surface water quality analysis has been done from the point of view of determining the suitability of water for aquatic flora & fauna and to determine the pollution load in the surface water which could affect the ecology of the water body. The suitability of surface water for irrigation purposes (where applicable) can also be assessed from these analyses. Nineteen (19) important parameters of physical as well as chemical elements from twelve (12) different sampling points have been collected and analyzed. In addition to the physical, chemical parameters and microbiological analysis was also done to determine the quality of water for various purposes. As mentioned earlier, 19 parameters of physical as well as chemical elements were selected and analyzed to assess the surface water quality. Parameters used for physical, chemical and biological analysis of the surface water quality are presented in table 1, 2 and 3 respectively.

Table4.1. Parameters used for Physical analysis of the surface water quality

Samples	Turbidity	Color	pH	EC	TDS
Units	NTU	**-**	**-**	μs/cm	ppm
1Sample	5.1	Colorless	8.46	952	571
Sample 2	5.2	Colorless	8.45	956	574
3Sample	7.4	Colorless	8.46	953	572
4Sample	5.4	Colorless	8.45	957	574
5Sample	8.2	Colorless	7.66	960	576
6Sample	19.6	Colorless	8.45	948	569
7Sample	25.3	Light Turbid	8.49	945	567
Sample 8	30.00	Muddy	7.6	786	472
Sample 9	38.20	Muddy	7.42	719	431
Sample 10	70.00	Muddy	7.76	975	585
Sample 11	36.4	Light Turbid	8.3	902	542
Sample 12	99.00	Muddy	7.44	291	160

Table4.2. Parameters used for chemical analysis of the surface water quality

Samples	Ca	Mg	Hardness	Alkanity	HCO_3	CO_3	Cl	Na	F	K	NO_3	SO_4
Units	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Sample 1	24	29	180	255	235	20	128	132	0.94	4.7	1	79
Sample 2	24	29	180	260	240	20	124	132	0.88	4.5	1	77
Sample 3	26	24	165	265	250	15	119	140	0.87	4.5	4	71
Sample 4	24	27	170	260	240	20	120	145	0.9	4.4	1	71
Sample 5	28	24	170	270	270	BDL	124	145	0.88	4.8	1	81
Sample 6	26	22	155	265	245	20	121	140	0.93	4.7	1	71
Sample 7	22	26	160	260	240	20	112	144	0.93	4.8	1	86
Sample 8	34	21	170	190	190	BDL	78	98	0.91	5.2	3	104
Sample 9	32	23	175	170	170	BDL	80	82	0.75	4.6	3	102
Sample 10	24	27	170	270	270	BDL	120	146	0.94	5.00	1	70
Sample 11	30	24	175	280	280	BDL	130	135	0.87	4.5	1	20
Sample 12	24	16	125	145	145	BDL	4	5	0.15	10.2	1	2

Table4.3. Parameters used for Biological analysis of the surface water quality

Samples	**Total - coli form**	**Fecal Coli form**
Units	MF/100ml	MF/100ml
Sample 1	120	80
Sample 2	160	100
Sample 3	250	180
Sample 4	150	100
Sample 5	300	200
Sample 6	400	250
Sample 7	425	265
Sample 8	450	270
Sample 9	470	283
Sample 10	210	95
Sample 11	180	70
Sample 12	250	195

4.3 Surface Water Quality Parameters

The water quality standards vary according to the ultimate usage of water. Drinking water quality standards are more stringent than the water quality standards for irrigation water or standards for discharges to the surface bodies. The Pakistan Environmental Protection Act N0. XXXIV of 1997 contains only the standards for municipal and industrial wastes discharges to surface stream. However, no standards have been fixed for irrigation, surface water or drinking water by Pakistan Environmental Protection Agency (Pak EPA). The results of surface water quality were compared with National Environmental Quality Standards (NEQS) as well as other international standards such as United States-Environmental Protection Agency (US EPA), Food and Agriculture Organization (FAO) and World Health Organization (WHO) where applicable and/or available. In order to establish the water quality baseline conditions the surface water quality of Dharabi dam was assessed at twelve different locations.

4.4 Test Results of Surface Water Quality

Parameter of surface water quality such as temperature was analyzed on-site with the help of appropriate and calibrated thermometer. All other parameters were analyzed in the laboratory. Samples of surface water from different sampling points were collected in sterilized bottles and transported in a potable cooler to the laboratory in Islamabad. It was ensured by the Laboratory analysts that all water samples were collected and preserved in appropriate containers as per guidelines. The results were compared with NEQS as well as other international standards such as US EPA- National Water Quality Criteria (NWQC).

4.5 Description of Surface Water Parameters

In the following parameters used to determine physical and chemical aspects of water quality are described. These contaminants are present in water where they enter from different sources.

4.6 Physical Parameters

The physical parameters include such as Color, Turbidity, Hardness, TDS and PH. The physical parameters observed in our study was explained with their results in the following section.

4.6.1 Turbidity

Turbidity is a measure of the cloudiness of water; the cloudier the water, the greater the turbidity. Turbidity in water is caused by suspended matter such as clay, silt, and organic matter and by plankton and other microscopic organisms that interfere with the passage of light through the water. Turbidity is closely related to total suspended solids (TSS), but also includes plankton and other organisms. Turbidity itself is not a major health concern, but high turbidity can interfere with disinfection and provide a medium for microbial growth. It also may indicate the presence of microbes. Ecological and health impacts of turbid water depend upon the type and amount of suspended solids. As the amount of suspended solids detected in the dam remained high therefore, the level of turbidity also remained high (Fig. 1). This high turbidity level can be attributed to the presence of contaminations as a result of sewage effluents in the water body. The 1 – 5 samples showed satisfaction result where as the samples 6 – 12 showed high amount Turbidity. The required value of turbidity should be less then 5 NTU.

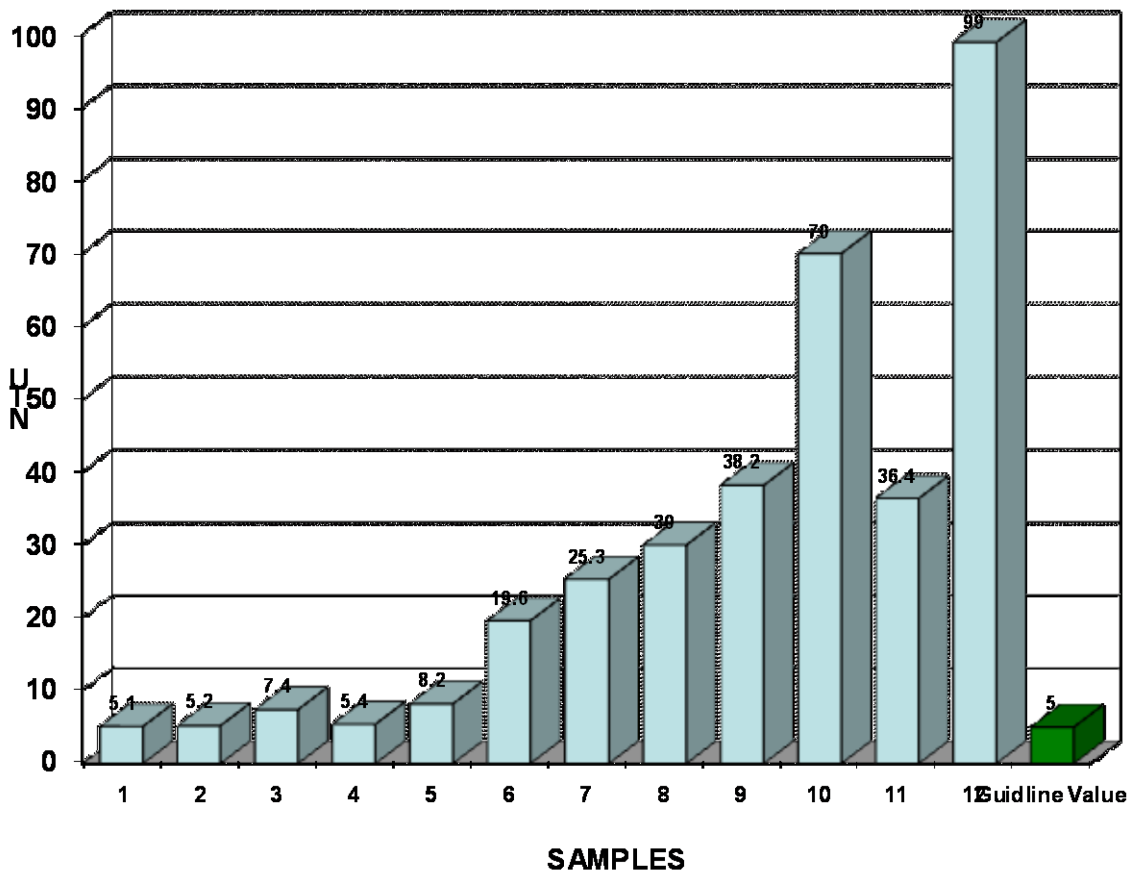


FIGURE.1 TURBIDITY OF WATER

4.6.2 Color

The color of the samples collected showed some variation. The Number of 4 samples found Muddy and two samples found light Turbid and where as the rest of them found colorless. The Required Standard of color must be colorless and light turbid according to WHO.

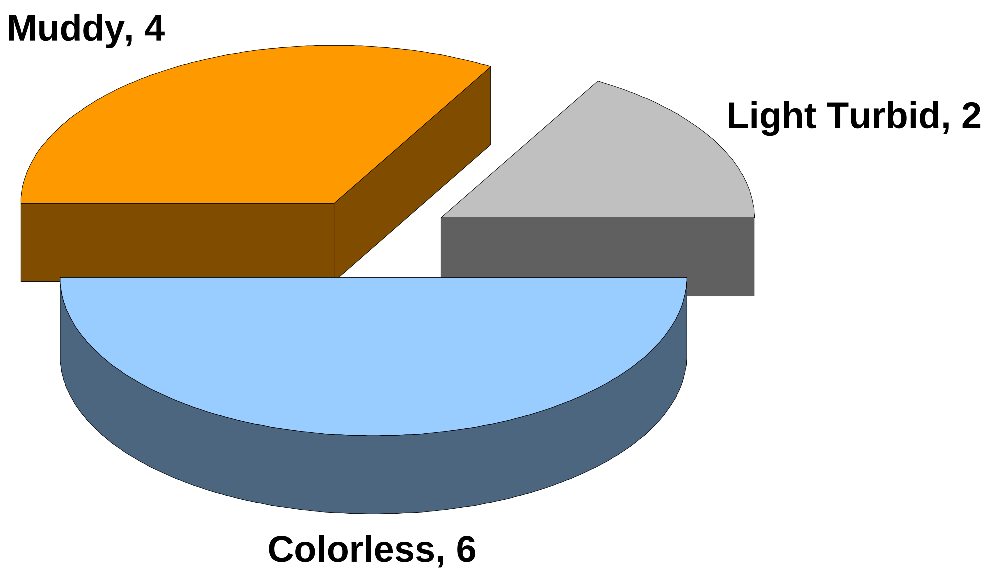


FIGURE. 1B: COLOUR OF WATER

4.6.3 pH

The pH is an indication for the acidity or basicity of a substance. It is determined by the number of free hydrogen ions (H^+) in a substance. The pH is an important factor, because certain chemical processes can only take place when water has a certain pH. For instance, chlorine reactions only take place when the pH has a value of between 6.5 and 8. Water is a solvent for nearly all ions. The pH serves as an indicator that compares some of the most water-soluble ions. The outcome of a pH measurement is determined by a consideration between the number of H^+ ions and the number of hydroxide (OH^-) ions. When the number of H^+ ions equals the number of OH^- ions, the water is neutral and it will than have a pH of about 7. The pH of water can vary between 0 and 14. When the pH of a substance is above 7, it is a basic and when it is below 7, it is an acidic substance. Measurement of pH is one of the most important and frequently used tests in water chemistry. Particularly every phase of water supply and wastewater treatment, e.g. acid based neutralization, water softening, precipitation, coagulation, disinfection and corrosion control is pH dependent. According to US EPA freshwater standards, pH of a river or a stream should not be less than 6.5 and not be more than 8.5. According to WHO, desirable pH for drinking water is 6.5 to 8.5. As per Pakistan NEQS the pH value for municipal and industrial effluents should be in between 6 to 9. pH results of water samples are shown in figure 2. And the level of PH in all samples was good.

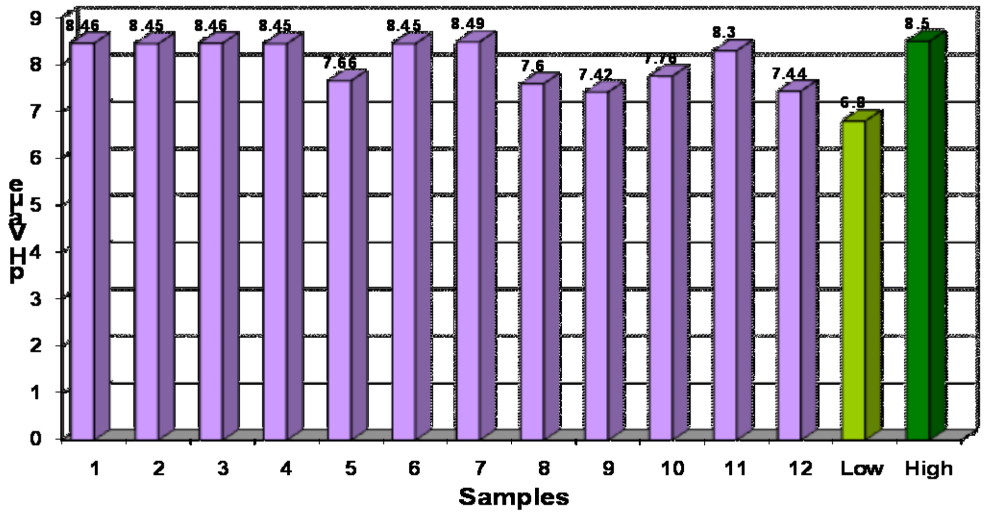


Figure 2: pH of Water

4.6.4 Temperature

In a qualitative manner the temperature of an object is that which determines the sensation of warmth or coldness felt from contact with it. In limnological studies water temperatures as a function of depth often are required. Temperature change can lead to disturb the natural setting of an aquatic ecosystem. Hot water released in a water body causes scorching of plants and put severe stress on organisms. It can deplete the key gaseous components of water as oxygen and carbon dioxide and can increase the dissolution of metals from sediments to water. These happenings would disturb the nutrient balance and metabolic processes occurring in the water body that causes long chain adverse impacts on the health of the water body. There are no US EPA standards established for temperature. But it should not be changed beyond natural seasonal fluctuations. The water temperature of Dharabi dam during the month of August was recorded between 27°C to 28°C.

