HYDRO- CHEMICAL INVESTIGATIONS OF HIGH ALTITUDE ALPINE LAKES OF GILGIT AND GHIZAR DISTRICTS, NORTHERN AREAS OF PAKISTAN

BY

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Dedicated

To
My
Loving
Parents and
Teachers

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Abbreviations	Captions
ADD	Average Daily Dose
AKRSP	Agha Khan Rural Support Programme
AT	Average Time
BDL	Below Diction Level
BW	Body Weight
CR	Cancer Risk
DOC	Dissolved Organic Carbon
DON	Dioxynivalenol
DHQ	District Head Quarter
DDT	Dichloro Diphenyl Trichloroethane
EEA	Extracellular Enzyme Activities
EC	Electric Conductivity
ED	Exposure Duration
EF	Exposure frequency
HQ	Hazard Quotient
FANA	Federally Administrated Northern Areas
GIS	Geographical Information System
HCB	Hexachlorobenzene

IR	Ingestion Rate
IUCN	International Union for Conservation of Natural Resources
HCH	Hexachlorocyclohexane
KKH	Karakoram Highway
L	Liter
Mg/L	Milligram Per Liter
MSH	Mercury Hydrated System
NAs	Northern Areas
NASED	Northern Areas State of Environmental Development
PCBs	Polychlorinated Biphenyls
POC	Particulate Organic Compound
POP	Persistent Organic Pollutant
PON	Particulate Organic Nitrogen
REEs	Rare Earth Elements
SKM	Southern Karakoram Metamorphic
Std.dev	Standard Deviation
TDS	Total Dissolved Solids
µg/l	Microgram Per Liter
USEPA	US, Environmental Protection Agency
UNEP	United Nation Environmental Programme
WSHSP	Water Sanitation, Hygiene, and Health Studies Project
WWF	World Wilde Fun for Nature
WHO	World Health Organization

ABSTRACT

Glaciers and their melt fed streams and lakes are most important as their analysis provides essential information on current continental geochemical processes. They drain the continental weathered products to downward rivers and oceans and play a major role in the global sea-water evolution. The present study is to investigate the physio-chemical parameters in water of nine selected high altitude alpine lakes (i.e., Naltar wetland complex, Uttar, Hundrap and Baha lakes), and their respective streams possessing four sites within the two districts (Gilgit and Ghizar), northern areas of Pakistan. The northern areas cover an isolated mountainous terrain in the northern extreme of Pakistan referred to as the roof of the world. The northern areas of Pakistan is sandwiched between three famous mountain ranges, the Himalayas, Karakuram and the Hindukush, containing natural landscape, glaciers, tracking paths and beautiful high altitude alpine lakes. These high altitude alpine lakes are the major water resources that fulfill the basic life requirements in the region. People use the water from lakes for drinking and irrigation purposes. Besides fulfilling the basic needs of the inhabitants of the area, these lakes also have great significance in promotion of tourism in the region. No detail studies of the high altitude alpine lakes of the northern areas of Pakistan have ever been conducted in regard to the physico-chemical contamination and consequent environmental degradation. Therefore, the present study is purposed to investigate the environmental degradations, if any, related to these lakes in the region.

The present work involves 50 various water samples of lakes and streams which have been analysed in regard to environmental impact assessment of water of the study area. The data obtained after the analysis of these water samples were compared with the international water quality standards set by WHO (2008) and USEPA (2009). Analyses

of these samples were performed by using instruments such as Consort Electrochemical analyzer, JENWAY 6035, Turbidity meter, DR/2800 Photospectrometer and Electrothermal Atomic Absorption spectrometer.

The physical, and chemical parameters of water determined during the study include Temperature, pH, electric conductivity, total dissolved solids, turbidity, resistivity, salinity. The anions (Cl^-, NO_3^-, SO_4^{-2}, CO_3^{-2} and HCO_3^-), light elements (Na^+, Ca^{+2}, K^+, and Mg^{+2}) and trace and heavy metals (Mn, Fe, Cu, Pb, Zn, Ni, Cr, Cd, Hg, and As) were also included.

The calculated maximum values of physical parameters of water of lakes and streams of the study area were found as Temperature <9 ^oC, pH <7.9, electric conductivity <281us/cm, total dissolved solids <181mg/L, turbidity <5 NTU, resistivity <23 kΩ and salinity <3.8. These parameters were found within the permissible limit set by WHO and USEPA.

The concentrations of anions such as Cl^-, NO_3^-, SO_4^{-2}, and HCO_3^- in the water of lakes and streams of the study area were found <42mg/L, <3.2mg/L, <50mg/L, and <360mg/L, respectively. These values were found within the permissible limit set by WHO and USEPA. However, it was found that the concentrations of HCO_3^- were relatively higher with respect to other anions in all the water samples. Therefore, water was considered as HCO_3^- type when classified on piper diagram scheme.

The concentrations of light elements such as Na^+, K^+, Ca^{+2} and Mg^{+2} in the water of lakes and streams of the study area were found as <141.75mg/L, <5.30mg/L, <74.39mg/L and <38.66mg/L, respectively, which were found within the permissible limit of WHO.

Among trace and heavy metals, the concentrations of Hg was found below the detection level in all the water samples, while the remaining metals such as Mn, Fe, Cu, Pb, Zn, Ni, Cr, Cd, and As were having concentrations <110µg/L, <868µg/L, <84µg/L, <10µg/L, <1282µg/L, <29.39µg/L, <8µg/L,<5µg/L and <6µg/l, respectively. It was noticed that the concentrations of Cu, Zn, Ni, and Cr were within the permissible limits set by WHO and USEPA, while the concentrations of Fe, Pb, Cd, and As in some of the samples were found slightly higher than those of USEPA.

Statistically, the quality of water in the study area was analyzed by Pearson's correlationship and it was found that some of the physio-chemicals pairs have not any interrelationships, however, in most of the pairs strong positive (r =≥50) and strong negative (r =-≥50) interrelationships were found.

Finally, health risk assessments like average daily dose (ADD), hazards quotient (HQ) and cancer risk (CR) indices for the trace and heavy metals in the water of lakes and streams of the study area were calculated by using statistical formulas set by USEPA, and it was found that all trace and heavy metals have an average values of HQ <1 and CR <1 per 1, 000,000 inhabitants which was vary low when compared with USEPA. Therefore, neither any chronic risk (HQ), nor carcinogenic risk (CR) was found in the water of lakes and streams of the study area.

It is concluded on the basis of the hydro-chemical investigations of high altitude alpine lakes with their respective streams of Gilgit and Ghizar Districts of northern areas of Pakistan, that the water of lakes and their related streams is suitable for drinking and irrigation.

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CHAPTER 1

INTRODUCTION

1.1. General statement

Today our planet is facing a lot of obstacles in which the most significant is the degradation of environment (Khan, 1996). Environment is the circumstances or conditions that surrounding an organism, or group of organisms. It includes the physical, cultural and biological resources. The relationship of an organism to its surrounding is called its Ecosystem. Degradation of environment destroys the ecosystem and makes the existence of life difficult (Enger and Smith, 2006).

The word environment has been defined by William et al. (2005) as, the complex of social or cultural condition that affects an individual or community. Therefore, an environment is the some or all the features and conditions surrounding an organism that may influence on that organism. An individual's physical environment encompasses rock, soil, air, water, light and temperature, and other organisms, while in case of their social environment includes a network of family and friends, a particular political system, and set of social customs that affect one's behavior (Montgomery, 2006).

The main objective of environmental crises is the release of different types of pollutants to the environment. A pollutant can be defined as the existence of substances in greater abundance than that of its natural concentration and is harmful to the environment (Manahan, 2005). There are two agencies, which are responsible for the degradation of environment i.e., human impact and natural processes. Human impact on environment has produced unexpected, unpleasant and even dangerous consequences. Water logging and overgrazing have converted hundred of thousand of acres of fertile land into barren desert. Improper plugging and tilling techniques cause fertile soil to wash away in heavy rain. Industrial pollution is another main environmental problem caused by human. Industrial wastes that drained in to the rivers and lakes cause killing of the fish and other organisms living in the water. On the other hand natural process include earthquake, floods, volcanoes, water and soil contamination with heavy metals are the main cause of degradation (Coleman and Gressey, 1947).

The global degradation of environment is mainly caused by the rapid development (poorly planed), lack of environmental awareness, and over exploitation of world renewable and non-renewable resources (Asian Development Bank, 1986).

Among the physical environment water is one of the most important segments of the ecosystem. It is a basic tool to combat poverty, hunger, diseases and environmental degradation. Lack of data on water quality hinders attempts to address water related issues in any region. Water borne diseases are major threats to human health in the developing world. According to United Nation Environment Programs (UNEP), many of the populations of the world are lacking access to safe drinking water (UNEP, 2004). This lack of access to safe drinking water may further aggravate the health related problems in future. The provision of safe drinking water and hygienic sanitation to households and communities help in reducing deaths through waterborne diseases, such as cholera, diarrhea and dysentery (Pertti and Ziglio, 2000). Therefore, it is imperative to look for sources of water, which are safe and healthy for consumption.

Throughout the history, the quality and quantity of water available to humans have been vital factors in determining their well-being. Waterborne diseases such as cholera and typhoid killed millions of people in the past and also in the present

(Manahan, 2005). According to the World Health Organization (WHO), 80% diseases are caused in the world by inadequate sanitation and polluted water (WHO, 1981). All these problems are due to population growth, improperly discarded hazardous waste, and lack of awareness and drinking of contaminated (polluted) water.

Water can be polluted by physical, chemical, or biological change in water quality that adversely affects living organisms or make water unsuitable for desired uses (Narayan, 2000). As the water pollution is due to addition of any substance from the external sources, it leads to excess their normal concentration in water and hence adversely affect the aquatic environment and the normal activities of various living communities in or near water bodies (Triveddi and Raj, 1992). When we think of water pollution, we usually visualize sewage or industrial effluents pouring out of a discharge pipe and some toxic chemicals introduce in to water as a result of human activities, but there are natural toxicants that threaten us as well. Some toxic inorganic chemicals are released from rocks by weathering which are carried out by run off into lakes or river, or percolate into ground aquifers and cause contamination of a water body (William et al., 2005).

A unique feature that strongly increases the complexity of fresh-water chemistry is the seasonal variation. These seasonal variations are found across a wide range of catchments with contrasting climate, geology and type of ecosystem (Ponter et al., 1992). In the high altitude alpine zone, the major hydrological event in catchments is the melt-water discharge in spring (April–June depending on the latitude). During melt-water discharge, the concentrations of dissolved organic carbon (DOC) and several trace elements commonly increase in contrast to most major elements that are commonly diluted (James, 2005).

The solubility of metal ions and organometallic complexes and co-precipitation or co-existence of these with the colloidal clay fraction are the main components that lead to the enrichment of lake and reservoir water in metal. Due to their potential impact, the distribution and fate of metals in lake environments can be of significant social importance. It has already been reported that metal contamination in lakes of tropical countries has a significant impact on environmental health (Ratan et al., 1997). The hydrochemistry for both lakes and streams influenced by watershed characteristics (pedology, geology, vegetation, hydrology, climate, etc.) but also by lacustrine biological processes: diatom productivity in epilimnetic water and degradation or preservation in deeper waters (Branchu et al., 2005).

Glaciers, springs, lakes and ponds are the major water resources that fulfill the basic life requirements in the northern areas of Pakistan. Among these, most of the lakes are situated at a height of 2133.59 meters above the sea level and are known as high altitude alpine lakes (Manawar, 2007). When we used the word high altitude, we assumed elevation in relation to the surrounding lowland, which is of course variable, or the land that theoretically misleading due to the difference of sea level from place to place, time to time depending upon different conditions such as, soil erosion, wind tide, glaciers effect and other natural disasters. The fundamental thing which makes climatic difference between the high altitude and lowland ecosystem is altitude, having low temperature, snow peaks, glacier lakes, alpine trees and specific high altitude biodiversity as their main indicators (Mani, 1986). These high altitudes alpine lakes in Gilgit and its surrounding regions are mostly glaciers dammed lake (Iturrizaga, 2005). These lakes provide water to the local communities for drinking as well as for irrigation purposes. People use these lakes for their socioeconomic benefits without any proper planning. Therefore, most of the lakes in the region may lose their natural beauty and get polluted by different anthropogenic and geogenic resources.

The above mentioned high altitude alpine lakes in Gilgit and Ghizar Districts are the main sources of water bodies. People use the lakes' water for drinking and irrigation purposes. These lakes are also used by the grazing animals of the area. Besides fulfilling the basic needs of the inhabitants of the area, these lakes also have great significance in promotion tourism in the region. Most of the tourists visit these lakes and do camping there. Due to improper management and lack of environmental awareness by local community most of the lakes in those regions degraded their natural ecosystem (Manawar, 2007). No detail studies of the high altitude alpine lakes of the Northern Areas of Pakistan have ever been conducted in regard to the physico-chemical contamination and resulted environmental degradation. Therefore, the present study is purposed to investigate the environmental degradations, if any, related to these lakes in the region.