4.6.5 Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) are solids in water that can pass through a filter (usually with a pore size of 0.45 micrometers). TDS is a measure of the amount of material dissolved in water. This material can include carbonate, bicarbonate, chloride, sulphate, sodium, organic ions and other ions. TDS is used to estimate the quality of drinking water because it represents the amount of ions in the water. Water with high TDS often has a bad taste and/or high water hardness and could result in a laxative effect. High TDS water is less thirst quenching and can interfere with the taste of foods and beverages and make them less desirable to consume. Some of the individual the tested samples shows values with in specified limits as shown in figure 3. The expert Opinion do recommended a value of around 200 to 300 mg/l for this parameter.

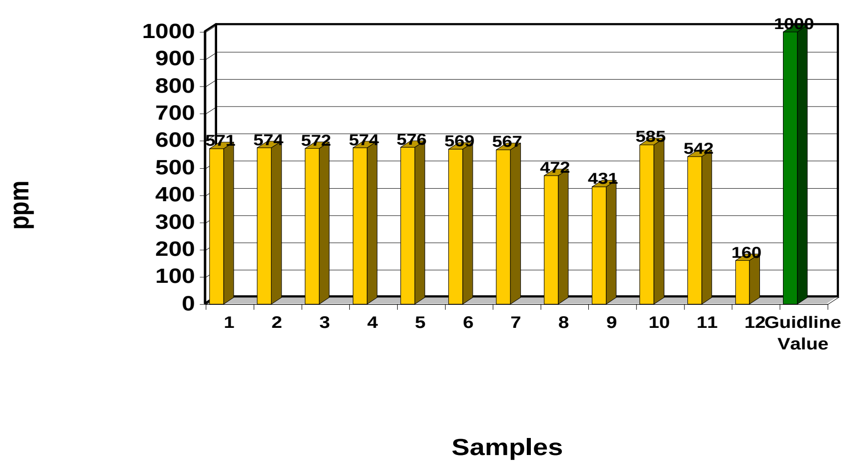


Figure 3: Total Dissolved Solids

4.6.6 Electrical Conductivity (EC)

All waters contain dissolved salts which dissociate into ions. Ions are electrically charged particles made up of individual elements or combinations of elements. The addition of fertilizers to irrigation waters increases the concentrations of positively charged ions (cations) and negatively charged ions (anions). Some of these ions such as sodium, calcium, magnesium, potassium, chloride, sulfate, nitrate, phosphate etc. have the greatest impact on irrigation water quality. Other ions of concern from the standpoint of plant nutrition include copper, zinc, manganese, iron, molybdenum and boron. Ions which may be potentially toxic to plants at high enough concentrations include fluoride and lithium. Electrical conductivity of water (EC) is a measurement of the ability of solutions to conduct electricity. Generally speaking the higher the mineral content (ions in solution) of water the greater the capacity of the solution to conduct electricity and the accompanying conductivity reading. There are no specific standards set for electrical conductivity either by US EPA or Pakistan NEQS. However, greater values of conductivity expressed the greater concentrations of ions in the water. The conductivity value at Dharabi dam is recorded very high Figure 4. There is no guideline value set and provided by the WHO and PCRWR standards. However it is recommended to have a value of <1000 µs/cm for this parameter. Which is generally equivalent to TDS value of <500 mg/l considered to be highest desirable level suggested in PCRWR standards. The electric conductivity observed in Dharabi dam was above the limits.

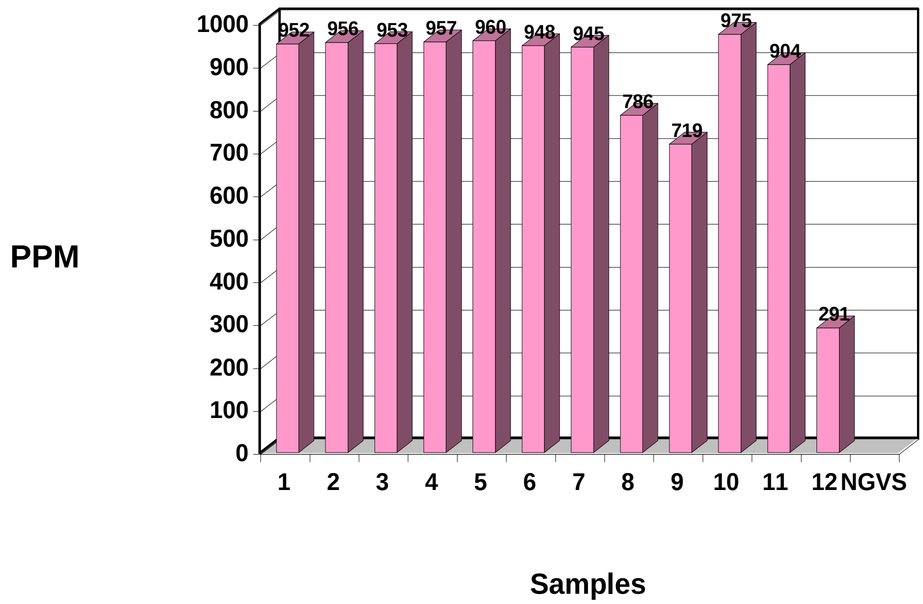
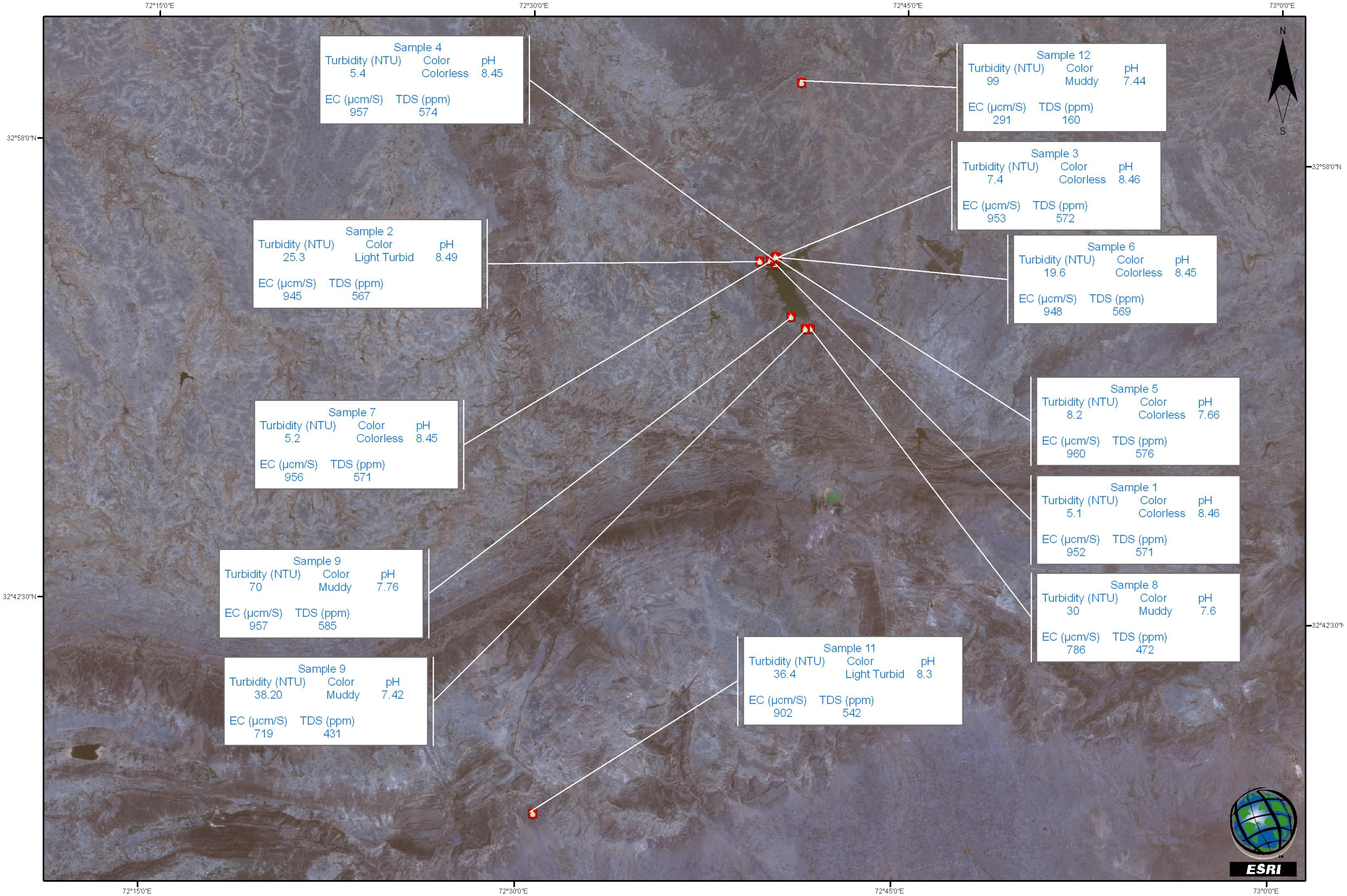
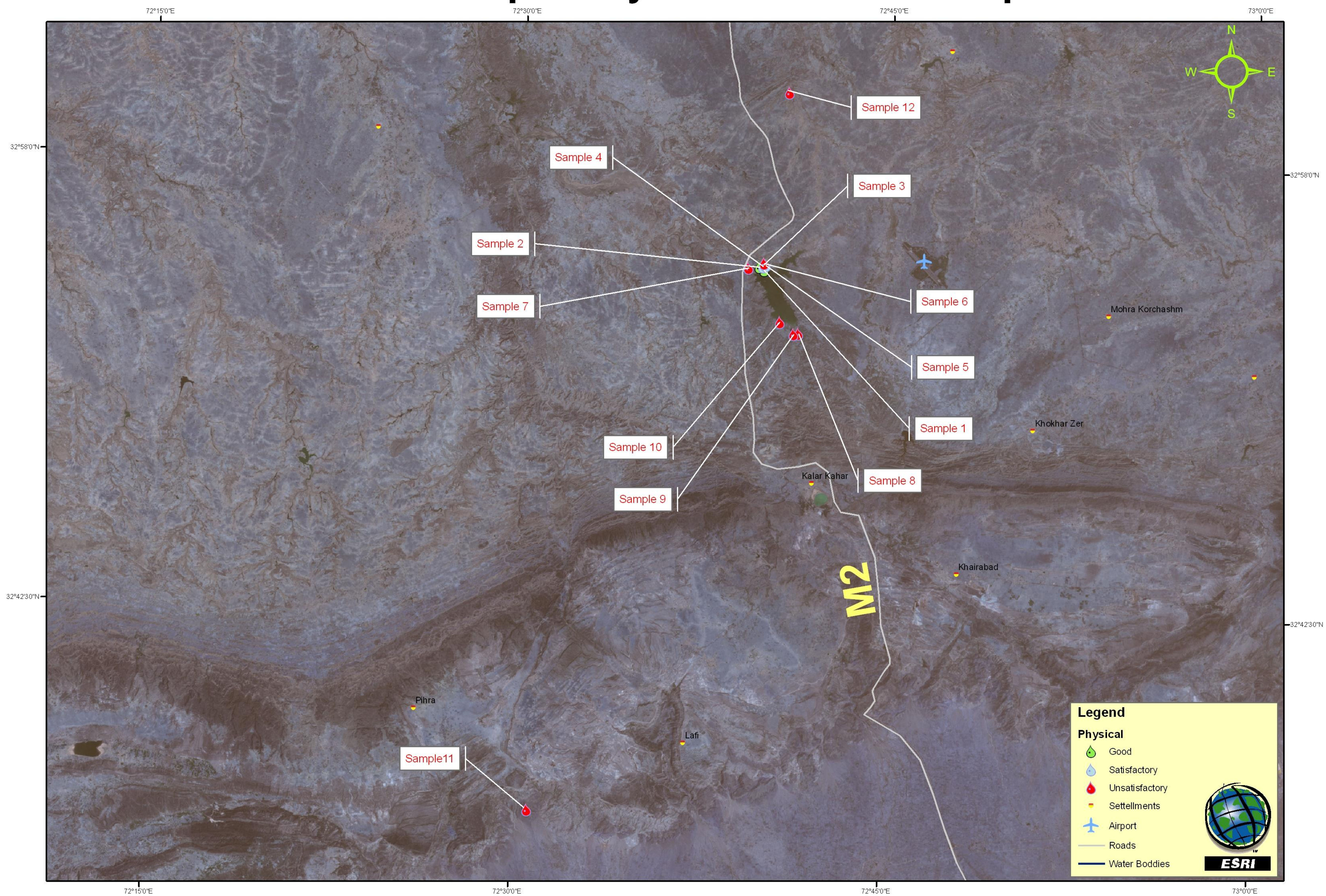


Figure 4: Electric Conductivity of Water

Geographical Representation of Physical Parameters



Water Sample Physical Condition Map



4.7 Chemical Parameters

The chemical parameters include Calcium, Magnesium, Chloride, Fluoride, Potassium, nitrate, nitirte, Sulphate, Carbonates, Bicarbonates, Alkanity,sodium and hardness. The chemical analysis conducted are illustrated under.

4.7.1 Calcium (Ca)

Calcium occurs in water naturally. Seawater contains approximately 400 ppm calcium. One of the main reasons for the abundance of calcium in water is its natural occurrence in the earth's crust. Calcium is also a constituent of coral. Rivers generally contain 1-2 ppm calcium, but in lime Areas Rivers may contains calcium concentrations as high as 100 ppm. Examples of calcium concentrations in water organisms: seaweed luctuca 800-6500 ppm (moist mass), oysters approximately 1500 ppm (dry mass). In a watery solution calcium is mainly present as Ca^{2+} (aq), but it may also occur as $CaOH^{+}$ (aq) or $Ca(OH)_2$ (aq), or as $CaSO_4$ in seawater. Calcium is an important determinant of water hardness and it also functions as a pH stabilizer because of its buffering qualities. Calcium also gives water a better taste the concentration of calcium in Dharabi dam was satisfactory Figure 5.There is not NGVS value set for calcium according to WHO and PCRWR for the irrigation purpose but for drinking purpose there are some standards.

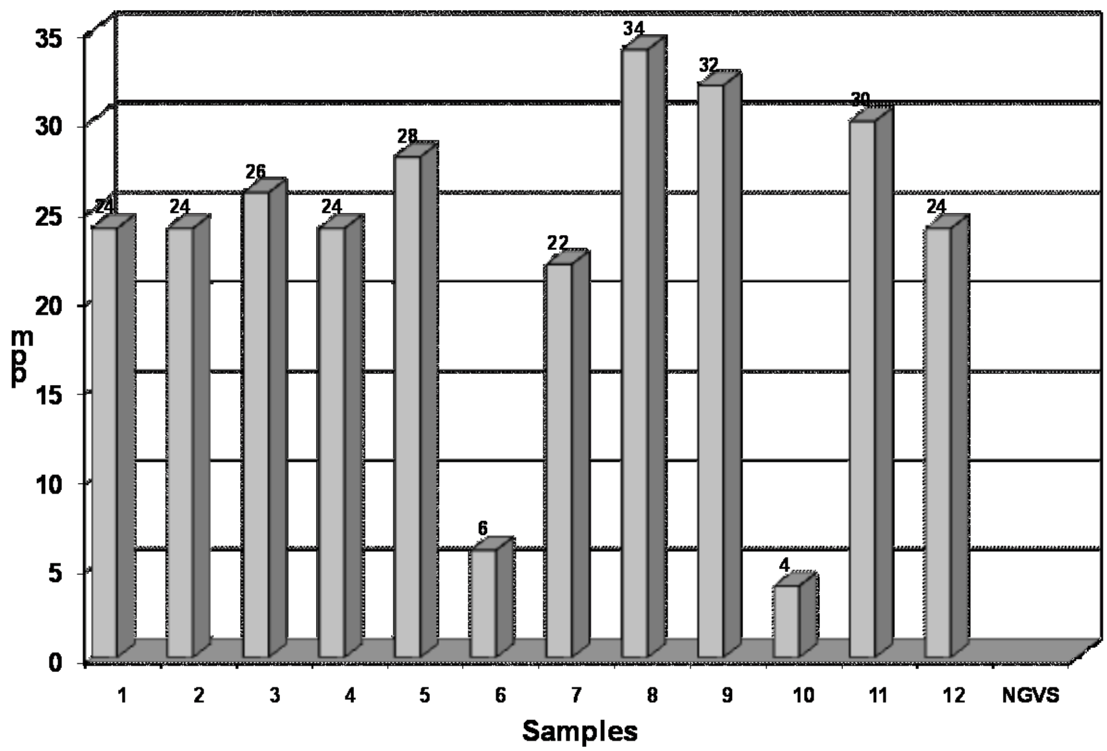


Figure . 5: Calcium Level in Water

4.7.2 Magnesium (Mg)

Magnesium is present in seawater in amounts of about 1300 ppm. After sodium it is the most commonly found cation in oceans. Rivers contains approximately 4 ppm of magnesium marine algae 6000 -20,000 ppm and oysters 1200 ppm. Dutch drinking water contains between 1 and 5 mg of magnesium per liter. Magnesium and other alkali earth metals are responsible for water hardness. Water containing large amounts of alkali earth ions is called hard water and water containing low amounts of these ions is called soft water. The concentration of magnesium in water was higher in our study Figure 6. The magnesium values varies in the figure the water sample ranges from 28 – 34 ppm which are well within the range of limits as 30 mg/l to 150 mg/l set by PCRWR.

This trend normally follow trend of calcium and have similar affects on body. Higher values are sometimes related to stomach disturbances in some of the people.

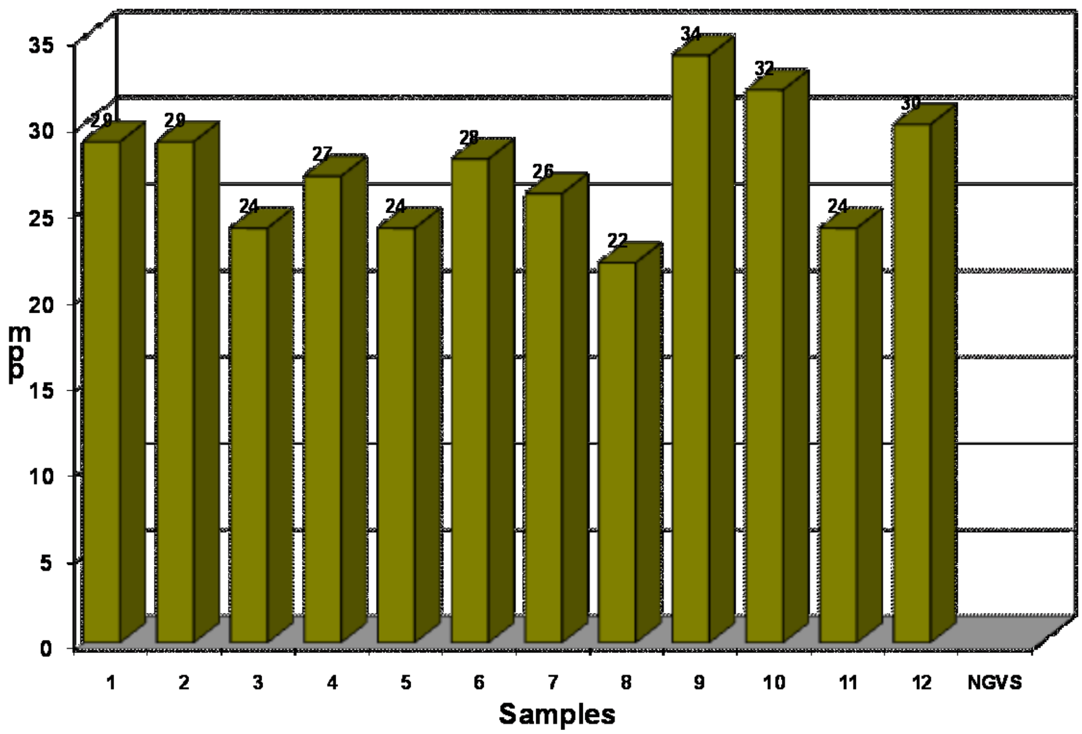


Figure.6: Magnesium Level in Water

4.7.3 Chlorine

Chlorine is a diatomic green gas and can react nearly with all other elements. Chlorine is extracted from chlorides through oxidation and more commonly by electrolysis and produced in large amounts. It is widely used both industrially and domestically as an important disinfectant and bleach. In particular it is widely used in the disinfection of swimming pools and treatment of drinking water. It is also used in manufacturing antiseptics, dyestuffs, insecticides, paints, medicines, plastics, solvents and many other consumer products. Effects of chlorine on human health depend upon the amount of chlorine, length and frequency of exposure and health condition of the person. Chlorine irritates skin, eyes, and respiratory system. Chlorine in water reacts with inorganic material to form salts and with organic material to form chlorinated organic chemicals that pose danger to aquatic life. Repeated exposure to chlorine can affect the immune system, blood, heart and respiratory system of animals. According to US EPA freshwater quality standards the acute limit for chlorine gas is 19µg/l and chronic limit is 11µg/l. WHO drinking water standard for chlorine is 5.0 mg/l. For municipal and industrial effluents as per NEQS the maximum limit is 1.0 mg/l. Sodium (Na) Sodium compounds naturally end up in water. In our study chlorine levels are shown in Figure 7.

The value of chlorine is < 250 ppm. The sample values as shown in the graph below show very low within the desirable limits. Higher values have contribution to the crossing nature of samples.

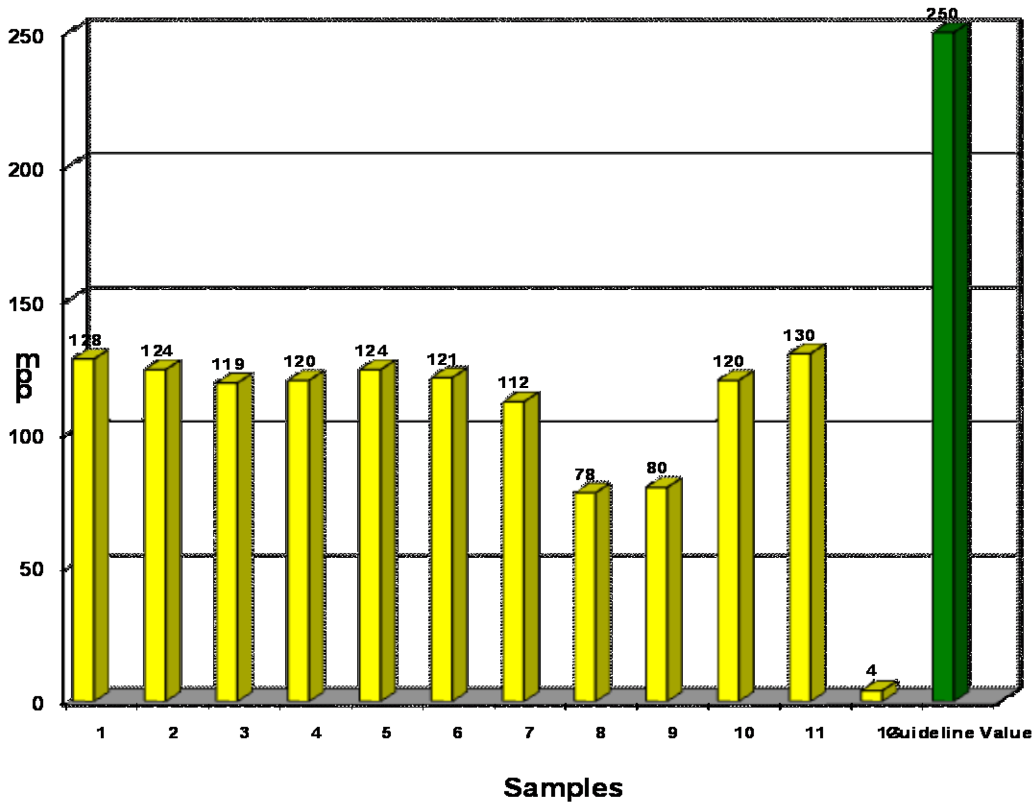


Figure. 7: Chlorine level in water

4.7.4 Fluoride

Fluoride accounts for about 0.3 g/kg of the Earth's crust and exists in the form of fluorides in a number of minerals. Fluoride is present in the body almost entirely in bone and teeth. Fluoride deficiency results in dental decay while its excess causes pain and tenderness in bones and mottled teeth in children. Fluoride concentration of approximately 1.0mg/l in drinking water effectively reduces dental caries without harmful effects on teeth and body. Sources of fluoride to water are water additives which promote strong teeth, erosion of natural deposits and discharge from fertilizer and aluminum factories. Therefore, fluoride may occur naturally in water or it may be added in control amounts. In rare instances the naturally occurring fluoride concentration may approach 10 mg/l in natural water. No guideline is given by US EPA for surface water fluoride however, according to NEQS for municipal and industrial effluents the maximum allowable concentration is 10 mg/l. At Dharabi dam the concentration of fluoride was observed as 0.94 mg/l Figure 8 and thus remained within the permissible limits of NEQS. Higher values of fluoride cause floursis and whereas lower values are some time considered as essential for healthy teeth and bones.

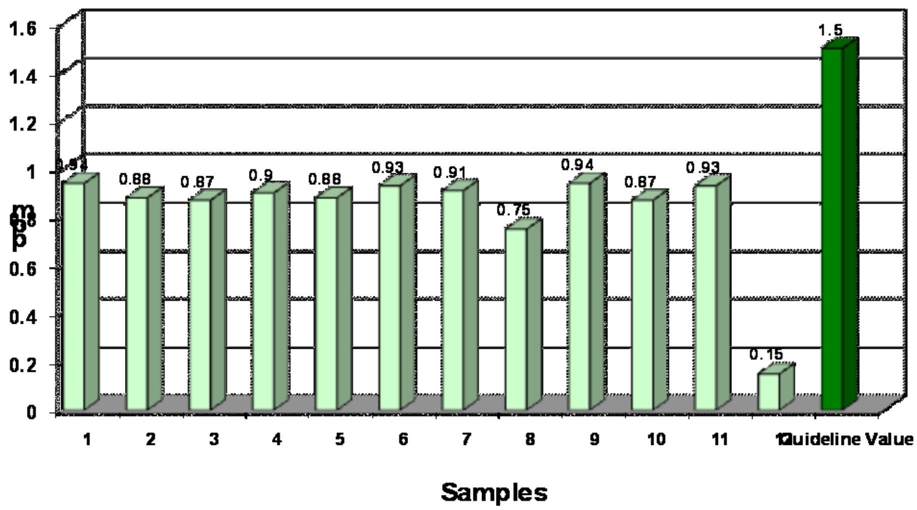


Figure 8: Fluorine level in Water

4.7.5 Potassium (K)

Rivers generally contains about 2-3 ppm potassium. This difference is mainly caused by a large potassium concentration in oceanic basalts. Calcium rich granite contains up to 2.5% potassium. In water this element is mainly present as K^+ (aq) ions. Potassium occurs in various minerals from which it may be dissolved through weathering processes. Examples are feldspars (orthoclase and microcline) which are however not very significant for potassium compounds production and chlorine minerals carnalite and sylvite which are most favorable for production purposes. Some clay minerals contain potassium. It ends up in seawater through natural processes where it mainly settles in sediments the concentration of potassium in the Dharabi dam was high Figure 9. There are NGVS for the potassium. The value is below any harmful level. However use of potassium salts is recommended to replace that of sodium for heart patients.

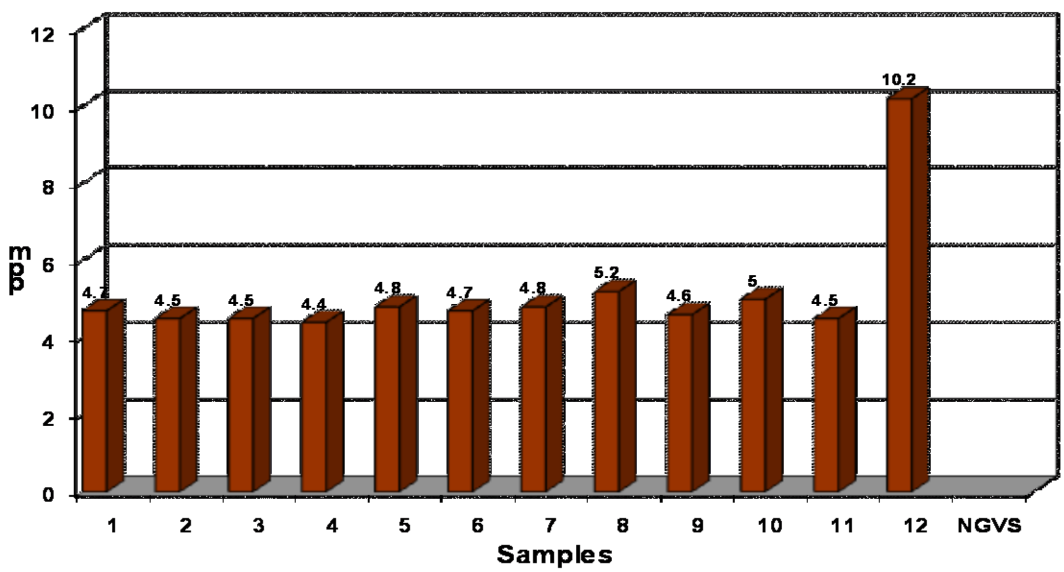


Figure. 9: Potassium level in Water

4.7.6 Nitrate and Nitrite (Nitrogen)

Nitrogen is one of the most abundant elements. About 80 percent of the air we breathe is Nitrogen. It is found in the cells of all living things and is a major component of proteins. Inorganic nitrogen may exist in the free-state as a gas N_2 or as nitrate NO_3.