1.2. Introduction of Northern Areas of Pakistan

1.2.1. Geographical location

The Northern Areas are officially named as Federally Administrated Northern Areas (FANA) an isolated mountainous terrain in the northern extreme of Pakistan referred to as the roof of the world and spread over an area of 72,500 square kilometers. It lies between latitude 35° 0′ to 37° 0′ N, to logititude 72°0′ to 75°0′ E, (ranging from 1500 – 8000 m above the sea level) and covered by high mountains. It is bounded by the

Xinjiang province of Republic of China in the north-east, Frontier Province of Pakistan (Khyber Phuktunkhawa) in the south, Kashmir in the east and Afghanistan in the west (Fig.1.1). The Northern Areas of Pakistan is sandwiched between three famous mountain ranges, the Himalayas, Karakuram and the Hindukush. Lofty mountain ranges are composed of a large number of gigantic and glorious snow capped peaks, K-2 (8613 meters) and Nanga Parbat (8126 meters), lush green valleys, lakes, and some of the biggest glaciers (Mashabrum, Rakaposhi, Siachen, Passu and Haramoish) in the world (Winter and Mannheim, 2000).

1.2.2. History of Northern Areas

The ancient history of the Northern Areas (NAs) is lost in antiquity. However the documentation of history of the Northern Areas shows that the areas have had a long and turbulent history. Despite the remoteness of the region, the inhabitants of the Northern Areas have never been completely isolated from the event taking place in Central Asia, Iran, India, Pakistan or China. Many different peoples and cultures have left their impact on the region, including 'Rock Arts People, 'who can be traced back to the 5th millennium B.C; the White Huns from Central Asia, the Turks, the Dogra rules of Kashmir. However the documentation of history and chronology was started when Sikhs (in 1840), dodgers (in 1846) and British's (in 1877) penetrated in the region. They have brought a new management and statecraft and laid infrastructure. People accepted these changes delightfully, although the areas are freed in November, 1948 and peoples wanted to live with Pakistan (Dani, 1991).

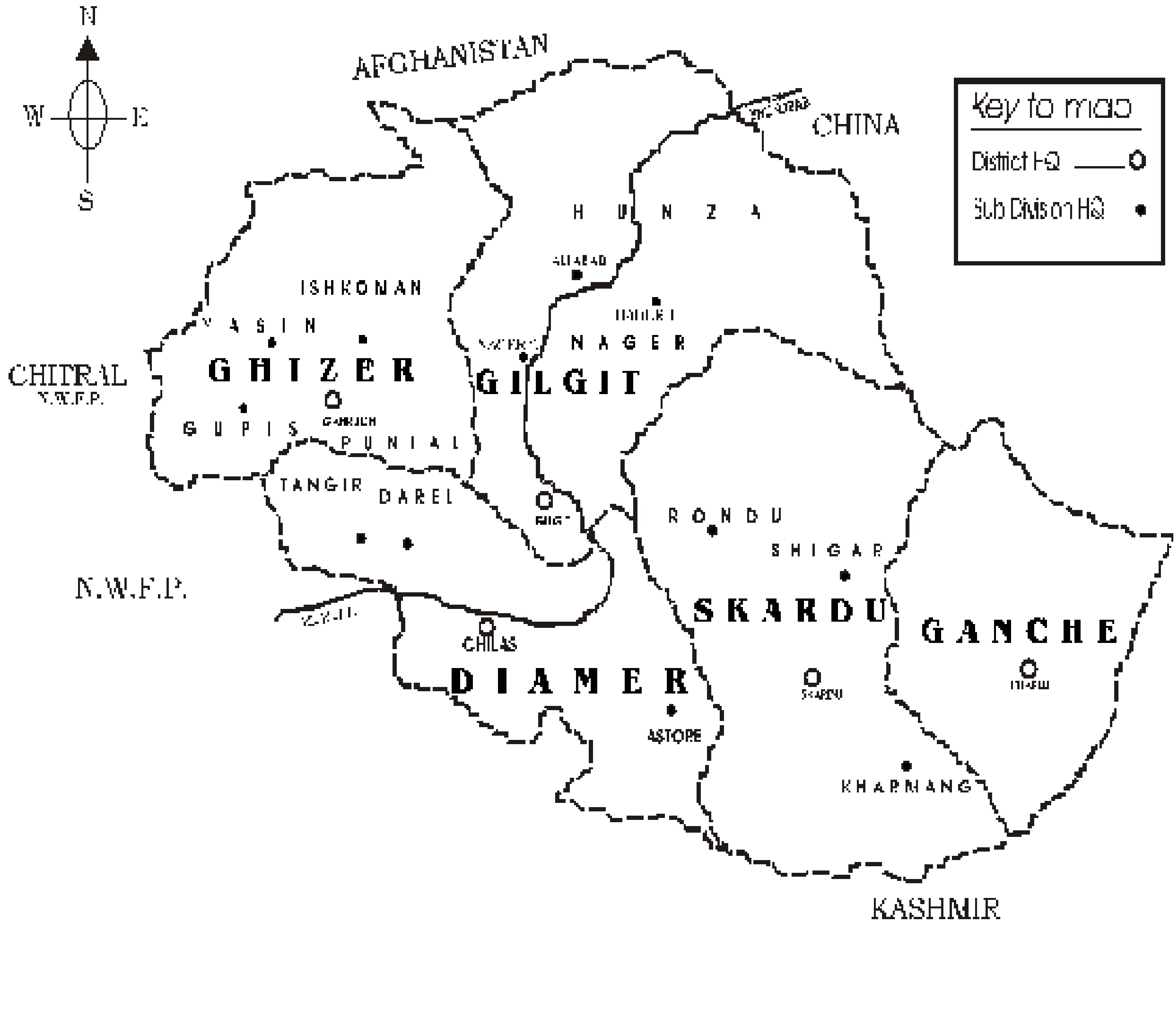


Fig. 1.1. Geographical location of Northern Areas of Pakistan (After Shahab, 2007)

1.2.3. Climate

The climate of the Northern Areas is dry continental Mediterranean. The barren mountains absorb solar radiations, which are converted into long-wave heat, giving rise too much higher temperature in summer. Average temperature in summer rises from 17.4 to 35 ^{0}C (June-August), in autumn it varies from 6.6 to 25.3 ^{0}C (September-November), in winter it varies from -2.7 to 10.8 ^{0}C (December-February) and in spring (March-May) from 8.8 to 22.8 ^{0}C (Fig.1.2). The Northern Areas occupy outer Himalayas and thus are cut-off from both the monsoons. The precipitation is consequently extremely low and moist air occasionally penetrates through the high mountains in late spring (May), summer and some times brings heavy and torrential rains causing hazards like floods, and mud flows. Largely it is an arid region (NASED, 2003).

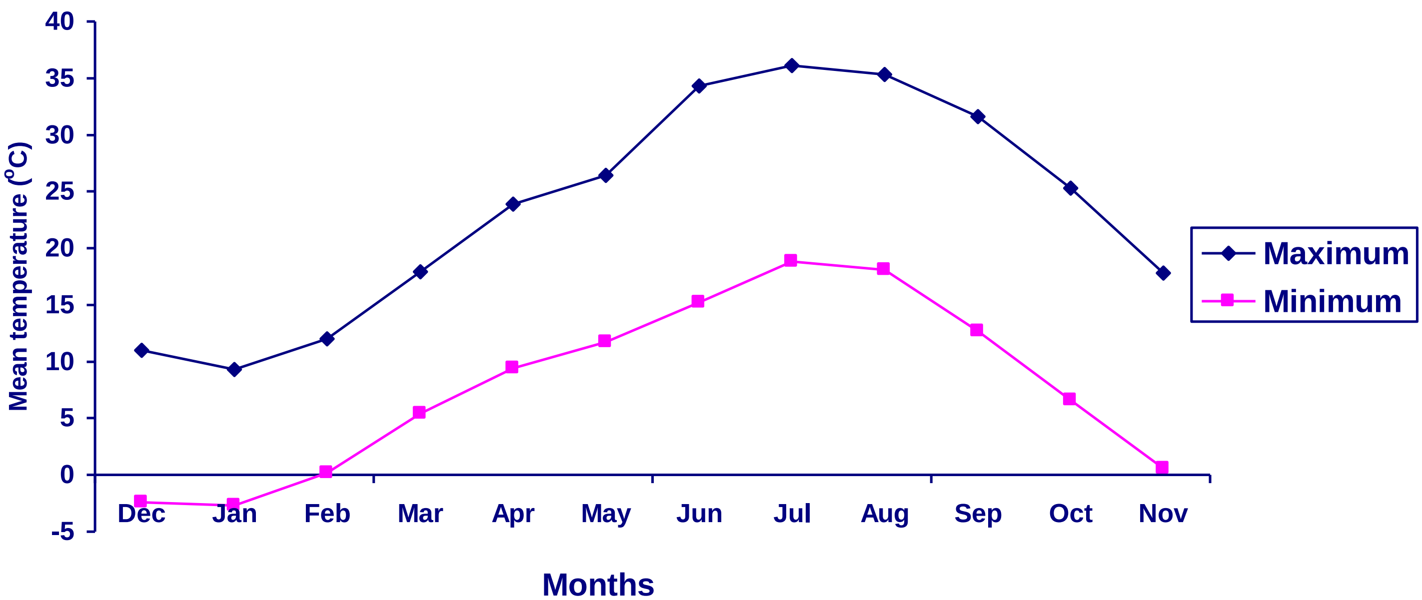


Fig.1.2.Temperature variation in Northern Areas of Pakistan (MET. Office Lahore)

1.2.4. Land and Soil Status

Cultivated areas have been developed mainly on alluvial fans and to a lesser extent from the reclamination of old river terraces. Soils are generally low in clay content, high in silt and sand fraction, and low in organic matter (usually less than one per cent). They tend to poor in nitrogen, although major and minor nutrients are reported to be adequate. However, as soil testing is not carried out systematically, little is really know about the available nutrient content of the Northern Areas soil (Hashmi and Shafiullah, 2003).

1.2.5. Topography

The Northern Areas are dominated by one of the most mountainous landscape on the earth, with an arm of the Hindu Kush to the west, the lesser Himalaya to the south, the karakuram to the east, and the Pamir to the north. In total, 101 peaks above 7,000 meter (Table 1.1), including Nanga Parbat and K.2 (the world’s second highest mountain), are found in the Northern areas, and also contain some of the largest glaciers outside the polar region (Table 1.2). The Baltoro glacier, for example, extends for 62 km and covers an area of 529 square kilometer. The Northern Areas also form a critical watershed for the Indus river. The early tributaries of the Indus run through the mountain in narrow, steep-sided valleys, and play a central role in the ecology and land –use region (NASED, 2003).

Table.1.1. Important Peaks of Northern Areas

S/No	Peaks	Altitude (meters)	Range	World Ranking
1.	K-2 (Chogori)	8,611	Karakoram	2

2.	Nanga Parbat	8,125	Himalaya	9
3.	Gasherbrum I	8,068	Karakoram	11
4.	Broad Peak	8,047	Karakoram	12
5.	Gasherbrum II	8,035	Karakoram	14
6.	Gasherbrum III	7,952	Karakoram	15
7.	Gasherbrum IV	7,925	Karakoram	17
8.	Disteghil Sar	7,885	Karakoram	20
9.	Kunyang Chhish	7,852	Karakoram	22
10.	Masherbrum NE	7,821	Karakoram	24
11.	Rakaposhi	7,788	Karakoram	27
12.	Batura	7,785	Karakoram	28

Source, www.tourism gov.pk/ mountaineering.hmtl.

Table.1.2. Important glaciers of Northern Areas

S/No	**Name of Glaciers**	**Area (sq km^2)**	**Length (km)**
1.	Siachen	685	72
2.	Baltoro	529	62
3.	Biafo	383	65
4.	Hispar	343	49
5.	Panmah	254	42
6.	Chongo Lungma	238	44
7.	Batura	220	56

8.	Khurdopin & Yukshin Garden	135	37
9.	Braldu	123	36
10.	Barpu	123	33
11.	Yaqghil	114	31
12.	Virjerab	112	38
13.	Mohmil	68	26
14.	Gasherbrum	67	25
15.	Malangutti	53	22

Source, Mol, 1991.

1.2.6. Lakes

There are 25 to 33 wetland sides in the Northern Areas of Pakistan. Most of these are fresh water lakes, which are fed by snowmelt streams, glaciers and springs water. Among them, most of the wetland (lakes) sites are found at the elevations between 2,800 and 4000 meters (Tabl3 1.3). These wetland provide a wide range of ecological and socioeconomic benefits. These are the basic sources of water in the region, regulate water level, best tourism potential sports by recreational activities and provides important fish and wildlife habitats (WWF-Gilgit, 2006). Some of important identified high altitude alpine lakes in the northern areas of Pakistan are shown in table 1.3.