Nitrogen-containing compounds act as nutrients in streams, rivers, and reservoirs. The major routes of entry of nitrogen into bodies of water are municipal and industrial wastewater, septic tanks, feed lot discharges, animal wastes (including birds and fish), runoff from fertilized agricultural field and lawns and discharges from car exhausts. Bacteria in water quickly convert nitrites to nitrates and this process uses up oxygen. Excessive concentrations of nitrites can produce a serious condition in fish called "brown blood disease." Nitrites also can react directly with hemoglobin in the blood of humans and other warm-blooded animals to produce methemoglobin. Methemoglobin destroys the ability of red blood cells to transport oxygen. This condition is especially serious in babies under three months of age. It causes a condition known as methaemoglobinemia or "blue baby" disease. Water with nitrate levels exceeding 1.0 mg/l should not be used for feeding Babies' High nitrates in drinking water can cause digestive disturbances in people. The major impact of nitrates/nitrites on freshwater bodies is that of enrichment or fertilization called eutrophication. Nitrates stimulate the growth of algae and other plankton which provide food for higher organisms (invertebrates and fish); however an excess of nitrogen can cause over-production of plankton and as they die and decompose they use up the oxygen which causes other oxygen-dependent organism to die. There are no standards set by Pakistan NEQS. The concentration of Nitrate at Dharabi dam was recorded as 0.6 mg/l Figure 10 that is considering as safe.

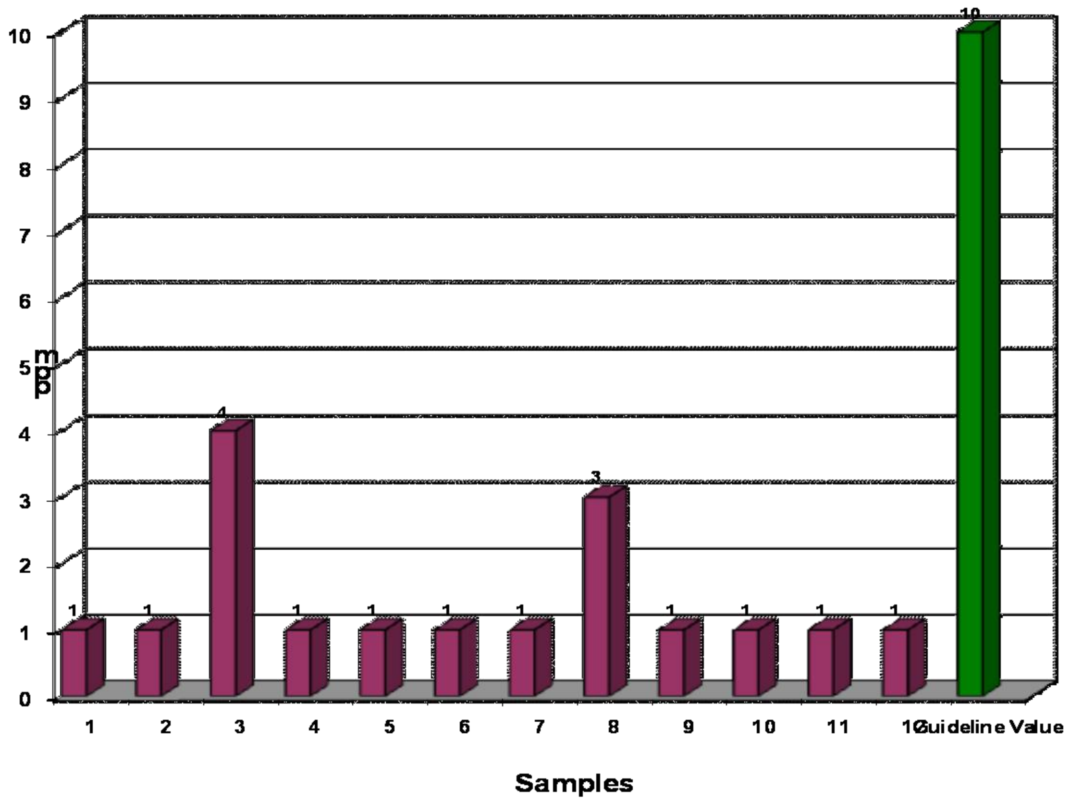


Figure. 10: Nitrate level in water

4.7.7 Sulphates

Sulphate (SO_4) is widely distributed in nature and can be found in almost all natural waters in concentrations ranging from a few to several thousand milligrams per liter. The origin of most sulphate compounds is the oxidation of sulphite ores the presence of shale's or the industrial wastes. Sulphate is one of the major dissolved components of rain. High concentrations of sulphate give a medical taste to water and make it undrinkable and it can also cause laxative effect when combined with calcium and magnesium the two most common constituents of hardness. People not used to drinking water with high levels of sulphate can experience dehydration and diarrhoea. The maximum level of sulphate suggested by WHO and US EPA in their drinking water guidelines is 250 mg/l. As per Pakistan NEQS the maximum allowable limit of sulphate for municipal and industrial effluents is 600 mg/l. Sulphate levels of water samples are presented in Figure 11. There are no NGVS for the sulphate in irrigation purpose but according to WHO standards the water should have 250 mg/l. The values observed in Dharabi dam lies within the desirable range.

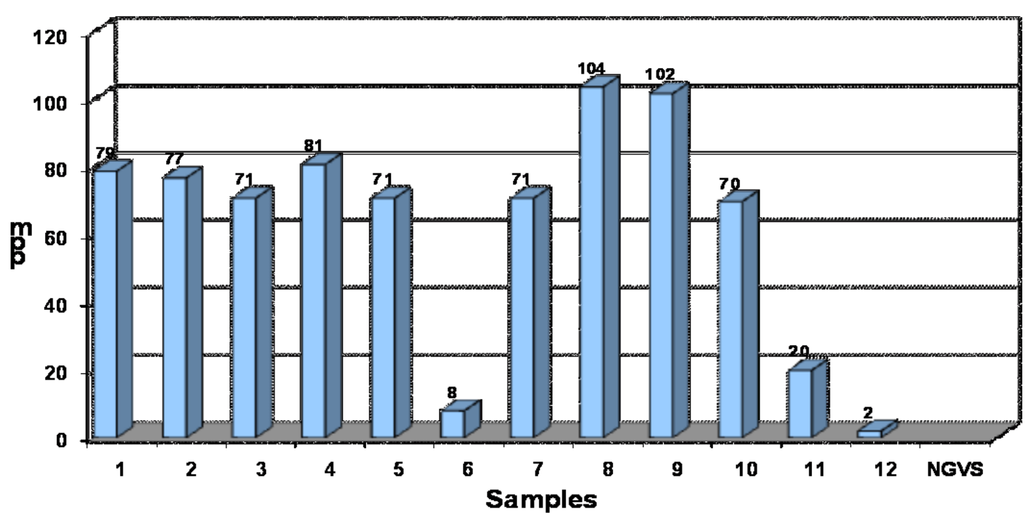


Figure. 11: Sulphate level in water

4.7.8 Carbonates and Bicarbonates

High carbonate ($CO_3^{=}$) and bicarbonate (HCO_3^{-}) increases SAR index (around >3-4mEq/L or >180-240mg/L). Let's explain why: Bicarbonate and carbonate ions combined with calcium or magnesium will precipitate as calcium carbonate ($CaCO_3$) or magnesium carbonate ($MgCO_3$) when the soil solution concentrates in drying conditions. The concentration of Ca and Mg decreases relative to sodium and the SAR index will be bigger. This will cause an alkalizing effect and increase the PH. Therefore when a water analysis indicates high PH level it may be a sign of a high content of carbonate and bicarbonates ions. In our study levels of bicarbonate and carbonate ions in water samples are shown in Figure 12 and Figure 13 respectively. There is NGVS for the carbonate and bicarbonates for the irrigation purpose but for drinking purpose according to WHO the limit values for them are within the given range which is < 500 mg/l and the value of carbonates in some samples are beyond the detection limit (BDL). These parameters are important in relation to the total of calcium, magnesium content and hardness of the sample. Higher values sometimes are connected with some corrosive properties and some time must be associated with taste forming properties.

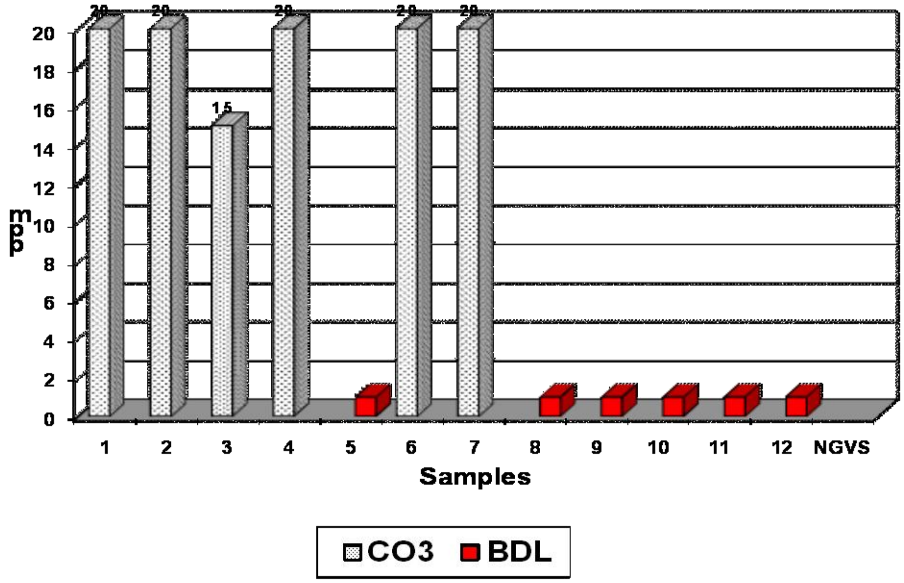


Figure. 12: Carbonates level in water

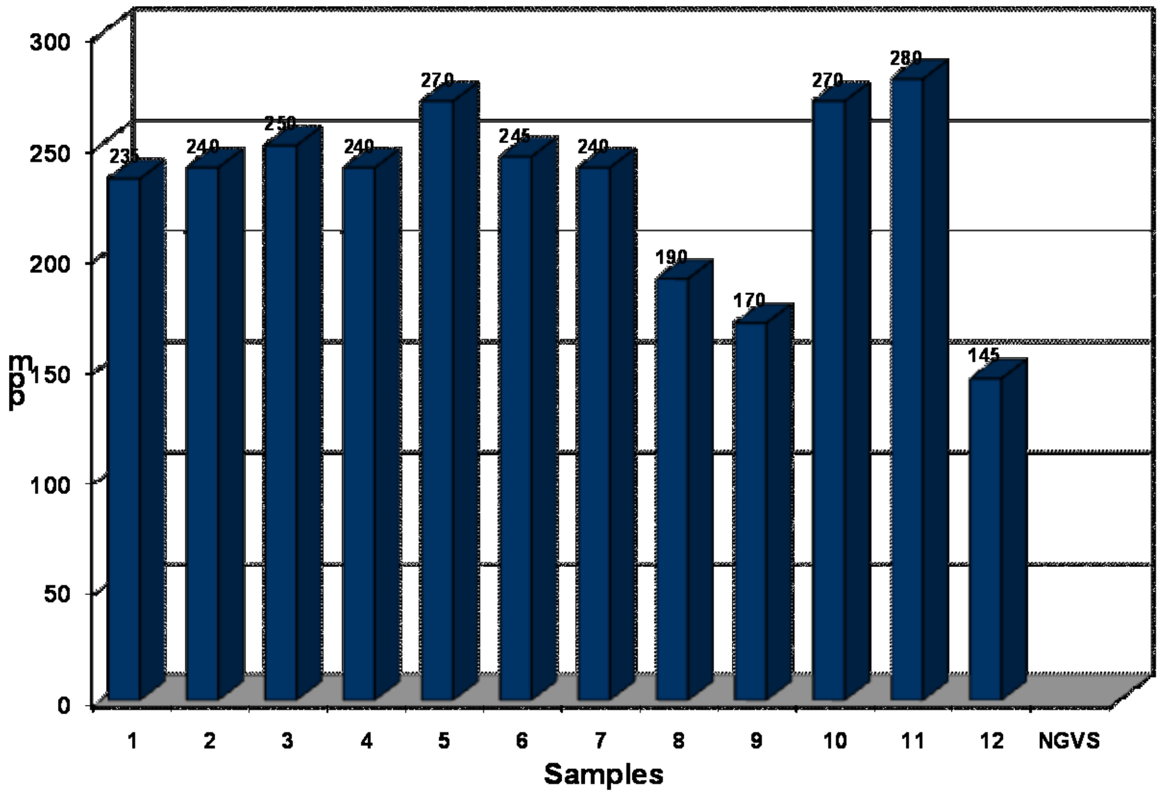


Figure. 13: Bicarbonates level in water

4.7.9 Alkalinity

The pH levels in water determine if the source is more acidic or alkaline. The alkaline level of water relates to its ability to neutralize acid. A moderate percentage of alkalinity helps balance the less desirable effects of acid. Although most don't consider water corrosive water (for example, some of the springs at Yellowstone Park) can have a high degree of acidity--and be as acidic as battery acid. Fresh water though, is generally more balanced with alkalinity levels of 20-20 mg/L. However, when water becomes too alkaline it may taste like soda and could have a drying effect on the skin. Moreover, it becomes what is termed "hard water." If it seems soda-like water should be soft consider the sources of those ions that contribute to making water hard. Carbonate rocks, such as limestone, are the main sources to turning water alkaline. Alkalinity results of our samples are presented in Figure 14. The values observed in Dharabi were satisfactory.

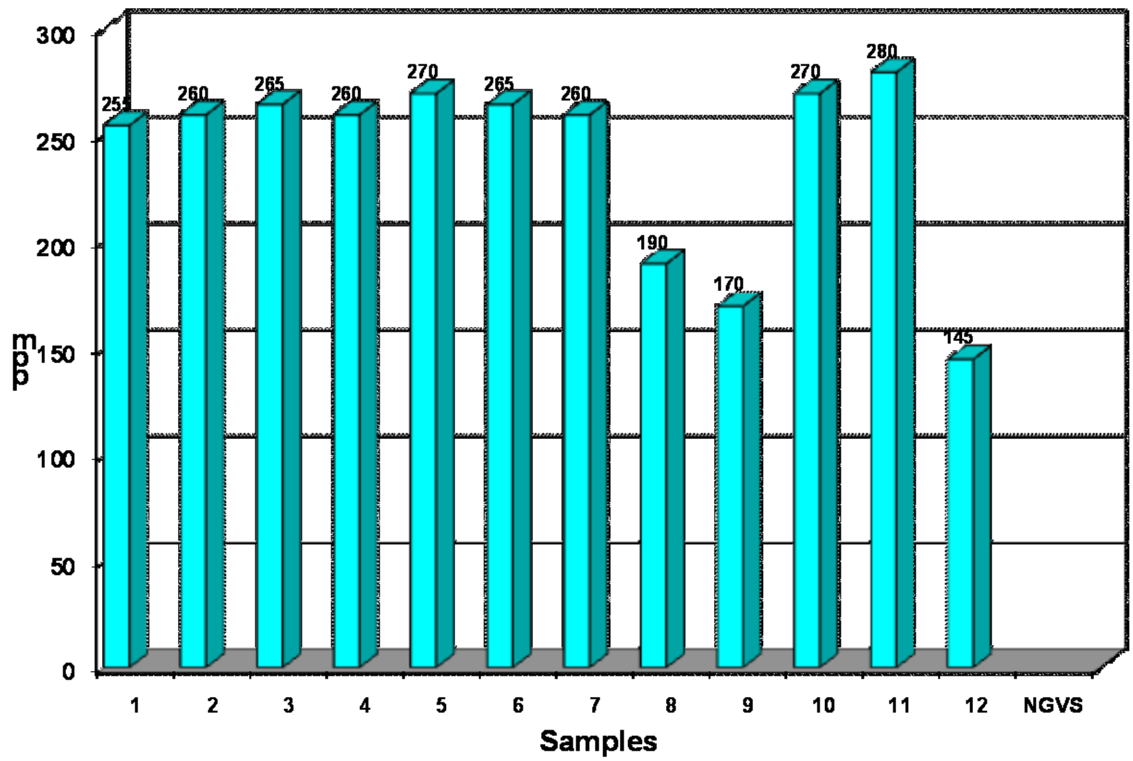


Figure. 14: Alkanity level in water

4.7.10Sodium

Sodium is the sixth most abundant element on Earth and is widely distributed in soils, plants, water and foods. Most of the world has significant deposits of sodium-containing minerals most notably sodium chloride (salt). Sodium and chloride occur naturally in water as a result of erosion or salt water intrusion. Sodium may reach both ground and surface water supplies as a result of residential, commercial and industrial activity such as road salting. The U.S. Environmental Protection Agency (EPA) does not mandate a maximum level of sodium permitted in public water supplies. However, the agency has released a Drinking Water Equivalence Level or guidance level that recommends sodium levels not exceed 20 parts per million (ppm) in order to protect those individuals who may be susceptible to sodium in drinking water. In our study sodium levels in water samples are much higher than 20 ppm except in one sample. Sodium levels are presented in Figure 15. The observed value of Sodium in Dharabi dam is within the desired limits. Higher values even within the guidelines sometimes are considered as undesirable for the blood pressure patients. Further the higher values are also connected with the corrosive nature of water especially when it is required for industrial applications.

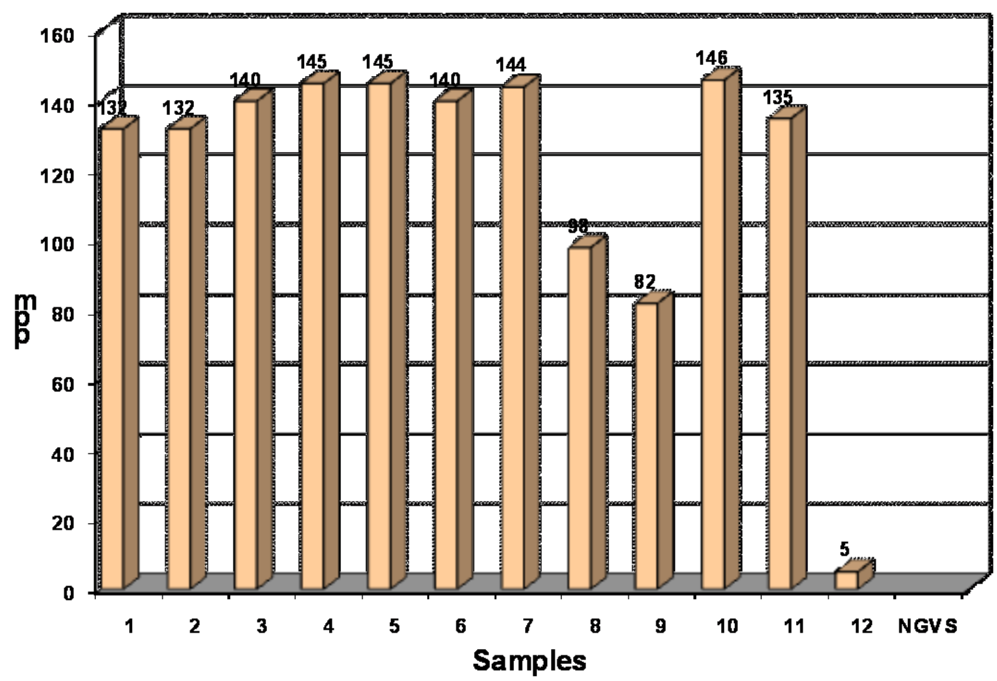


Figure. 15: Sodium level in water

4.7.11 Hardness

Hardness in water is defined as the presence of multivalent cations. Hardness in water can cause water to form scales and a resistance to soap. It can also be defined as water that does not produce lather with soap solutions but produces white precipitate (scum). The World Health Organization says that "there does not appear to be any convincing evidence that water hardness causes adverse health effects in humans." Some studies have shown a weak inverse relationship between water hardness and cardiovascular disease in men. Water hardness levels in our study samples are presented in Figure 16. According to PCRWR the maximum permissible level for hardness of drinking water is < 500 mg/l where as the highest desirable level is < 200 mg/l. The results as depicted in graph show that all samples fall within the maximum permissible level. This factor no doubt bears a relation to the total Ca+ Mg content and is often referred to Ca Magnesium hardness. Although this parameter may not be very important with respect to drinking and nor irrigation water quality yet it is considered as important factor with respect to the other domestic uses and some time may also be important with reference to taste of such samples it is recommended to boil the water which would reduce the Ca and Mg dissolved content.

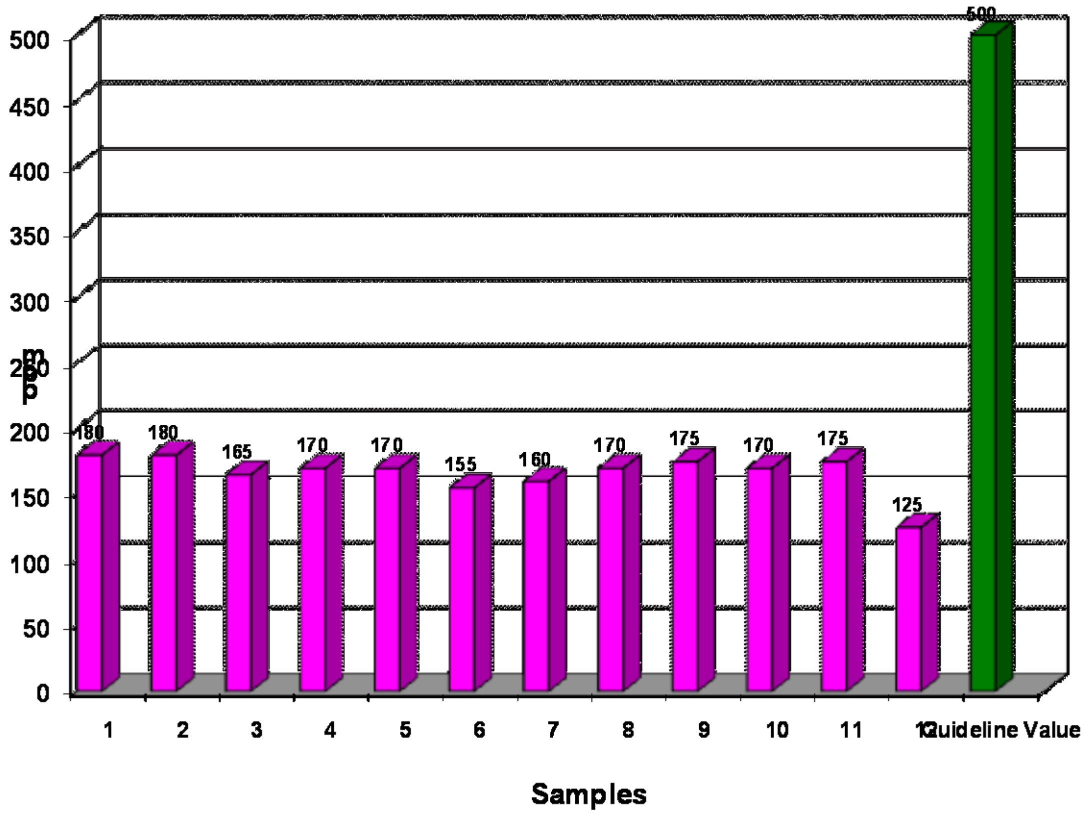


Figure. 16: Hardness level in water

4.7.12 Sodium Adsorption Ratio

Sodium adsorption ratio (SAR) is a ratio of the sodium (detrimental element) to the combination of calcium and magnesium (beneficial elements) in relation to known effects on soil dispensability. It is also a measure of the sodicity of soil, as determined from analysis of water extracted from the soil. The formula for calculating sodium adsorption ratio is:

$$SAR = [Na^{+}] / \{([Ca^{2+}] + [Mg^{2+}]) / 2\}^{1/2}$$

where sodium, calcium, and magnesium are in mill equivalents/liter.

4.7.13 SAR hazard of irrigation

A high sodium ion in water affects the permeability of soil and causes infiltration problems. This is because sodium when present in the soil in exchangeable form replaces calcium and magnesium adsorbed on the soil clays and causes dispersion of soil particles. This dispersion results in breakdown of soil aggregates. The soil becomes hard and compact when dry and reduces infiltration rates of water and air into the soil affecting its structure. This problem is also related with several factors such as the salinity rate and type of soil. For example sandy soils may not get damage so easy as other heavier soils when it is irrigated with a high SAR water.

4.7.14 Sodium & crops

High sodium concentrations become a problem when the infiltration rate is reduced to such a rate that the crop does not have enough water available or when the hydraulic conductivity of the soil profile is too low to provide adequate drainage. Other problems to the crop caused by an excess of Na is the formation of crusting seed beds, temporary saturation of the surface soil, high pH and the increased potential for diseases, weeds, soil erosion, lack of oxygen and inadequate nutrient availability. Recycled water can be a source of excess Na in the soil compared with other cations (Ca, K, Mg) and therefore it should be appropriately controlled.

4.7.15 Solutions to SAR problems in soils

The following solutions apply for SAR problems in soils:

- Change irrigation sources
- Blend irrigation water with water lower in sodium levels
- Increase aerification
- Application of sulfur, gypsum, or sulfuric acid injection

4.7.16 Residual Sodium Carbonate (RSC)

The RSC has the following equation:

$RSC=(CO_3^{-}+HCO_3^{-})-(Ca^{2+}+Mg^{+2})$

It is another alternative measure of the sodium content in relation with Mg and Ca. This value may appear in some water quality reports although it is not frequently used.

- If the RSC < 1.25 the water is considered safe
- If the RSC > 2.5 the water is not appropriate for irrigation.

4.7.17 Solutions to RSC

- Injection of sulfuric acid to dissociate the bicarbonate ions (PH around 6.2) giving off carbon dioxide. It allows the calcium and magnesium to stay in solution in relation with the sodium content.
- Add gypsum when soils have low free calcium plus leaching.
- Add sulfur to soils with high lime content plus leaching

4.7.18 SAR (Conversion ppm to miliequalent/Litre)

Sample 1

Sodium = 132/23 = 5.74 miliequalent/litre

Calcium= 24/20 = 1.2 miliequalent/litre

Magnesium = 29/12.16 = 2.38 miliequalent/litre

Sample 2

Sodium = 132/23 = 5.74 miliequalent/litre

Calcium = 24/20 = 1.2 miliequalent/litre

Magnesium =29/12.16 = 2.38 miliequalent/litre

Sample3

Sodium = 140/23 =6.08 miliequalent/litre

Calcium = 26/20 = 1.3 miliequalent/litre

Magnesium = 29/12.16 = 2.38 miliequalent/litre

Sample 4

Sodium = 145/23 = 6.30 miliequalent/litre

Calcium = 24/20 = 1.2 miliequalent/litre

Magnesium = 27/12.16 miliequalent/litre

Sample 5

Sodium = 145/23 = 6.30 miliequalent/litre

Calcium = 28/20 = 1.4 miliequalent/litre

Magnesium = 24/12.16 = 1.97 miliequalent/litre

Sample 6

Sodium = 140/23 = 6.08 miliequalent/litre

Calcium = 26/20 = 1.3 miliequalent/litre

Magnesium = 22/12.16 = 1.8 miliequalent/litre

Sample 7

Sodium = 144/23 = 6.26 miliequalent/litre

Calcium = 22/20 = 1.1 miliequalent/litre

Magnesium = 26/12.16 = 2.13 miliequalent/litre

Sample 8

Sodium = 98/23 = 4.2 miliequalent/litre

Calcium = 34/20 = 1.6 miliequalent/litre

Magnesium = 21/12.16 = 1.72 miliequalent/litre

Sample 9

Sodium = 82/23 = 3.5 miliequalent/litre

Calcium = 32/20 = 1.6 miliequalent/litre

Magnesium = 23/12.16 = 1.89 miliequalent/litre

Sample 10

Sodium = 146/23 = 6.34 miliequalent/litre

Calcium = 32/20 = 1.6 miliequalent/litre

Magnesium = 27/12.16 = 1.89 miliequalent/litre

Sample 11

Sodium = 135/23 = 5.8 miliequalent/litre

Calcium = 30/20 = 1.5miliequalent/liter

Magnesium = 24/12.16 = 1.97 miliequalent/litre

Sample 12

Sodium = 5/23 = 0.21 miliequalent/litre

Calcium = 24/20 = 1.2 miliequalent/litre

Magnesium = 16/12.16 = 1.3 miliequalent/litre

Table 4.7.1Sodium Adsorption Ratio

Sodium	Calcium	Magnesium	Formula	SAR = meq/l
5.74	1.2	2.38		3.72
5.74	1.2	2.38		3.72
6.08	1.3	2.38		3.87
6.30	1.2	2.22		4.2
6.30	1.4	1.97		4.2
6.08	1.3	1.8		4.28
6.26	1.1	2.13	SAR = $[Na^+] / \{([Ca^{2+}] + [Mg^{2+}]) / 2\}^{1/2}$	4.34
4.2	1.7	1.72		2.6
3.5	1.6	1.89		2.20
6.34	1.2	2.2		4.22
5.8	1.5	1.97		3.7
0.21	1.2	1.3		0.18