Table. 1.3. High altitude alpine lakes in the Northern Areas of Pakistan

S/No	Name of Lake	Elevation	Location
1.	Sheosar lake	4,115 m	Doesai plain
2.	Satpara lake	2636m	Skardu

3.	Katchura lake	2500m	Katchura (Skardu)
4.	Borith lake	2600m	Upper hunza
5.	Rama lake	3,535 m	Rama (Astore)
6.	Koramber lake	4,304 m	Koramber (Ghizar)
7.	Uttar lake	3,840 m	Iskoman (Ghizar)
8.	Hundrap lake	3,291 m	Hundrap (Ghizar)
9.	Baha lake	1,2400 m	Khukosh (Ghizar)
10.	Naltar wetland complex	3,364 m	Naltar (Gilgit)
11.	Gasho lake	2,877 m	Sai-bala (Gilgit).
12.	Austi lake	3,292 m	Bumburat (Chitral)
13.	Shuvorth lakes	4,755 m	Shimshal (Hunza)
14.	Rush lake	4,206 m	Nagar (Gilgit)
15.	Lulusar lake	3,613 m	Naran valley
16	Dodipat lake	3,779 m	Naran valley
17	Saifulmuluk Lake	3,510 m	Naran valley

Source, Virk, et al., 2003.

1.2.7. Forest

The natural forests of the Northern Areas are limited to the south-western portion of the region. They occur primarily in Diamer District, the southern part of the Gilgit District the Punial area of Ghizar District and few packets of Baltistan District (i.e., Basho and Kharmang). Designated forest (both private and protected) covers some 281,600 hectares this is equivalent to nearly four percent of the Northern Areas. In the

Northern Areas mostly four types of forest are found which are sub tropical scrub, dry temperate coniferous, dry temperate Broad-Leaved and Sub alpine forest (Alam, 1976).

1.2.8. Biodiversity

The biodiversity of Northern Areas is believed to include some 230 species of birds, 54 species of mammals, 20 species of fresh water fish, 23 species of reptiles and 6 species of amphibians. The region's floral diversity has not yet been assessed, but the northern Areas are believed to support some of the reaches plants communities in Pakistan, including many different species of medicinal plants (Khan et al., 2004).

1.3. Aims and objectives

1. Identification and characterization of the lakes' waters of the Gilgit region
2. Assessment of physico-chemical parameters of the lakes' waters in regard to their role in the environmental degradation of the ecosystem of the region
3. Investigation of sources for the environmental degradation, if any, and giving recommendations for taking possible remedial measures

CHAPTER 2

STUDY AREA DESCRIPTION

The study area consists of nine selected high altitude alpine lakes possessing four sites within the two districts (District Gilgit and District Ghizar), Northern Areas of Pakistan (Fig. 2.1). Complete descriptions of lakes and their configuration are given below.

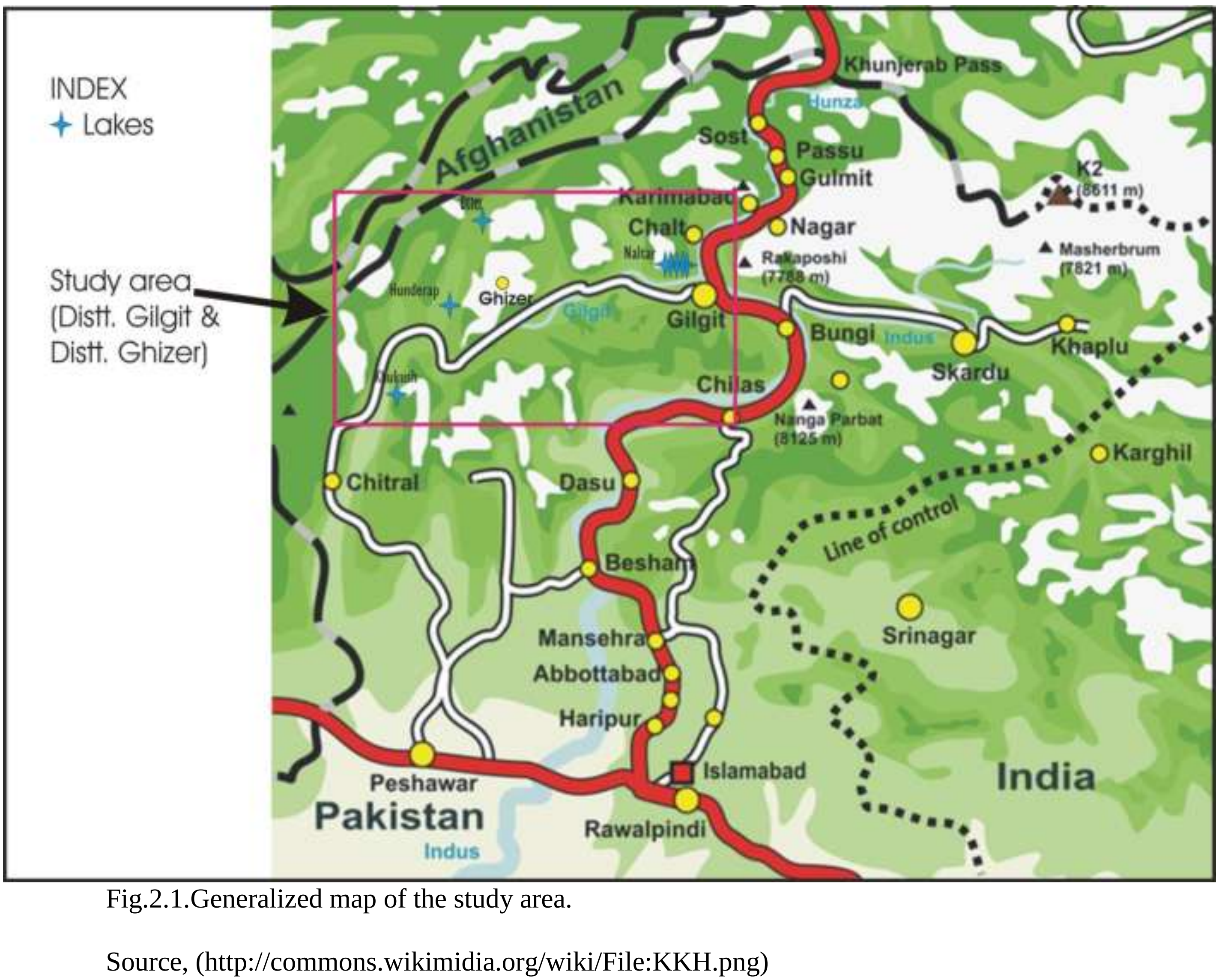


Fig.2.1.Generalized map of the study area.

Source, (http://commons.wikimidia.org/wiki/File:KKH.png)

2.1. Naltar Wetland Complex at Naltar

It is a wetland complex situated in the Gilgit District between latitude 36º10′ to 36º15′ N and longitude 74º05′ to 74º10′ E, with an easy access from Gilgit town. It comprises of six small-and medium-sized lakes which are generally located within 2 km^2 area (Fig.2.2 & 2.3). All these lakes are fed by melting of glaciers in the form of springs and streams. Lake-1 is called as "Berloki-bari", which is situated at an elevation of 502.615 meters. Lake-2 is called as, "Singo-bari", which is basically a peat land, located at an elevation of 3452.774 meters. Lake-3 is called as, "Chakar-bari" which is basically twins of two small lakes locating at an elevation of 3254.654 meters. Lake-4 is called as, "Chomo-bari" and is comparatively a small lake, situated at an elevation of 3202.534 meters. Lake-5 comparatively smallest lake within the wetland complex and is know as, "small bari" which is situated at an elevation of 3282.391 meters. Lake-6 is called as, "Koto bari" and is situated at an elevation of 3269.589 meters (WWF-Gilgit, 2006).

2.1.1. Hydrology

The main source of water to Naltar lakes is several small and medium size perennial streams which are fed by glacial melt water. In summer (Jun-Aug) the lakes water level increases to its maximum and in winter (Nov-Dec) it reaches to its lowest level. Occasionally heavy rains cause floods in the area.

2.1.2. Geology of the area

The geology of the area is dominantly characterized by subaerial fore-arc basaltic andesite, rhyolite, ignimbrite and volcanic clastic sedimentary rocks. There are also Chalt group (Abtain-blain), rocks and related calac-alkaline andisites, high-Mg tholleiites and boninites. Rakaposhi volcanic Formation and lower part of the Baumaharel Formation are also exposed (Searle et al., 1996).

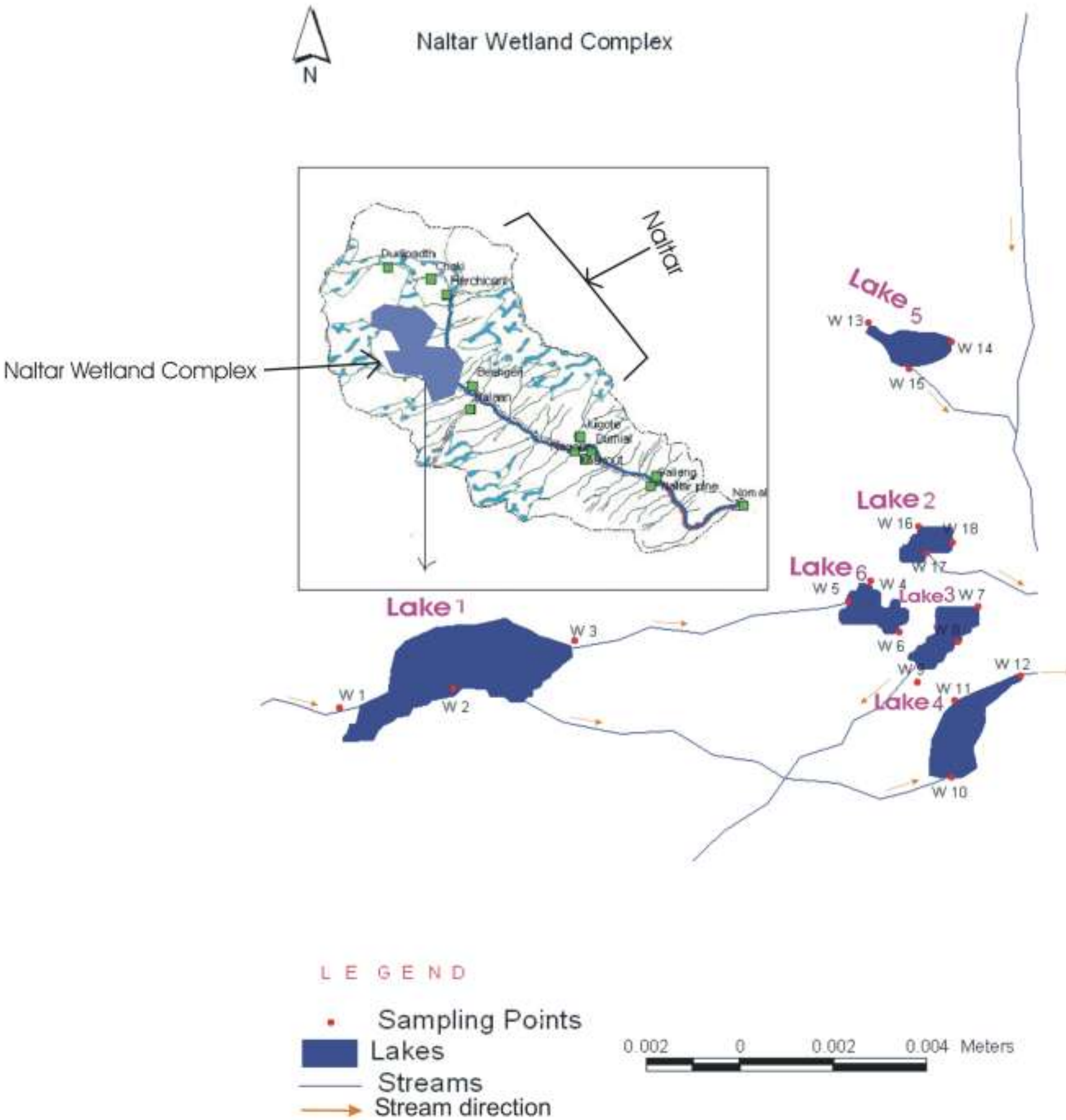


Fig.2.2. GIS based map showing various lakes of the Naltar wetland complex at Naltar