4.7.19 RSC (Conversion ppm to miliequalent/Liter)

Sample 1

Bicarbonate = 235/61 = 3.8 miliequalent/Litre

Carbonate = 20/60 = 0.33 miliequalent/Litre

Calcium = 24/20 = 1.2 miliequalent/Litre

Magnesium = 29/12.16 = 2.38 miliequalent/Litre

Sample 2

Bicarbonate = 240/61 = 3.93 miliequalent/Litre

Carbonate = 20/60 = 0.33 miliequalent/Litre

Calcium = 24/20 = 1.2 miliequalent/Litre

Magnesium = 29/12.16 = 2.38 miliequalent/Litre

Sample 3

Bicarbonate = 250/61 = 4.09 miliequalent/Litre

Carbonate = 15/60 = 0.25 miliequalent/Litre

Calcium = 26/20 = 1.3 miliequalent/Litre

Magnesium = 24/12.16 = 1.97 miliequalent/Litre

Sample 4

Bicarbonate = 240/61 = 3.93 miliequalent/Litre

Carbonate = 20/60 = 0.33 miliequalent/Litre

Calcium = 24/20 = 1.2 miliequalent/Litre

Magnesium = 27/12.16 = 2.22 miliequalent/Litre

Sample 5

Bicarbonate = 245/61 = 4.01 miliequalent/Litre

Carbonate = 20/60 = 0.33 miliequalent/Litre

Calcium = 26/20 = 1.3 miliequalent/Litre

Magnesium = 22/12.16 = 1.8 miliequalent/Litre

Sample 6

Bicarbonate = 270/61 = 4.42 miliequalent/Litre

Carbonate = 1/60 = 0.01 miliequalent/Litre

Calcium = 28/20 = 1.4 miliequalent/Litre

Magnesium = 24/12.16 = 1.97 miliequalent/Litre

Sample 7

Bicarbonate = 240/61 = 3.93 miliequalent/Litre

Carbonate = 20/60 = 0.33 miliequalent/Litre

Calcium = 22/20 = 1.1 miliequalent/Litre

Magnesium = 26/12.16 = 2.13 miliequalent/Liter

Sample 8

Bicarbonate = 190/61 = 3.11 miliequalent/Litre

Carbonate = 1/60 = 0.01 miliequalent/Litre

Calcium = 34/20 = 1.7 miliequalent/Litre

Magnesium = 21/12.16 = 1.72 miliequalent/Litre

Sample 9

Bicarbonate = 170/61 = 2.78 miliequalent/Liter

Carbonate = 1/60 = 0.01 miliequalent/Liter

Calcium = 32/20 = 1.6 miliequalent/Litre

Magnesium = 23/12.16 = 1.89 miliequalent/Litre

Sample 10

Bicarbonate = 270/61 = 4.42 miliequalent/Litre

Carbonate = 1/60 = 0.01 miliequalent/Litre

Calcium = 24/20 = 1.2 miliequalent/Litre

Magnesium = 27/12.16 = 2.22 miliequalent/Litre

Sample 11

Bicarbonate = 280/61 = 4.6 miliequalent/Litre

Carbonate = 1/60 = 0.01 miliequalent/Litre

Calcium = 30/20 = 1.5 miliequalent/Litre

Magnesium = 24/12.16 = 1.97 miliequalent/Litre

Sample 12

Bicarbonate = 145/61 = 2.37 miliequalent/Litre

Carbonate = 1/60 = 0.01 miliequalent/Litre

Calcium = 24/20 = 1.2 miliequalent/Litre

Magnesium = 16/12.16 = 1.31 miliequalent/Litre

Table 4.7.2 Residual Sodium Carbonate

HCO_3	Co_3	Ca	Mg	Formula	RSC= meq/l
3.8	0.33	1.2	2.38		0.55
3.93	0.33	1.2	2.38		0.68
4.09	0.25	1.3	1.97		1.07
3.93	0.33	1.2	2.32		0.84
4.42	0.01	1.4	1.97		1.06
4.01	0.33	1.3	1.8	$(CO_3^{-}+HCO_3^{-})-(Ca^{2+}+Mg^{+2})$	1.24
3.93	0.33	1.1	2.13		1.03
3.11	0.01	1.6	1.89		-0.3
2.78	0.01	1.2	2.22		-0.65
4.42	0.01	1.7	1.72		1.01
4.59	0.33	1.5	1.97		1.45
2.37	0.33	1.2	1.31		0.19

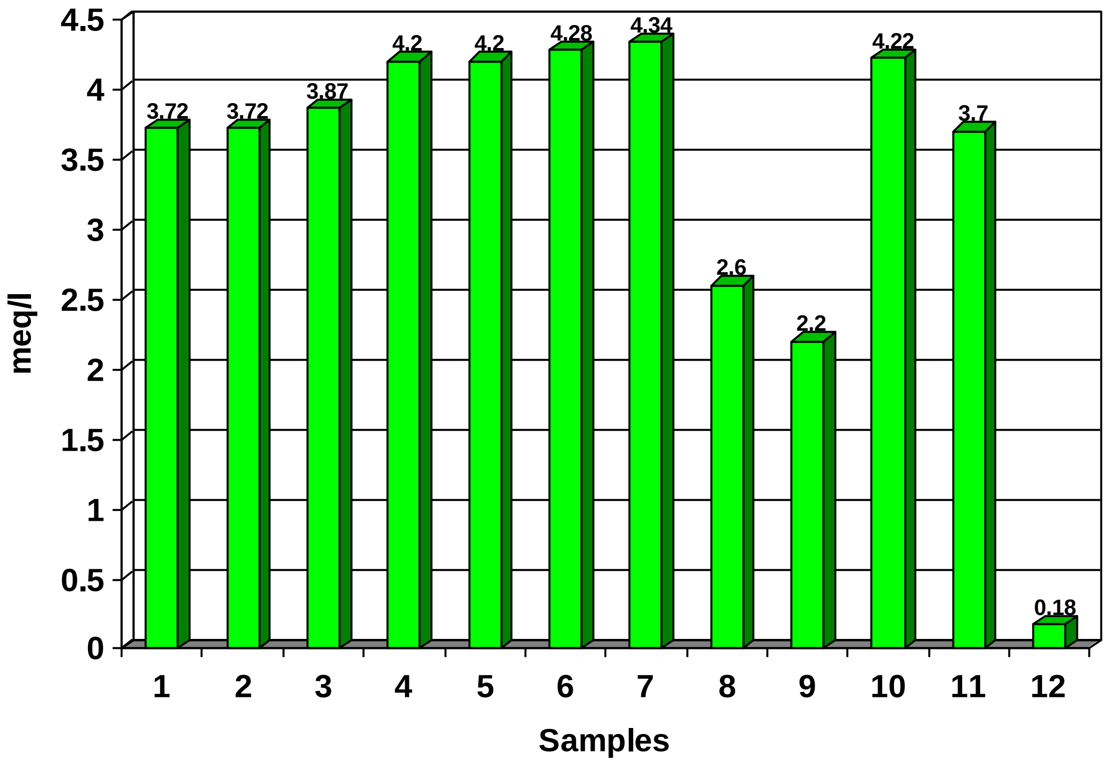


Fig.17: SODIUM ADSORPTION RATIO

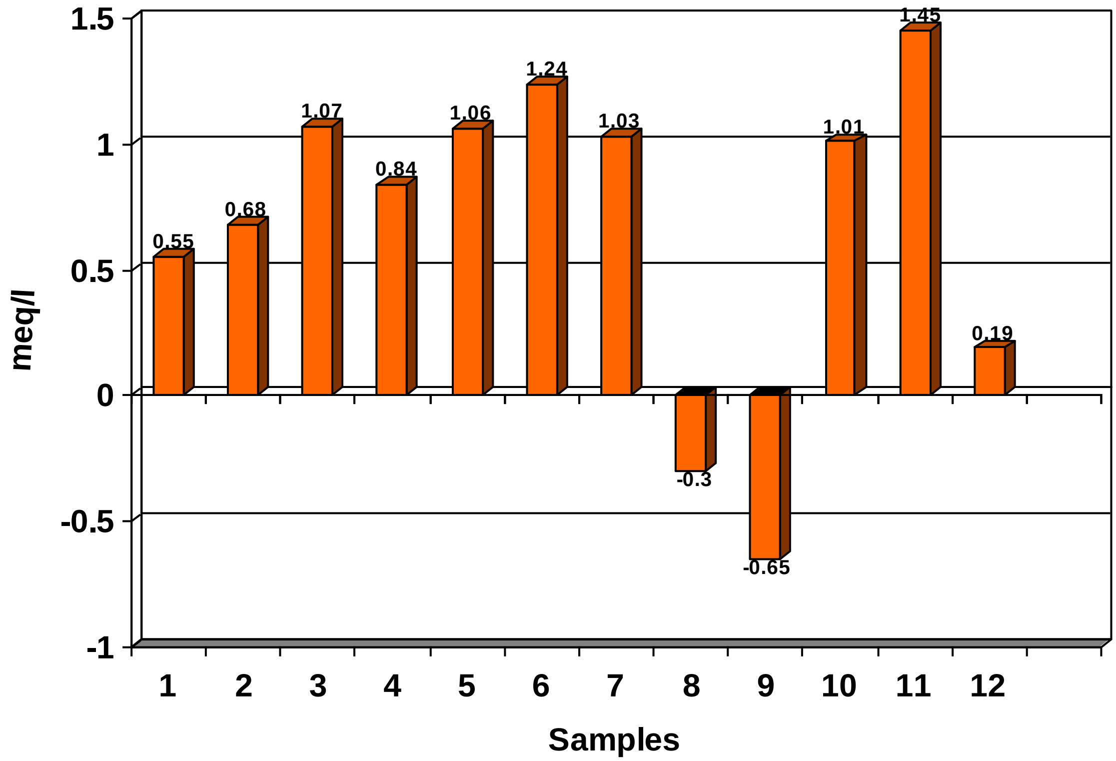
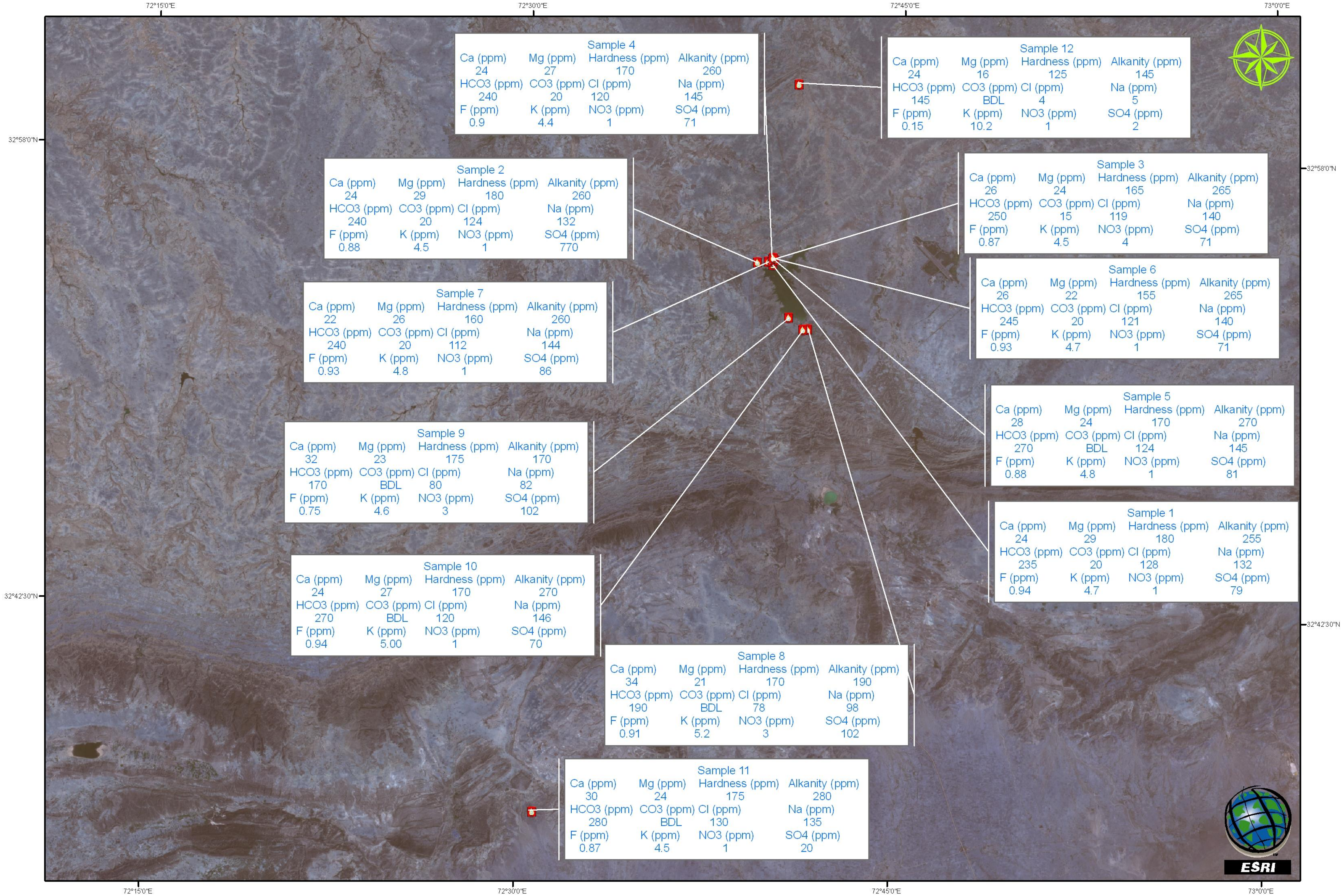
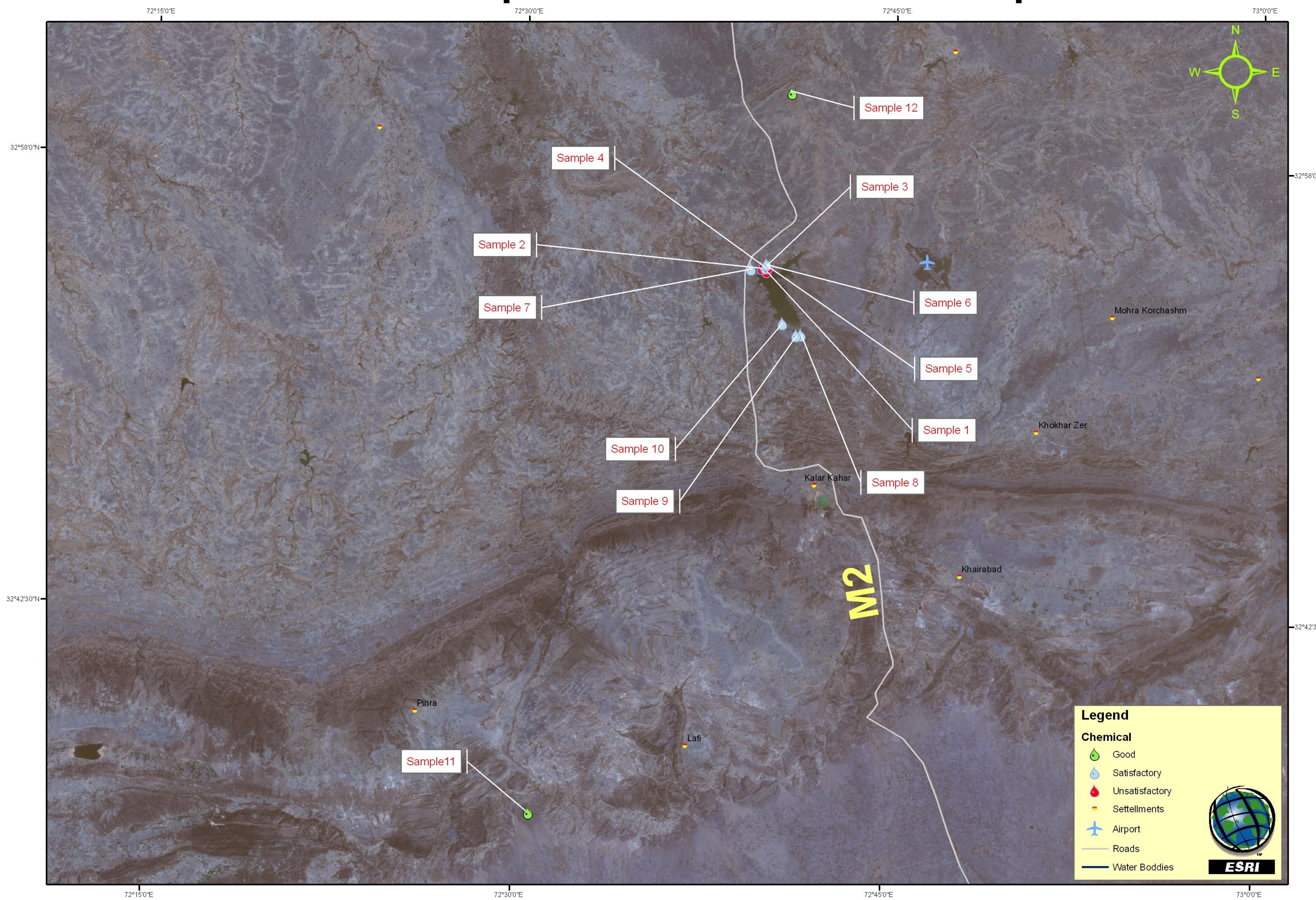