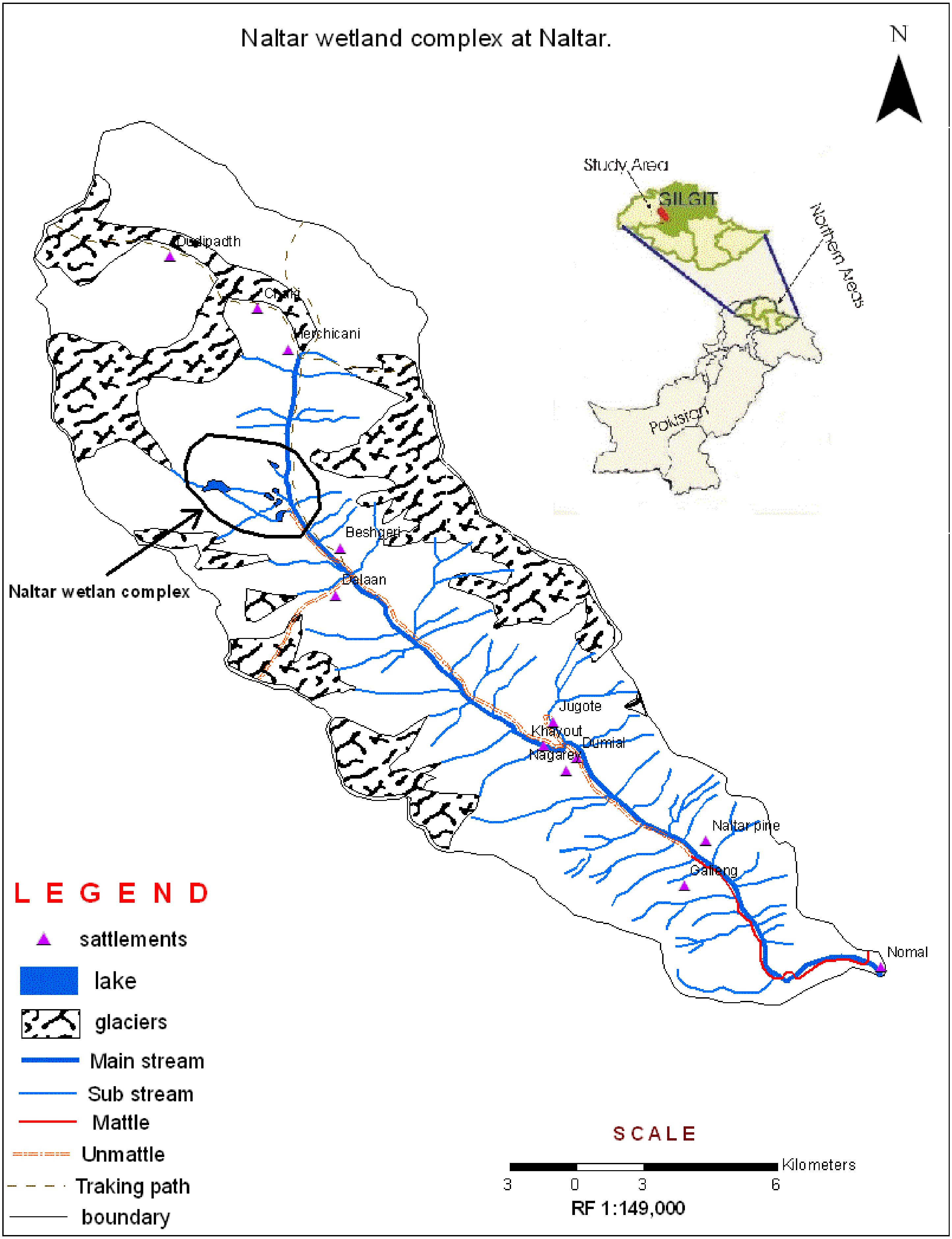


Fig.2.3 GIS based map showing accessibility to the Naltar wetland complex at Naltar

2.2. Uttar lake at Iskoman

It is an ecologically important lake (Fig. 2.4), in Ghizar District between latitude 36°35′ to 36°40′ N and longitude 73°35′ to 73°40′ E and is at an elevation of 3840.48 meters above the sea level. It is situated in Iskoman nullah (pasture) approximately 20 km away from Iskoman village. It takes about 18 hours of tracking to reach the lake. The area of the lake is 107.06 hectares (WWF-Gilgit, 2006).

2.2.1. Geomorphology

The Iskoman nullah runs in a steep narrow valley which opens into a comparatively wide plateau forming Uttar Lake. Behind the lake there are high mountain peaks which are the sources of perennial flow of water into the lake. The main outlet stream of the lake called Matintar river, flows down towards Iskoman village collected so many sub streams on the way, and finally merges with the Iskoman River.

2.2.2. Hydrology

The lake is fed by two main streams, Bolvadagov and Shaheen-pang and various snow melt streams which are combining to form a main inlet of the Uttar Lake. The main outlet stream is called Matintar stream. The various small and medium water channels and streams mix with Matintar stream which finally merges into the Iskoman river at the end of Iskoman village. A slight seasonal water fluctuation is observed in the lake, especially during the summer and winter seasons due to melting of snow in catchments area (WWF-Gilgit, 2006).

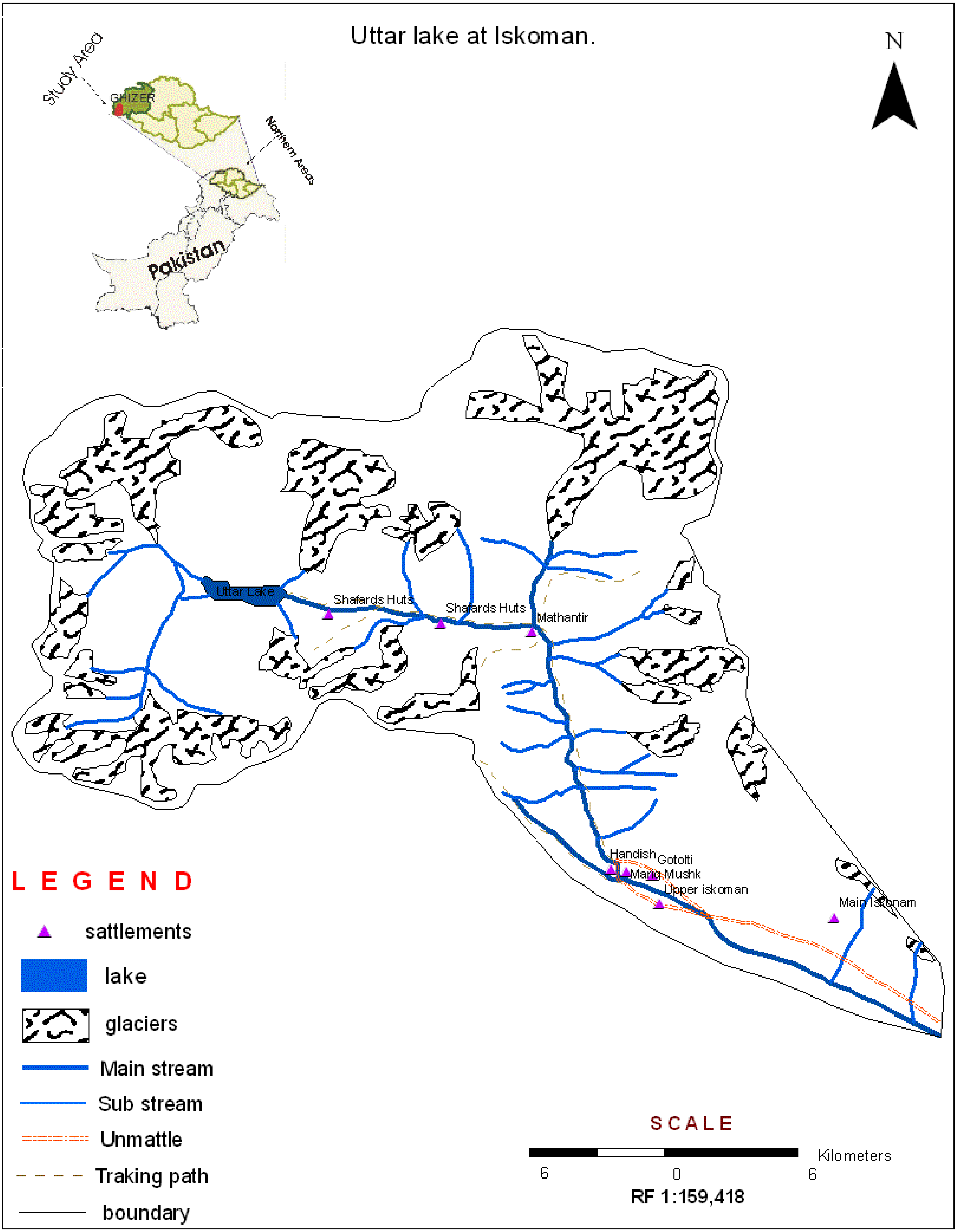


Fig.2.4.GIS based map showing accessibility to the Uttar lake at Iskoman

2.2.3. Geology of the area

Uttar Lake is located on the Ghamu Bar Plutonic Unit (GB).The area is also has the lithology of southern Karakoram metamorphic complex (SKM), toward the lower parts of Iskoman, in which rocks exposed are mostly parageneisses including interbanded pelite, marble, amphibolites (Ganschan, Dumordu, Askoli units) with rare ultramafic lenses (panmuh unit). Here Pelites contain micas, granet, staurolite, kyanite sillimanite + muscovite and sillimanite + K feldspar assemblages (Searle et al., 1996).

2.3. Hundrap Lake at Hundrap

This Lake is located in Ghizar District in Northern Areas of Pakistan (Fig. 2.5). It is considered to be one of the magnificent and ecologically significant lake in the region that attracts tourists due to its natural beauty. It lies between latitude 36°00′ to 36°10′ N and longitude 72°40′ to 72°50′ E and is at the elevation of 3291.84 meters above sea level. The actual area of the lake is 24.43 hectares (WWF-Gilgit, 2006).

2.3.1. Geomorphology

Hundrap valley is slightly narrow and bounded by rugged mountains, with alpine and sub alpine vegetation. Hundrap Lake is a perennial water body formed by glacial and snow melts water. Hundrap nullah (Pasture) extends up to the Swat valley of Khyber pothunkhawa on one side and on the other side it reaches the boundaries of Shandur pass. There are a variety of sedimentary and metamorphic rocks in the area. The soil is generally shallow and immature, containing fragments of rocky material, drifted sand and clay (WWF-Gilgit, 2006).

2.3.2. Hydrology

The lake is fed by numerous snow melting and glaciers melting perennial small and medium channels produced by the upstream catchments of Hundrap valley. In summer the lake water level rises to its maximum level due to melting of snow on glaciers and peaks, while in winter season the water level in the lake is goes to its minimum. Occasionally heavy rain causes floods in the area. The Hundrap nullah (outlet stream of the Hundrap lake) passes through the valley and merges with Gupis river at the end of Hundrap population (WWF-Gilgit, 2006).

2.3.3. Geology of the area

Dominant lithology of this area is characterized by Trondhjemite, calc alkaline gabbro-diorite, hornblende cumulates e.g. Matum Das pluton (Calc alkaline gabbro-diorite, granodiorite, granite), Shirot, Gindai, Gilgit plutons (Biotite $\pm$ Muscovite $\pm$ granet leucogranite), Indus confluence dyke swarm (Parri acid sheet).While the lower elevated parts of the area dominantly characterized by Utror volcanics, Dir group and shamram volcanic group (Searle et al., 1996).