Fig.18: RESIDUAL SODIUM CARBONATE

Geographical Representation of Chemical Parameters



Water Sample Chemical Condition Map



4.9 Microbiological Analysis of Surface Water

Microbiology is the scientific field that is occupied with the study of microscopic organisms commonly known as micro-organisms. Microscopic plants and animals play an essential role in the life process of all organisms including humans. Contrary to their popular misconception that microbes are harmful the fact is that most of them are beneficial particularly in their role as decomposers in the food chain. Only a relatively small number of species are harmful to humans or otherwise the environment. Micro-organisms are divided up by their cell characteristics into two kinds. The first kind is the eukaryotic organism (Protista). Most organisms are eukaryotic which basically means that the cells they consist of contain nucleuses and other internal parts surrounded by membranes. The second kind of micro-organisms is the prokaryotic organism (monera). Prokaryotic cells are surrounded by a membrane but they contain no nucleus or other internal parts (organelles) contrary to eukaryotic cells. WHO guideline values for microbial quality of all waters intended for drinking is that E.coli or thermo tolerant coliform bacteria must not be detectable in any 100 ml water sample. The microbiological analysis of surface water shows the high colony forming at both sampling points. In addition to the total colony count total coli forms particularly fecal E. Coli was also present in the water samples Figure17 & 18. Presence of microbial content in water body can be linked to the agricultural runoff and sewage discharges leading to the contamination of Lake. The reason for this high values is the Anthropogenic activities based on these results it is therefore concluded that the dam water is heavily contaminated with microbiological element.

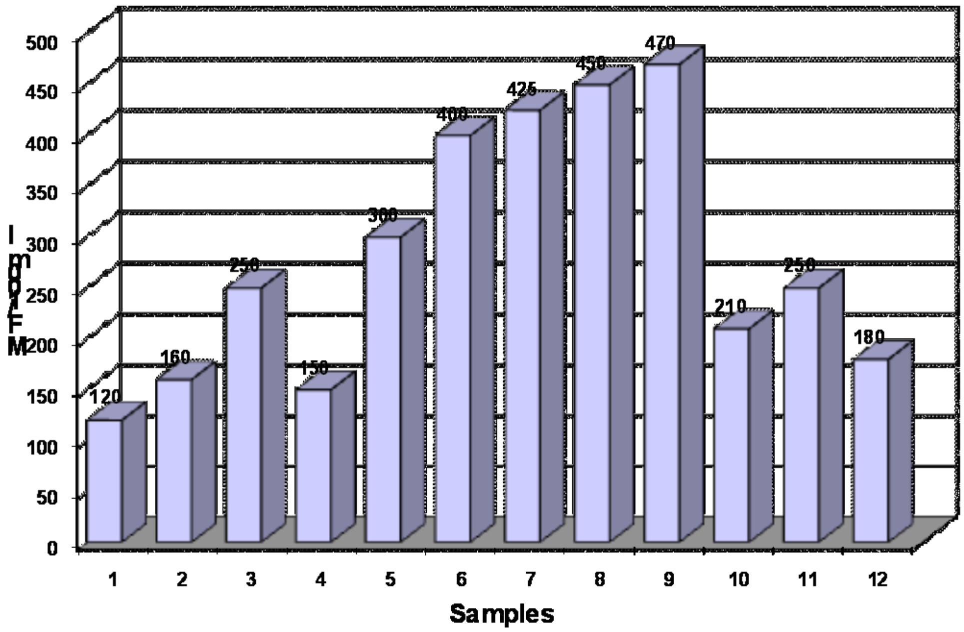


Figure. 19: Total-Coli form level in water

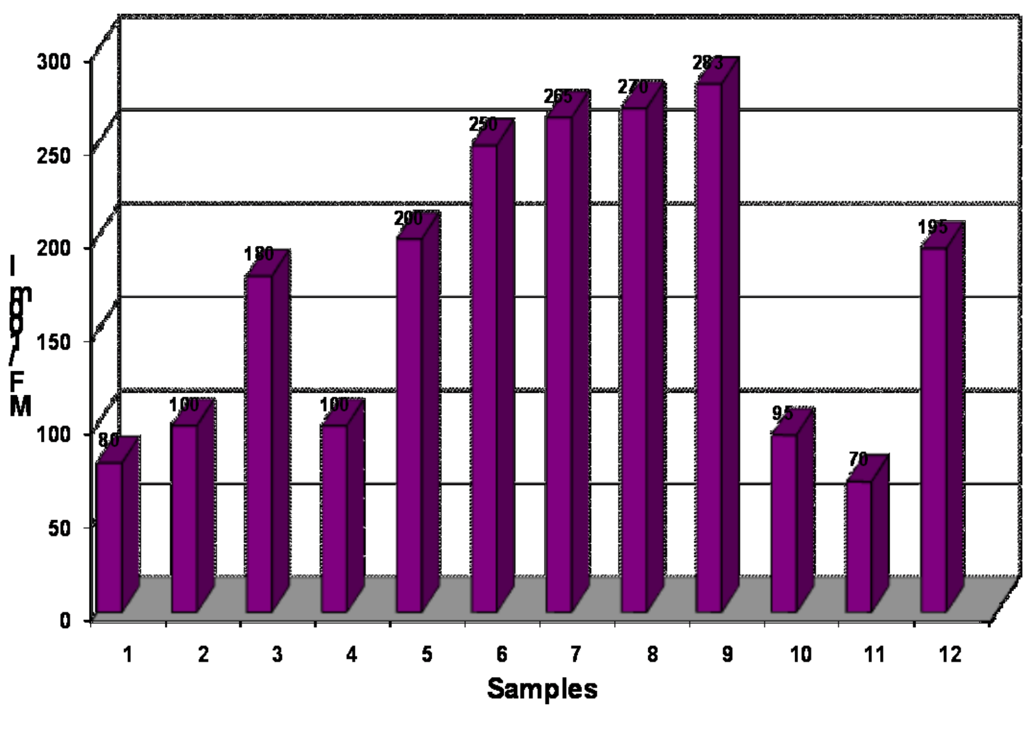
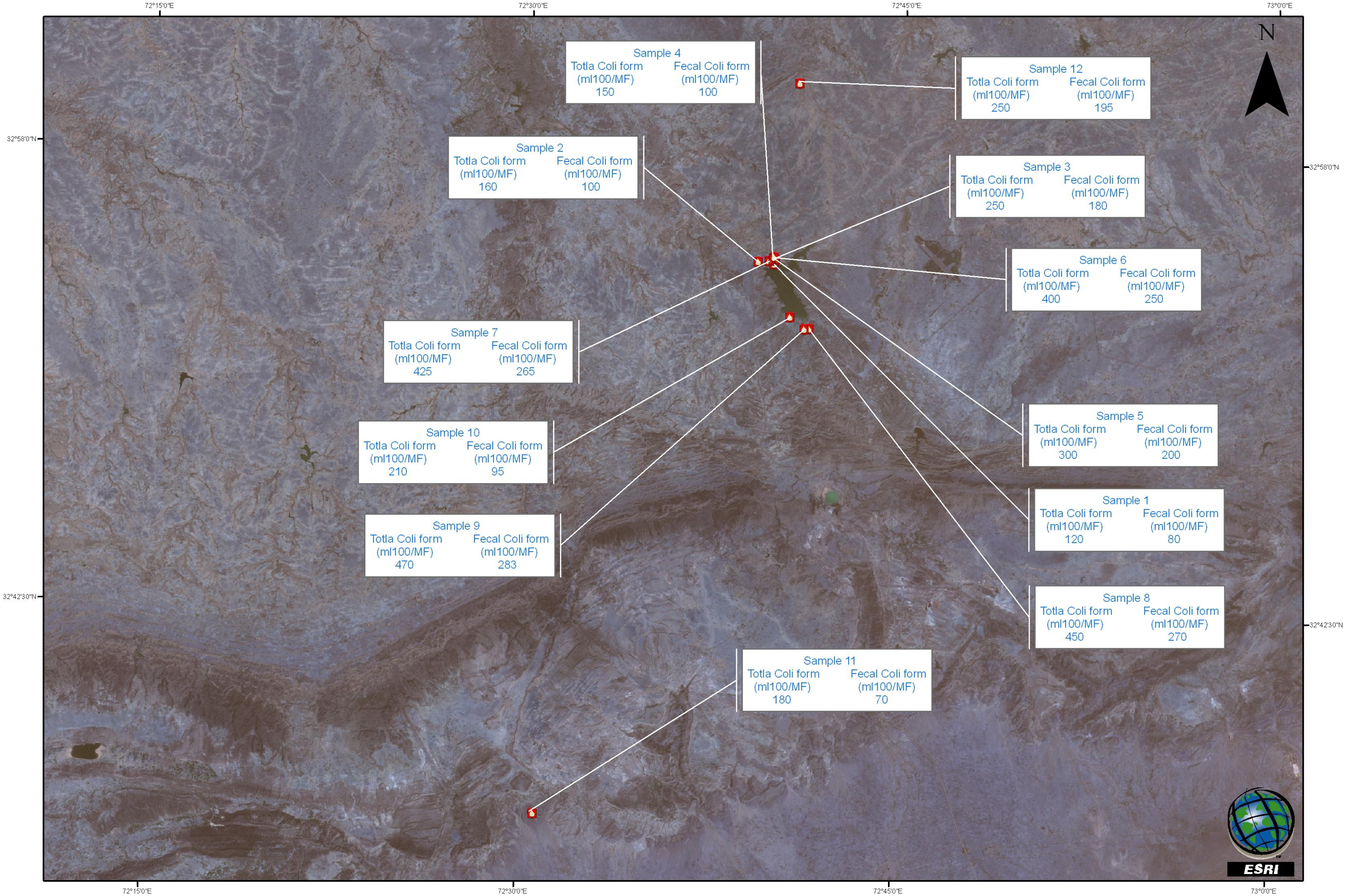
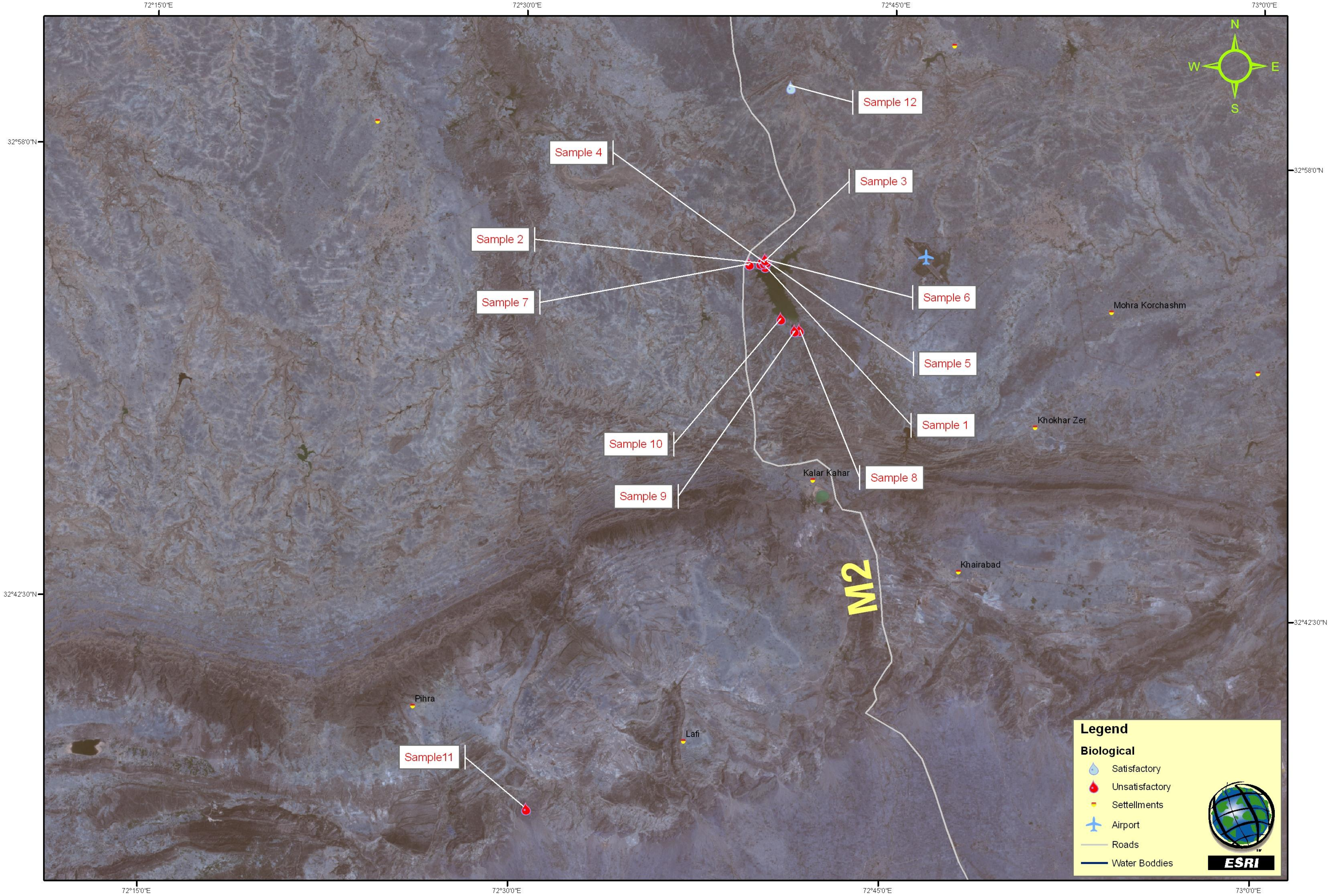


Figure. 20: Fecal Coli form level in water

Geographical Representation of Biological Parameters



Water Sample Biological Condition Map



Chapter 5
Discussion

DISCUSSION

The results from data analysis show that the water is certainly unfit for drinking purposes without any form of treatment but still it could be considered quite acceptable for various other surface water usage purposes like irrigation. But as we know once a trend in pollution sets in it generally accelerates to cause greater deterioration. So few years from now serious water quality deterioration could take place. The analytical data indicate that all sampling points are fit with respect to irrigation Parameters (pH, temperature) while parameters (conductivity, turbidity, TDS, and E.coli) exceeds NEQS limits for irrigation. The main reason for the water pollution is the discharge of untreated industrial effluents directly into the water reservoirs that results in a high level of pollution in the surface water of reservoirs and also in ground water. This poor quality water causes health hazard and death of human being aquatic life and also disturbs the production of different crops. The main reasons for this problem are lack of awareness, financial resources to build water treatment plants. From the present study it can be concluded that the results are within the acceptable range of NEQS standards but if we fail to implement preventive measures to control and treat waste industrial as well as sewage water before allowing it to fall in our water resources the toxic level of harmful material can mix up with the ground water and can cause serious damage to our whole environment. There is no easy way to solve water pollution if there were it wouldn’t be so much of a problem. Broadly speaking, there are three different things that can help to tackle the problem. These are education, laws, and economics which work together as a team.