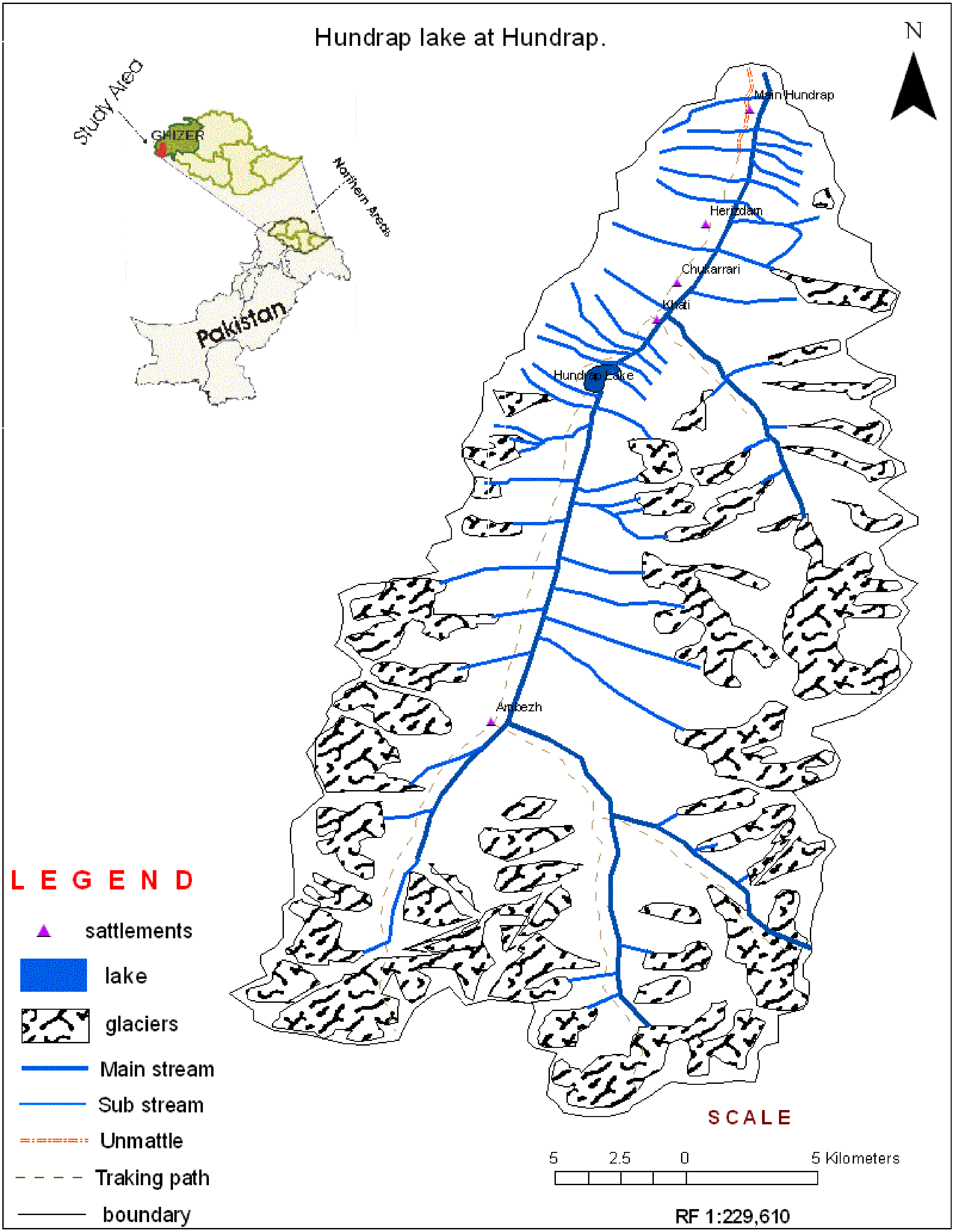


Fig.2.5. GIS based map showing accessibility to the Hundrap lake at Hundrap

2.4. Baha Lake at Khukosh nallah

This Lake is located in Khukosh nallah (Pasture) in Langer valley, just below Shandur plateau in Ghizar District Northern Areas of Pakistan. It lies between latitude 36°06′ to 36°40′ N and longitude 72°37′ to 72°50′ E, and is at elevation of 3640 meters above sea level. Langer valley has extensive peat bogs and perennial stream which originate from Baha Lake outlet stream and Shandur pass stream. The actual area of the Baha Lake is 81 hectares (WWF-Gilgit, 2006). Baha lake and its stream (Khukosh nallah), are famous for trout fish and considered as the best trout breeding ground in the Ghizar (Hussain, 2008).

2.4.1. Hydrology

Glaciers and snow melting small and large size different streams from the upper catchments of the lake are the basic feding source of the Lake. Out let from the Baha lake formed Khukosh nallah (pasture), which passes through the narrow valley and it joining with Shandur river at Langer. The Longer valley is basically pastureland for Tero, Barsat, Gulakhtori and other adjacent valleys of Ghizar district (WWF-Gilgit, 2006).

2.4.2. Geology of the area

The geology of this region is comprised of the rocks of Dir group and shamran group such as, subaerial for-arc basaltic andesite, rhyolite, ignimbrite and volcanic clastic sedimentary rocks. The area is also surrounded by trondhjemite, calc alkaline gabbro-diorite, hornblende cumulates e.g., Matum Das pluton (Calc alkaline gabbro-diorite, granodiorite, granite), Shirot, Gindai, Gilgit plutons (Biotite ± Muscovite ± granet leucogranite), Indus confluence dyke swarm (Parri acid sheet) toward the Gilgit (Searle et al., 1996).

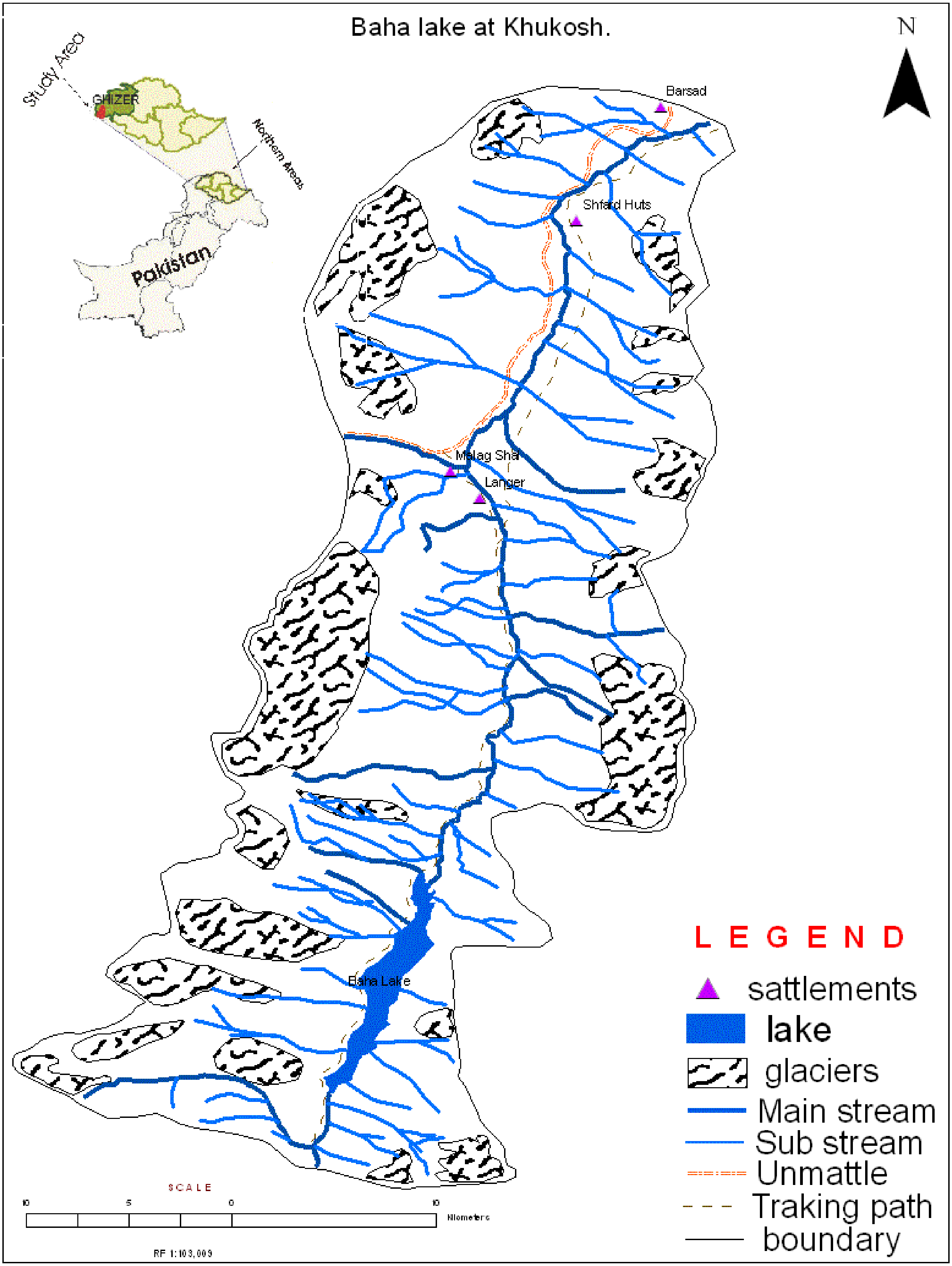


Fig.2.6. GIS based map showing accessibility to the Baha lake at Khukosh nallah

2.5. Ecological and socio-economic values of alpine lakes in Gilgit and Ghizar Districts.

2.5.1. Biological resources

Pastures and upstreams areas surrounding the lakes sustain a variety of wildlife. Important species such as snow leopard, wolf, Himalayan lynx, Himalayan ibex and brown bear have been reported in these regions, while in flora the wetlands (alpine lakes) and its upstream catchments are consisting of sub-alpine and alpine pastures such as, Willow, Birchand and Juniper. However, at lower altitudes sub tropical dry temperate species such as, Walnut, Russian olive, Mulberry, are present.

2.5.2. Sources of water

These high altitudes alpine lakes in these regions are considered as main resources of water, which are providing drinking, irrigation and other uses of water to the community living down hills these lakes.

2.5.3. Pastures

Scattered trees of Birch, Willow, Patches of coniferous (blue pine, spruce, juniper), broadleaved trees and scattered pastures exist around these alpines lakes, where the local communities graze their livestock in the summer.

2.5.4. Fish production

Some of the lakes like Hundrap and Baha lakes are famous for trout fishes and are considered as the best trout breeding ground in the Ghizar.

2.5.5. Tourism resorts

These high altitudes alpine lakes in the Northern Areas of Pakistan are popular tourist resorts since all the tourist attractions are available such as lakes, camping sides, beautiful landscape, tracking and wildlife. Therefore, these alpine lakes have excellent potential as a regional, national and international tourist destination for nature based recreation focusing on its rich flora and fauna.

2.6. Current potential threats to the alpine lakes

2.6.1. Overgrazing

The pastures surround the lakes are utilized by local communities during the summer season from April to September under a free grazing system. In winter most of the high altitude pastures are covered with snow. Due to the short season the right holders use the pastures intensively for a short amount of time. Their livestock overgraze palatable species and damage the regeneration of birch, juniper and other valuable flora.

2.6.2. Illegal hunting

Illegal hunting of wild life, fish and migratory birds is commonly practiced by some local community in these regions. Therefore, most of the endangered species are extincted from the region.

2.6.3. Ill managed tourism

Due to lack of tourist information centers and facilities in these regions, most of the tourists and local visitors are responsible for the degradation of natural ecosystem in these areas.

2.7. Geomorphalogical sitting of the lakes in the study area

Nine high altitude alpine mountain lakes in Karakoram and Hindukush ranges of North Pakistan are selected for the proposed study. Naltar wetland complex in district Gilgit is situated in the part of Karakuram Range, while Hundrap, Uttar and Baha lakes of

Ghizar district, are situated in Hindukush Range. General morphological sitting of these lakes are briefly discussed below.

2.7.1. Karakuram Range (Naltar Wetland Complex)

The Karakoram Mountains are situated at the western end of the Trans-Himalayan Mountains and are the result of the collision of the Asian and Indian continental plates. The region contains highest snow peaks, glaciers, lakes and some of the largest rivers with the highest sediment loads in the world, including the Indus, Gilgit and Hunza rivers (Ferguson et al., 1984). The rocks mostly exposed in the region are igneous and metamorphic. The region is still rapidly uplifting and being intensely denudated (Burbank et al., 1996). Denudational processes include frost shattering (Hewitt, 1968c; Goudie et al., 1984), chemical weathering by salt crystal growth (Goudie, 1984., Walley et al., 1984), glacial erosion (Goudie et al., 1984., Li Jijun et al., 1984), fluvial incision (Ferguson, 1984., Ferguson et al., 1984) and mass movement (Brunsden and Jones, 1984., Hewitt, 1988). All these processes are responsible to immense quantities of fine sediment, which has the potential to be deposited within lacustrine environments. The region is climatically transitional between central Asian and monsoonal south Asian types, varying considerably with altitude, aspect and local relief. Three extensive glaciations during Pleistocene times and at least five minor advances during Holocene times have been recognized (Derbyshire et al., 1984; Shroder et al., 1993). These have resulted in deeply eroded valleys and thick extensive deposits of till. The high supraglacial sediment loads give rise to large terminal and lateral moraines rather than subglacial till sheets. Many types of lakes have existed and still exist in the high mountains of Karakoram. There is no any tectonically formed lakes (the lake is formed as a result of tectonic process) have recognized in the Karakoram mountains, Although the orientation of the valley system, however, is strongly controlled by the tectonics and many of the valleys either lie a long fault or are controlled by rapidly uplifted massifs such as, Nanga Perbat, (Owen, 1989c), therefore most of the lakes situated in the Karakuran mountains are glacier damed lakes (Burgisser et al., 1982), or lakes formed from the blockage by debris flows, rock fall and by lansliding. Naltar wetland complex situated in the Gilgit District between latitude 36º10′ to 36º15′ N and longitude 74º05′ to 74º10′ E, comprises of six small and medium sized lakes which are located within 2 km^2 area of Karakuram Range are also glaciers dammed lakes in the Naltar region.

2.7.2. Hindukush Range (Uttar, Hundrap and Baha Lakes)

Uttar, Hundrap and Baha Lakes are glacier dammed alpine lakes situated in Ghizar District, District Ghizar in the Hindukush range is located in the west of Gilgit city, bordering with Chitral in the west, and Afghanistan to north. Towards south it borders with district Diamer. The Northern Areas specially Ghizar District has got extensive inland water resources comprising rivers and glacier lakes with varying potential for the development of inland fisheries on aquaculture in the region. The above mentioned alpine lakes (Utter lake, Hundrap lake and Baha lake) are the part of glaciers dammed lakes in the Hindu Kush range of Ghizar District (WWF-Gilgit, 2006).