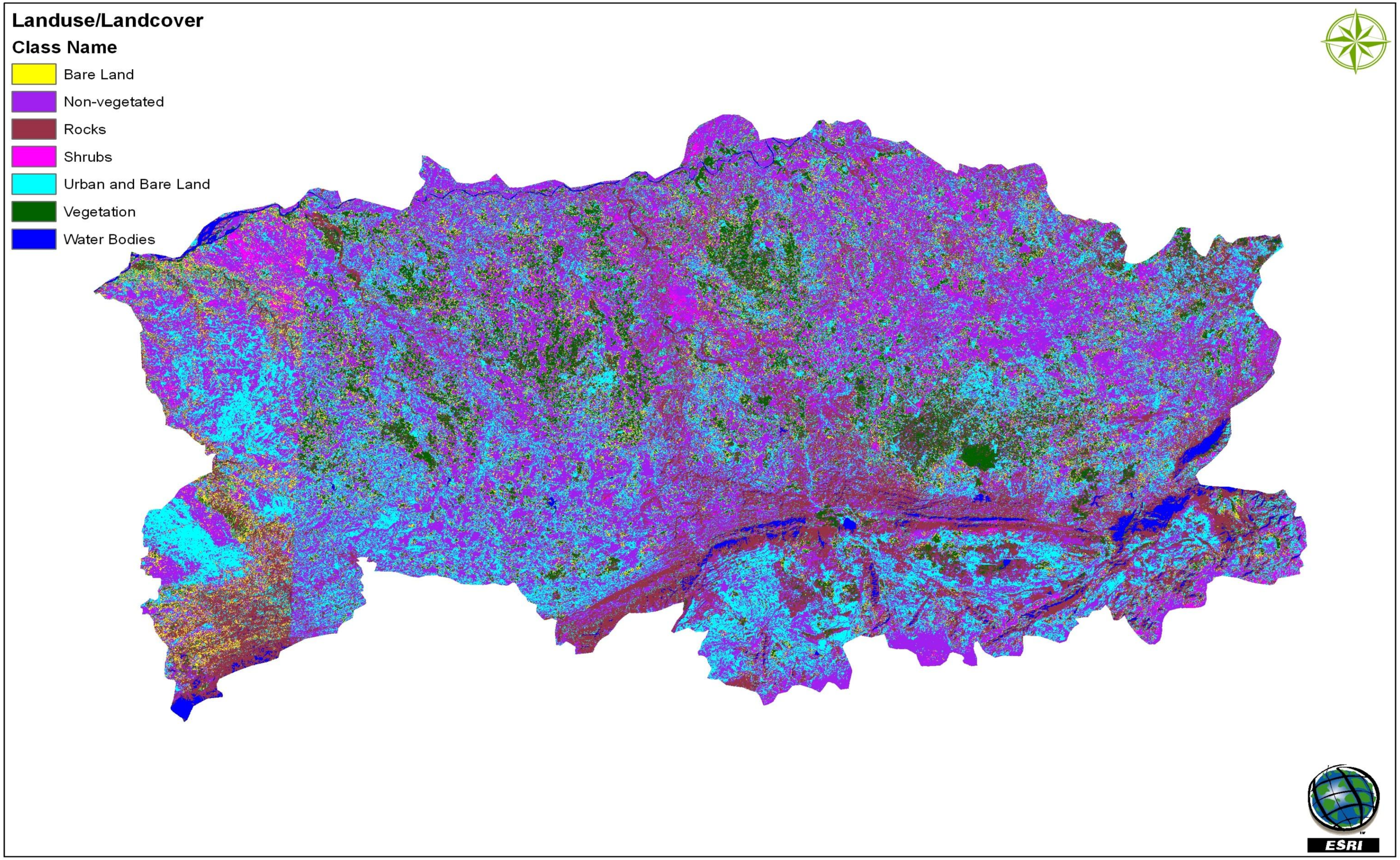
The satellite image was Land Sat (2010) geo-referenced. This mapping procedure removes geometric distortions of the image and changes the co-ordinate system of the image to spatial database coordinate system. Maximum possible Ground Control Points [GCPs] were selected by using Google earth uniformly over the total area for better interpolation.

Image classification using various techniques including visual interpretation digital enhancement techniques were used as they help to improve the feature sharpness and contrast for simple interpretation along with visual interpretation techniques. The training sites were selected based on limited field checks and visual interpretation of imagery for areas that represent known features. Based on these identified sites classification techniques were applied to generate the required thematic maps. Certain mathematical models and filters were used as well to enhance certain features like water resources to help in easy interpretation and mapping the same.

Various thematic layers generated using remote sensing data like, land use/land cover like Water bodies, Vegetation, Rock, Urban and Bare soil, Shrubs, Non-Vegetated and Bare Land and other collateral data in a Geographic Information system (GIS) framework and analyzed.

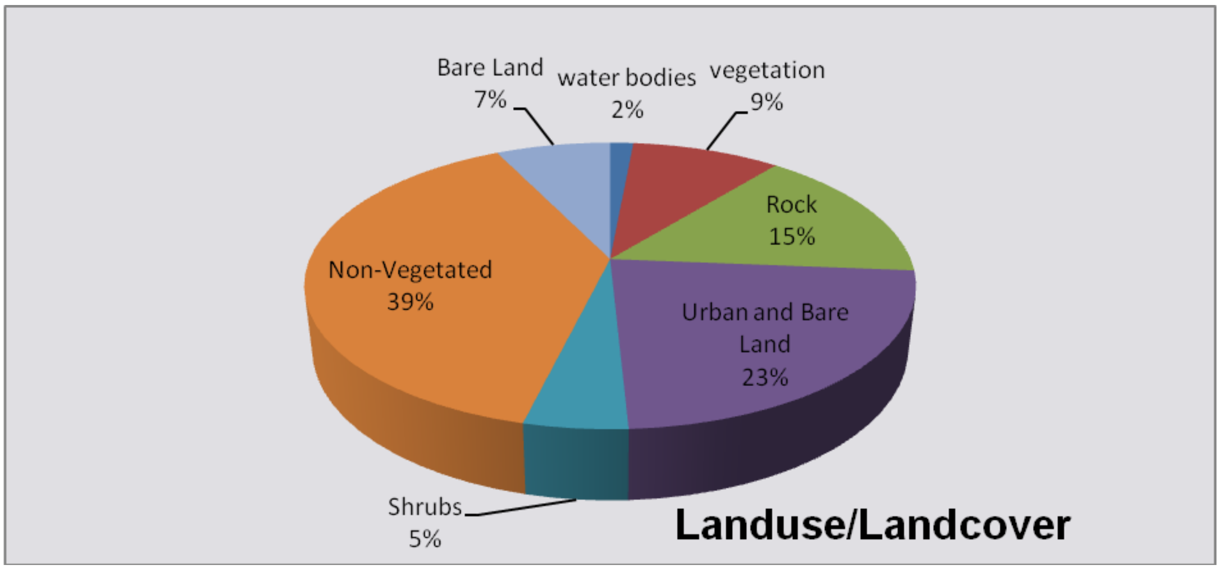
Different thematic maps generated by using GIS technique to represent the different water quality analysis like geographical representation of physical, chemical and biological parameters. GPS points were collected and reflected on the satellite image to show the water sampling locations. Water quality situation maps from different locations were generated to show the safe and unsatisfactory conditions.

Landuse/Landcover Map

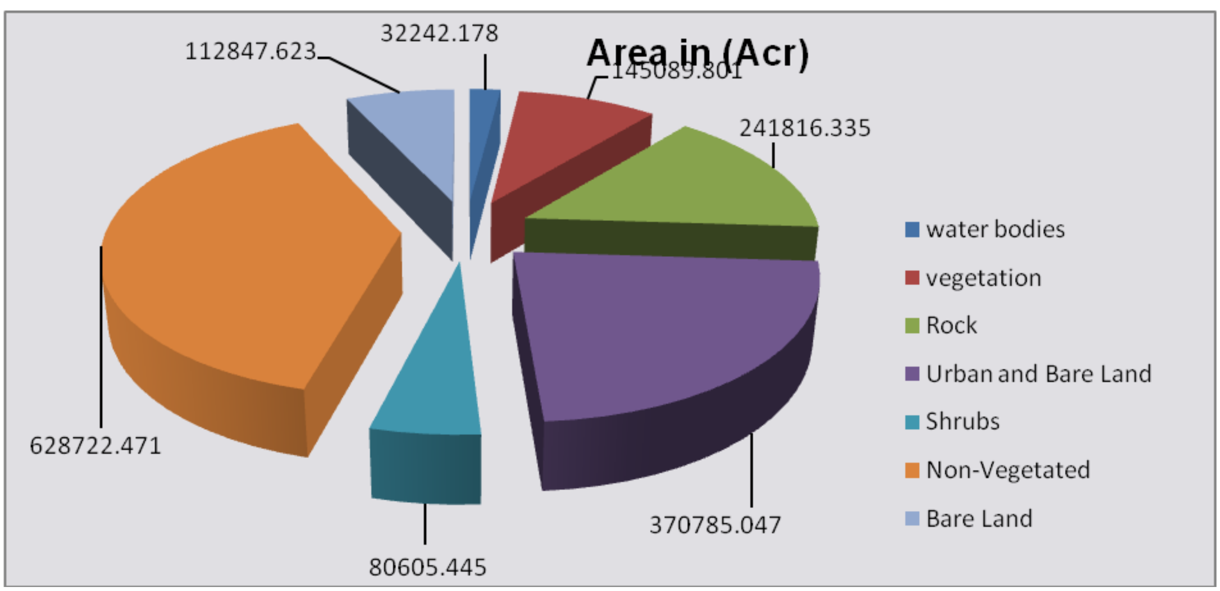


Land use/Landcover (2010)	Percentile %	Area (Acr)
water bodies	2	32242.178
vegetation	9	145089.801
Rock	15	241816.335
Urban and Bare Land	23	370785.047
Shrubs	5	80605.445
Non-Vegetated	39	628722.471
Bare Land	7	112847.623
Total Area (Acr)		**1612108.9**

Landuse/ landcover



Area in acres



Conclusion and Recommendations

After going through the review of literature, data analysis, results and discussion we conclude and recommend the following:

5.1. Conclusion

- Surface water analysis of the Dharabi dam has shown the presence of physical, chemical and microbiological contaminations.
- Around 19 parameters for surface water including pH, EC, Temperature, Chloride, Nitrate, Fluoride, calcium, sulphates, megnesium, sulphates, TDS, and Total Coliform and Fecal Coliform were analyzed and few of them were found above or closer to the maximum limits of Pakistan NEQS, USEPA and WHO standards.
- Agricultural and domestic discharge into and around the vicinity of dam can be associated with the high contamination of the water body.
- Lack of proper management practices for dam and control of sewage and agricultural discharge into the surrounding locality is also linked with the deterioration of water quality.
- Microbiological analysis of surface water has shown the presence of fecal and total coli form therefore making the water incompatible for drinking purposes.
- TDS values were also found at the higher side in the surface water because of the presence of biological waste and residual surface runoff.
- Turbidity values are higher then prescribed values. Because urbanized areas contribute large amounts of turbidity to nearby waters through stormwater

pollution from paved surfaces such as roads, bridges and parking lots. Certain industries such as quarrying, mining and coal recovery can generate very high levels of turbidity from colloidal rock particles.

- The TDS and the electrical conductivity are in a close connection. The more salts are dissolved in the water the higher is the value of the electric conductivity. The majority of solids which remain in the water after a sand filter are dissolved ions. The water temperature affects the electric conductivity so that its value increases from 2% up to 3% per 1 degree Celsius.

5.2. Recommendations

- Technical and financial assistance to plan and implement proper management plan for Dharabi dam.
- Stringent regulations should be implemented to control the sewage and agricultural discharge into the dam.
- Strict actions leading to shutdown of unit should be taken by the Environment Department in Pakistan against the industrial units that are directly draining their waste water effluents without proper treatment into the drains and rivers.
- Water Quality Standards such as NEQS should be applied strictly to big industrial units draining huge amount of wastewater effluents into drains that ultimately reaches to rivers.
- Controlling the discharge of wastewater into the water body.
- With the help of researchers, engineers and international organization, training workshops can be planned in order to train the individuals from different institutions to protect and preserve small dams.
- Involvement of local community in decision making process should be ensured to achieve sustainability and success of the proposed projects.
- Contamination risks can also be avoided by ceasing irrigation 3-4 days before harvesting if the crop is less sensitive to water loss. It can allow the pathogens to die off.
- Increasing environmental awareness by providing local community with the information about the environment and the conservation of small dams. Fishery

board development is located at the dam where a large number of are cultivating so all this contamination is effecting the aquatic life so there should be a proper management system to control this contamination and preserve the aquatic life because fishery industry is a big industry of Pakistan.

- A sustainable tourism or eco-tourism must be promoted in the area to conserve the environment and the dam.

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