The lakes in the Hindukush ranged are mostly glacier lakes mainly formed as a result of the blockage of the main river by advancing tributary glaciers. The topographic setting is at the current stage of glaciations in the Hindukush region favorable for the formation of this dam type. Tributary glaciers with catchments areas of over 7000 m in height descend down to low altitudes below 3000 m into the glacier-free trunk valleys and block temporarily the main river. A large number of glaciers terminate at confluence positions. The glacier dams consist of various glacier types, including short avalanche-cone glaciers as well as firnstream glaciers of up to 60 km in length (Iturrizaga, 2005).

In the Hindukush Mountains, a seasonal pattern dominates in July and August i.e., outburst chronologies, during the time of the highest discharge therefore failures of ice-dammed lakes mostly occurred between these month. But, most of the dams fail periodically with irregular possible return intervals of about 1-2 years (Iturrizaga, 2005).

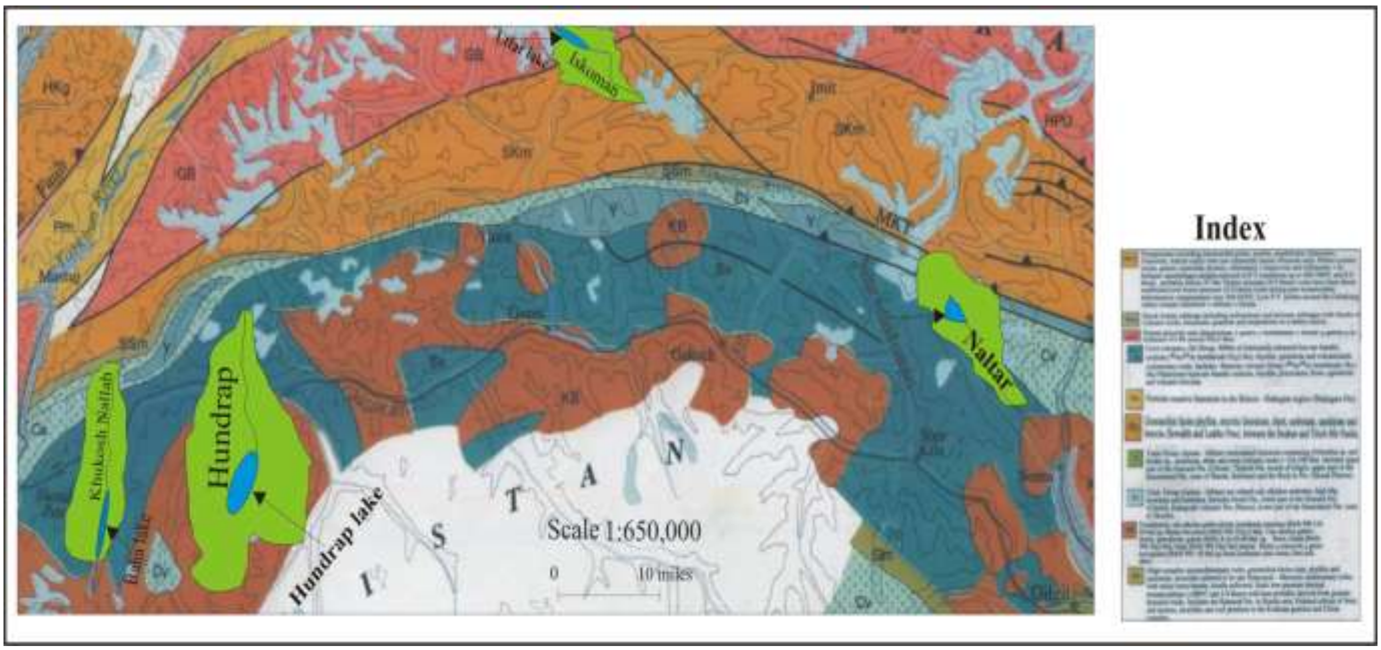


Fig.2.7. Generalized geological map of the study area and its surroundings (After Searle et al., 1996)

CHAPTER 3

LITERATURE REVIEW

A brief literature review of the related environmental studies conducted on similar kind of lakes in Pakistan as well as in other parts of the world has been discussed here to understand the importance of conducting the present research.

Matthew et al. (2008) conducted a study on local adaptation of microbial communities to heavy metal stress in polluted sediments of lake Erie in North America. They investigated the impact of heavy metal contamination on microbial communities. They performed two experiments; measuring extracellular enzyme activities (EEA) in polluted and unpolluted sediments of lake Erie. In the first experiment they found that, inoculations with moderate concentrations of copper and zinc appreciably diminished EEA from uncontaminated sites, whereas EEA from contaminated sediments increase or where only negligibly affected. In the second experiment, they compared the effects of three separate metals (i.e. copper, arsenic, and cadmium) on microbial community metabolism in polluted and unpolluted locations. When they compared the results, it was found that copper and arsenic were reacted differentially by inhabited EEA only in unpolluted while, cadmium inhibited in both polluted and unpolluted sediment. Multivariate analyses of EEA from polluted sediments revealed direct association among hydrolytic enzymes and inverse or absent association between hydrolyses and oxidizes; these associations demonstrated resilience of microbial communities to heavy metal stress. In contrast, addition of heavy metals to unpolluted sediments appeared to have a higher impact on the multivariate pattern of EEA associations as revealed by an increase in the number of associations, more inverse relationships, and potential enzymatic tradeoffs. At the last from the results of the study it is suggested that the community-level adaptations through the development of resistance mechanisms to the types and local levels of heavy metals in the environment.

Hussain (2008) had done assessment of production and market capacity of trout fish in fresh water (lakes, streams and rivers) in Ghizar District Northern Areas of Pakistan, under the supervision of AKRSP (Agakhan Rural Support Program). In their work they mention that, in Ghizar Districts, Northern Areas of Pakistan, there is no proper sanitation system, and most of the sewerages are openly entered in to the streams and rivers, which degradated the water quality and adversely affected the fish in these regions. They also mentioned that most of the communities in these regions use water from the nallah (water stream). As the water flows from the mountains to villages, it dissolves and carries the heavy metals. Therefore, the chances for the presence of heavy metals are common in water in these regions.

Tiercinlin et al. (2008) conducted a study on high-resolution sedimentary record of the last deglaciation from a high-altitude lake in Ethiopia, and in this study they linked sedimentary processes to the progressive retreat of a high-altitude glacier in the Bale Mountains surrounding the high-altitude lake in Ethiopia since1700 year recorded data. During the investigation they found that, Lake Sedimentation is interpreted as the result of discharges of melt water and glaciogenic sediment which progressively filled the accommodation space generated by glacier retreat within the basin. Monogenic sediment originated from glacial erosion of the trachytic tuff forming the cirque floor. Such type of studies will be helpful to illustrate the complex interaction between global (climate) and local (glyacier dynamics vs. local climate) processes and evolution of every sensitive environment of the Ethiopian highland regions.

Ahmad et al. (2007) did physical and microbiological assessment of drinking water of Nomal valley District Gilgit, Northern Areas, Pakistan. During the study they collected the water samples from the inlet and outlet of different water reservoirs and from other sources which distributing the water to the household in the Nomal valley. During the investigation of physical parameters it was found that the value of turbidity varies with the seasonal change and is because of heavy rainfalls, strong winds, and temperature. The value of temperature varied from 6 to 7.34C˚ during winter and autumn, 7 to 8.68C˚ during spring, while it was 11 to 14.34C˚ in summer. This increase of temperature enhances solid solubility, and microorganism's activities inside the water body. When the microbiological assessments were done, they found that the value of fecal coliform showed increasing pattern from source to outlet. The value of fecal coliform during the May and August at the source ranged to 90-280 fecal coliform/100ml, and was slightly increased toward the inlet water reservoir i.e.,195-434 fecal coliform/100ml. There is no treatment inside the water reservoir, therefore, the value of fecal coliform continuously increased and the value at the outlet was 202-437 fecal coliform/100ml. At the end they concluded that the microbiological assessment of water quality of Nomal region showed that the water in the region is highly contaminated with fecal coliform during summer and it is due to the agriculture activities and movement of livestock. Therefore, the gastrophil, and other abdomen related diseases are most common in the area during summer.

Ronnback and Strom (2007) conducted a study on hydrochemical pattern of Small lake and a stream in an area proposed as a Repository site for Spent Nuclear Fuel, Forsmark, Sweden. The over all aim of their study was to increase understanding of chemical dynamic of small catchments. In their study, they conducted the hydrochemical sampling campaign lasted nearly for four years with sample collection from monthly to semi-monthly and continuously they measured the water flow over the last twenty months. They concluded from their study that (1) as a result of the calcareous overburden caused by redistributed Paleozoic deposits in the catchments, pH of Ca^{+2} and HCO_3^- concentrations were relatively high in both the stream and lake throughout the period (2) limnic primary production resulted in decreased concentrations of Ca^{+2}, HCO_3^-, NH_4^+, NO_3^- and Si, and increased pH and concentrations of chlorophyll a, O_2, DON, POC, PON and POP in the lake in summer, while in other seasons (in winter in particular) when the production was minimal or non-existent, the concentrations of Ca^{+2}, HCO_3^- in the lake and the inflow stream were similar (3) high uranium concentrations in both stream and lake was derived most likely from reduced uranium minerals (i.e. uraninite, lanthinite and secoepite) in the overburden and was predicted to be carried to >90% in the form of calcium uranyl carbonate, in a model in which colloidal Fe and Al oxyhydroxides were not considered (4) the rare earth elements (REEs) had similar concentrations and fractionation patterns in the stream and lake, unlike those found in the overburden ground waters, and was predicted to be carried as organic complexes (e.g., dissolved organic matters, clay and alkali metals organic complexes). (5) the abundance of dissolved humic acids, predicted to carry the REEs, which consists of analogues for several actinides, deserve special attention in a safety assessment perspective focusing on radionuclide contamination.

Schenone et al. (2007) studied trace metal contents in water and sediments in samborombon Bay wetland, Argentina. In this project they investigated the phyio-chemical parameters of water and sediments in low and high water periods of different rivers, and channels that flow into the Bay wetland. During the study they found that the values of pH and temperature are increasing from northern to southern side in both water periods. In case of heavy metals, (i.e. Al, Mg, Ca, Na, K, As, Ba, Cr, Ni, Pb and Zn,) their concentrations were detected high in low water period and low in high water period due to dilution factor. The concentration of trace metals in sediments suggests, as a whole, that this wetland has been so far exposed to low to moderate levels of anthropogenic influence. They concluded that, the presence of metals in both water and sediments of this Bay might have effects on biota and on the regional tropical web chain. According to them, this study will be helpful to conservation of wetland environment in right manner for future.

Shah et al. (2007) conducted a study on determination of selected metals in drinking water of Water Purification Plants in Gilgit city, Northern Areas of Pakistan. To investigate the heavy metals in water, they collected the water samples from six representative water purification plants namely, (DHQ hospital, Konodas, Jutial, U.comps, Kashrote, and Oshkhandas) of Gilgit city. During the water samples analysis they found that pH and Electric Conductivity values of water samples were ranged from 7.42 to 7.92 and 0.12 to 0.25μs/cm respectively. Trace elements determined in all water samples where within the range permissible limits of WHO (2004). A concentration range of lead (Pb) determined in all the water samples was higher than the WHO permitted concentration values. Concentration of heavy metals except Pb falls within the WHO permissible value.

Yamada et al. (2007) conducted a nation wide acid deposition survey on long term trends in surface water quality of five lakes in Japan under the project of Ministry of the Environment in Japan. For this purpose they selected five representative lakes, (Lake Kuttara: northernmost; Lake Kamakita: near Tokyo; Lake Ijira: central; Lake Banryu: Westren; and Lake Unagiike: Southernmost), and their inlet streams to investigate the effects of acid deposition on surface water by using nonparametric Mann-Kendall test to find temporal trends in pH, Alkalinity, and Electrical conductivity (EC) in more than ten years recorded data. During the ten years of collected data they found that, there were no evidence of acidification in all the lakes, except Lake Ijira. The pH, in the water Ijira lake declined slightly and significant upward trend was noticed in electric conductivity (EC) since the mid 1990s. It is corresponding with the downward trends in pH and alkalinity of the river flowing into the lake water. The reason behind the acid deposition in Lake Ijira is the geology of the catchments, and the rate of acid deposition loading. They concluded that, because of the high acid-neutralizing capacity of the geology, in Japan acid depositions has so far had no obvious effect on acidification of surface water except lake Ijira.

Senpera et al. (2003) worked on persistent organic pollutants (DDT, PCBs and HCB) in little Egret Eggs from three selected Pakistani wetlands (i.e., Haleji lake in Sindh, Taunsa Barrege behind the Indus river in Punjab Province and Karachi Harbor, mangrove swamps in Karachi). During the study they selected Little Egert Eggs (water birds), prey, and sediments as representative samples from these wetlands. Among the three wetlands, Haleji lake generally considered as pristine lake because of its location in a rocky desert, while Taunsa Barrege and Karachi Harbor are considered as effected sites of industrial activities, agriculture runoff and large burden population. When all the compartments (Eggs, Prey and Sediment) of the samples collected from the selected wetlands were analyzed they found that, the concentration of organochlorine cyclodienes, of DDT, and PCBs were significantly lower in Haleji Lake than the other two sides. Tuansa Barrege show relatively lower concentration while the Karachi Harbor was characterized with high concentration of DDT and PCBs. They investigated that the presence of high concentration of organochlorine cyclodienes in all the samples of Karachi Harbor Swamps are due to the heavy industrial activities and presence agricultural forms in the surrounding area, while due to the stony or rocky desert and low burden of industrial activities of Haleji Lake showed low concentration of organochlorine. They investigated that, hydrocholobenzene (HCB) concentrations were generally low at all three study areas. However, they got highest concentrations at Haleji Lake where they were detected in all the compartments (Eggs, Prey and sediments).They suggested that the presence of HCB is due to the fungicide which were dumped in to the Lake. They concluded that the persistence of organochlorine in the living organisms (Bioaccumulations) of the areas is a result of transfer of these pollutants from their surrounding a biotic ecosystem through their Food web.

Sinyukovich (2003) conducted a study based on water quality and environmental aspects in lake Baikal which is natural lake in Southern Siberia between Buryat Republic and Irkutsk Oblast, Russia. He studied relationships between water flow and total dissolved solids (TDS) discharge in the major tributaries of lake Baikal. After the long term data observation of the relationships between the TDS and water flows of the three major tributaries of Baikal Lake, they found an inverse relation between the water flows and TDS of rivers water which is due to the predominance of hardly soluble gneisses, conglomerates, crystalline schist, and dolomite in the geological structure of their watersheds. By their ion composition these water belong to the hydrocarbonate class (Calcium group). They studied that the cause of alimentation are the main factor to understand the relationships between the water flow and ionic composition of water. They concluded that the governing role of water abundance in rivers in the dissolved solids discharged is important and their study will be helpful in improving the knowledge of the formation of total dissolved solids discharge in to the lake Baikal.

Islam et al. (2000) studied the Lake and reservoir water quality affected by metals leaching from tropical soil in Bangladesh. They studied the release of metals during the weathering in order to assess geochemical controls and possible effects on environmental health in Bangladesh. During comparative study of four sites (i.e., Rajarampur, Shamta, Mainamoti and Andulia of Bangladesh) they found that all the surface water samples were typically were enriched in Al, Mg, Ca, Na, K, As, Ba, Cr, Ni, Pb and Zn, which they considered are mostly due to weathering effect of strong climatic conditions. They concluded that the solubility of metal ions organometallic complexes and coprecipitation with the colloidal fraction are the main processes that lead to metal enrichment in the lake and reservoirs water.

Dua et al. (1998) conducted a study on organochlorine insecticide residues in Water from five lakes of Nainital (U.P), India. To investigate the contamination of organochlorine insecticides such as, DDT and HCH they selected five representative lakes namely Bhimtal, Sattal, Khurpatal, Naukuchiatal and Nainital. These are mostly situated in the hilly area of Nainital region. After the analyses of water samples collected from selected lakes, it was found that the concentration of DDT and HCH was maximum in July and minimum in March. The contamination of HCH in July ranged from 3.121 to 8.656μg/L. This range is higher than the limit established by Council of the European Communities (1980), for natural water, except in July the samples from the Bhimtal lake, all sample did not exceed the maximum permissible limit for HCH (4μg/L) reported by WHO (1984). While the mean contamination of DDT in all the lakes, ranged from 6.054 to 31.336μg/L which showed that all the lakes water exceeded the maximum permissible limit of DDT (1μg/L) for drinking water (WHO, 1984). They concluded that the higher concentration of DDT and HCH in lakes of Nainital are due to excessive use of DDT and HCH in the Terai and Bhabar area for malaria control.

Ogutu-Ohwayo et al. (1997) conducted a study on Human impacts on the African Great Lakes. During the studied they found that most of the African lakes and their catchments are under the pressure due to the human population around the lakes. Excessive use of fish and introducing the exotic species in the lake, native fish stocks will extinct. There are increased nutrient inputs from agricultural sewage and industrial discharges and combustion processes which can cause Eutrophication in the lakes. Overgrazing and deforestation phenomenon caused the loss of suitable habitats and biodiversity of the regions .They concluded that the thermal stability of lakes had been changed with the change in climates. According to them there is a human population increase around the lakes which resulted in the degradations of lakes.

Owen (1989) conducted a study on quaternary lacustrine deposits in a high-energy semi-arid mountain environment, the Karakuram Mountains, Northern Pakistan. In his study he used a facies model for lacustrine sedimentation in a high- energy semi-arid high mountain region, presented, using case studies from a glacially dammed palaeolake (Glacial Lake Gilgit) and a debris-flow dammed palaeolake (Lake Serat). During his study he found that, impressive quaternary lacustrine deposits terrace are present through- out the Karakuram Mountains, Northern Pakistan. They are mainly the result of damming of drainage systems during glacial advances or by catastrophic mass movement deposits. He found that longevity of most lakes is relatively short, in the order of years to tens of year, but sedimentation rates are extremely high as a consequence of the high sediment loads within the rivers. These sediments comprise dominantly planar bedded, massive and, less commonly, planar laminated, silts, comprising detrital quartz, feldspar, mica, calcite, chlorite and illite. He found that, as a result of rapid deposition of sediments and absence of organic materials, restricted the usefulness of these lacustrine sediments as proxies for palaeo environmental reconstruction, but they are helpful in reconstructing the former extent of glaciers and illustrating the importance of high-magnitude-low-frequency events, such as land sliding, as formative processes contributing to the evolution of the Karakuram land- escape. He concluded that, majority of Quaternary lacustrine deposits in the Karakuram Mountains are the result of drainage systems being dammed by glacial advances or catastrophic mass movements, and these lake deposits are probably important as a temporary storage for silts, which may later be reworked to contribute to aeolian deposits such as loess.

Water Sanitation, Hygiene, and Health Studies Project Northern Areas of Pakistan (WSHSP), conducted an in-depth weekly water quality surveillance study between 1993-1994**,** on micro-bacterial contamination in drinking water of Oshikhandass village where a piped water delivery system is in place, while in Jalalabad, the traditional open channels water delivery system is inplaced. Water samples were tested in-situ using the portable Del-Agued water kit and a standard membrane filtration. The range of contamination of E. coli in Oshikhandass region within were the piped water supply system was found as 48-372 *E. coli* /100ml in winter while during the summer it ranged from 191-417 *E.coli*/100ml. In case of traditional open channels water drinking system, it was significantly more contaminated with level as higher as 462-3025 *E.coli*/100ml in summer. This study concluded that the drinking water of Oshikhandass especially Jalalabad, Northern Areas of Pakistan are highly contaminated with bacterial contamination, therefore, gastrointestinal diseases is very common in such regions

CHAAPTER 4

METHODOLOGY

4.1. Field work

The following methods were used to collect the water samples from the selected high altitude Alpine lakes and streams of the study area (Naltar wetland complex, Uttar, Hundrap and Baha lakes with their related streams).

4.1.1. Water sampling

Representative water samples were collected from the inlet, centre, and outlet of the lakes (Fig.4.1, 4.2, 4.3 and 4.4). For comparative analysis representative water samples were also collected from the related downward streams of these lakes. All the water samples were collected in a cleaned polyethylene bottles. The polyethylene bottles were washed with double-ionized water before taking the water sample. Two water samples were collected from each point. One bottle was filled with water having no air bubble, while the other bottle was added with few drops of nitric acid after it was filled with the water from the same point. The former was used for the determination of physical parameters and anions while the later was used for the determination of major, heavy and trace elements (Mora et al., 2007).

4.2. Laboratory Methods

4.2.1. Determination of physical parameters

Among the physical parameters, the pH, EC, and T were determined on spot in the field by using various instruments such as pH meter, Consort Electrochemical analyzer and thermometer. The other parameters such as total dissolved solid (TDS), turbidity, salinity and resistivity were measured in the Geochemistry laboratory of the

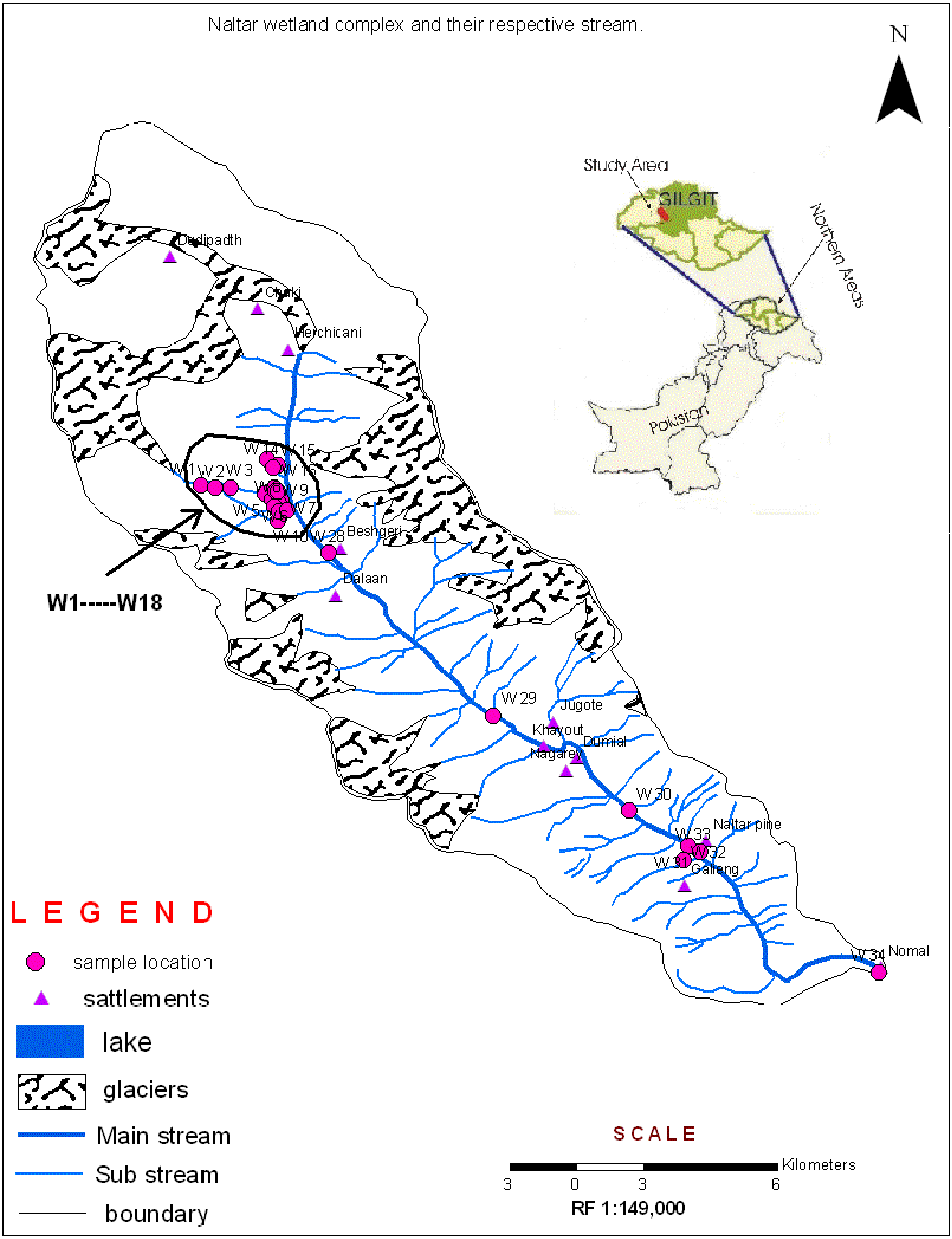


Fig.4.1.GIS based map showing sampling points in Naltar wetland complex and stream

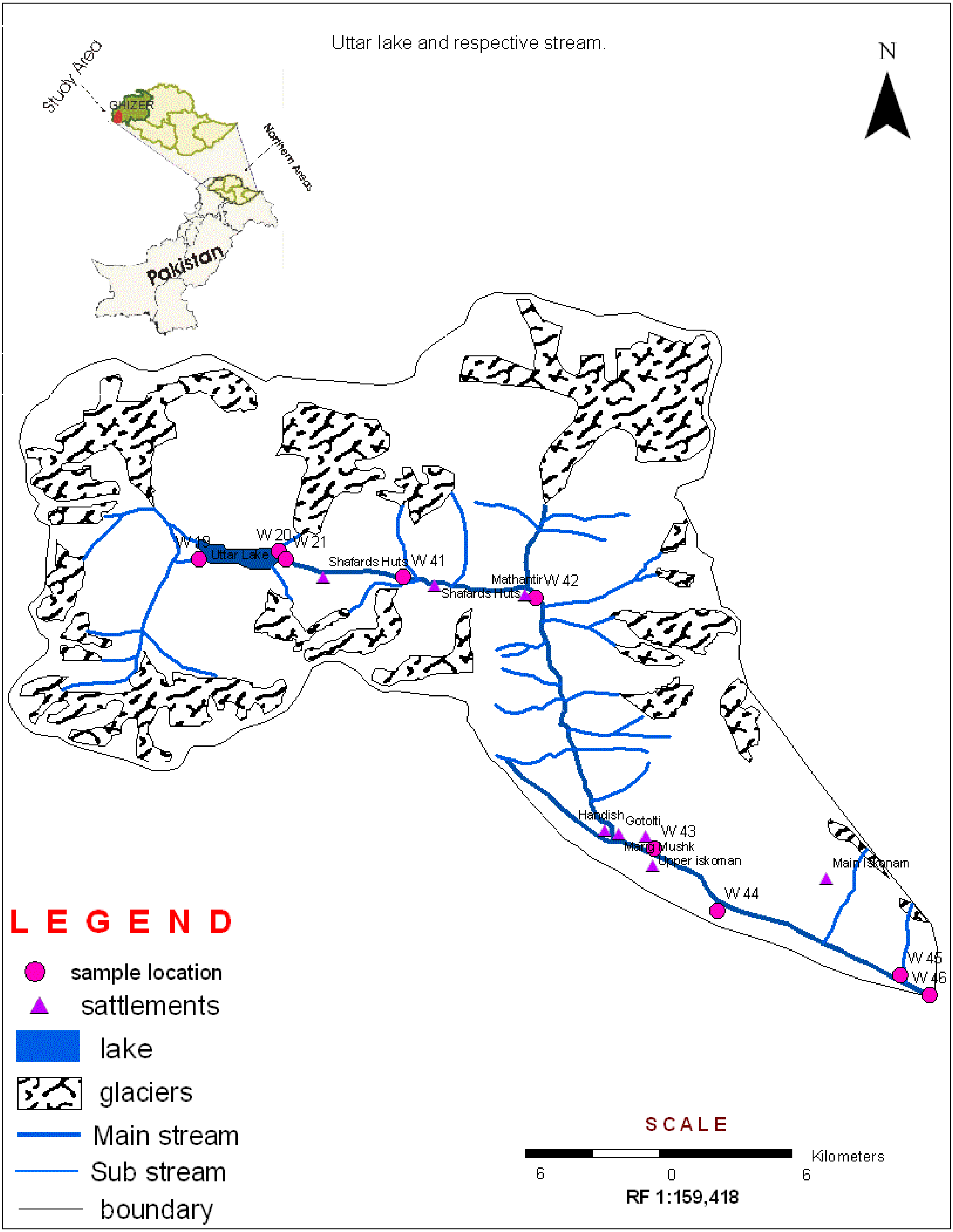


Fig.4.2.GIS based map showing sampling points in Uttar lake and respective stream

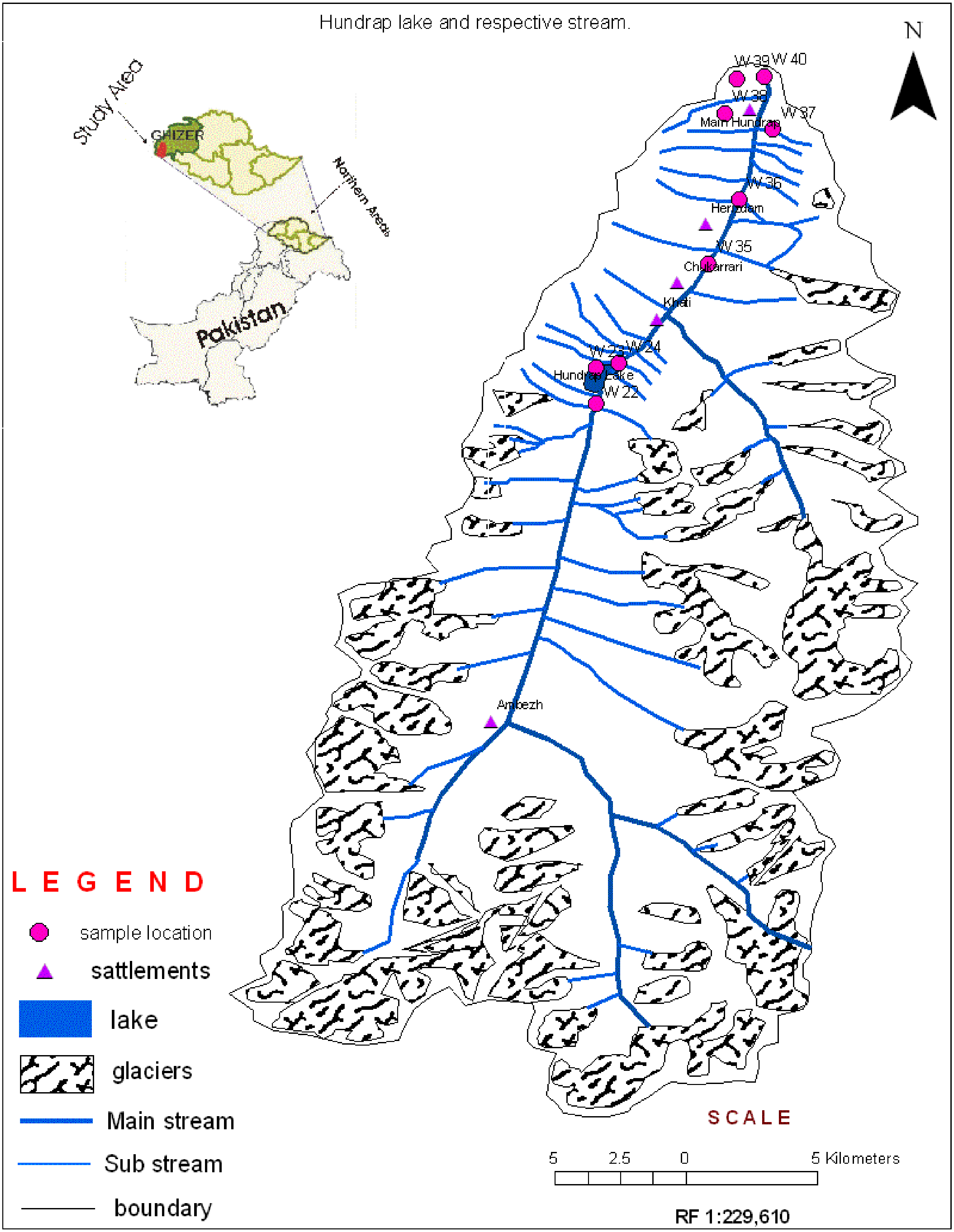


Fig.4.3.GIS based map showing sampling point in Hundrap lake and respective stream

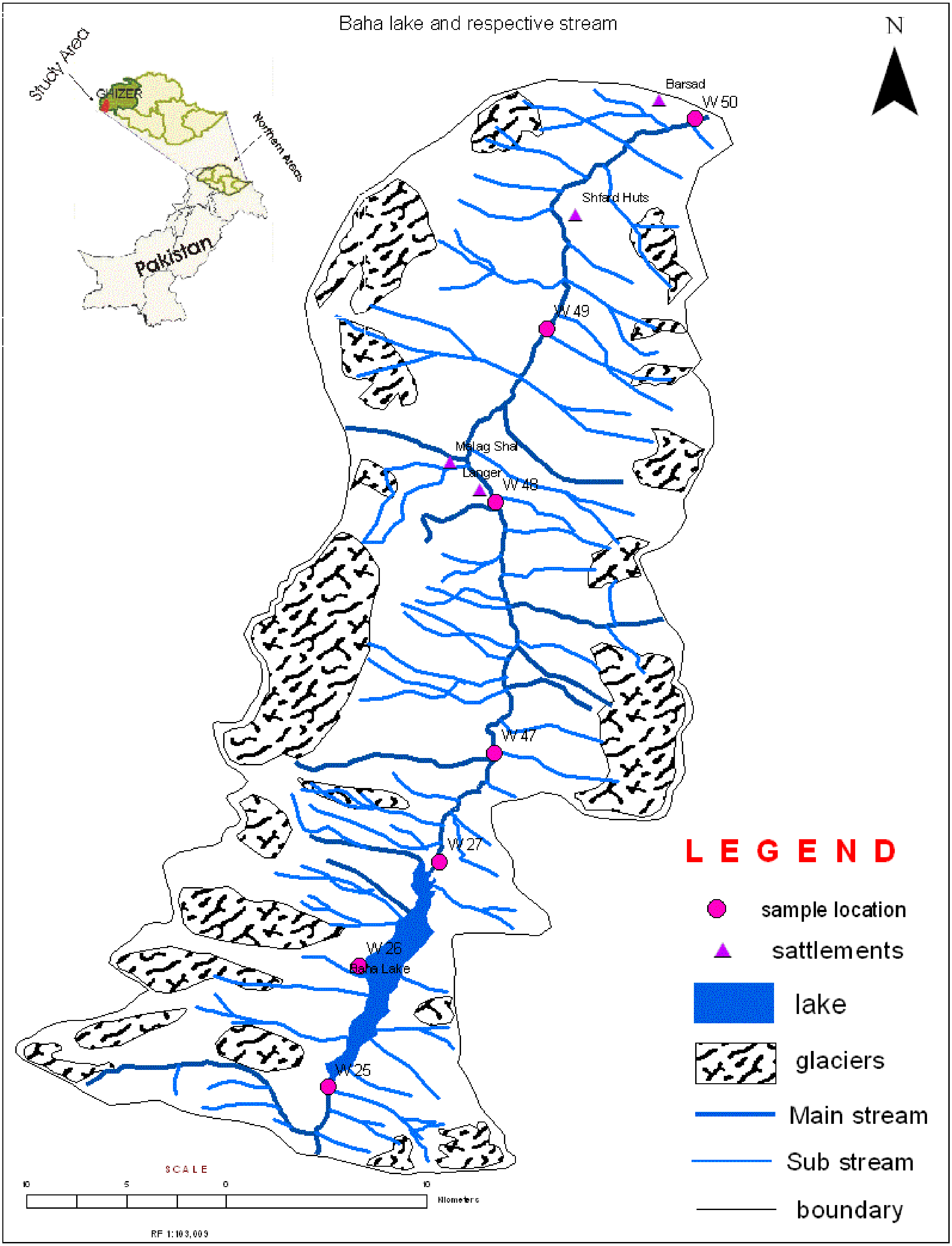


Fig.4.4.GIS based map showing sampling points in Baha lake and respective stream

National Centre of Excellence in Geology (NCEG), University of Peshawar.

4.2.1.1. Determination of Temperature

Temperature is one of the most important parameters for aquatic environment because almost all the physical, chemical and biochemical properties are governed by it. It is the temperature which limits the saturation values of solids and gases that are dissolved in it. Water temperature is a major factor in determining the different species present in the streams and lakes. Temperature was determined for the water samples in the field with the help of thermometer.

4.2.1.2. Determination of pH

Measurement of pH is one of most frequently used test in water chemistry.

pH refers to scale of intensity of acidity or alkalinity. For pH measurement of water samples, the pH meter was used. First the pH meter was standardized with buffer solution (solution whose pH tends to remain constant). The electrode was subsequently immersed in these buffer solutions and the instrument was calibrated in this way. Then immersed to the water sample and reading was directly noted from the pH meter. For accuracy the standardization of the instrument was checked by the buffer solution after running five samples.

4.2.1.3. Determination of Electric Conductivity (EC)

Conductivity is the ability of a material to conduct electric current. Since the charge on ion in solution facilitates the conductance of electric current, therefore conductivity in a solution is proportional to its ion concentration. In the laboratory electrical conductivity of water samples were analyzed by using Consort Electrochemical analyzer in μs/cm.

4.2.1.4. Total Dissolved Solids (TDS)

TDS contents of water are residue left upon evaporation at 103C˚ to 105C˚. The total dissolved solids (TDS) mostly comprise inorganic salts and small amounts of organic matter in a water body. TDS in water is due to its natural contact with the rock and soil with minor contribution from pollution, (Sinyukovich, 2001). TDS values were calculated in mg/L for water samples by Consort Electrochemical analyzer.

4.2.1.5. Determination of Turbidity /Transparency

Turbidity of water is responsible for the light to be scattered or absorbed rather than straight transmission through the sample. It is the size, shape and refractive index of the suspended particulates rather than the concentration of the latter present in the water samples that are responsible for turbidity. Turbidity was measured by JENWAY 6035 turbidity meter in NTU.

4.2.1.6. Determination of Salinity

The acid neutralization capacity of water is called Salinity of that water. Salinity of water is a function of carbonate, bicarbonates and hydroxide contents. In water samples, salinity was measured through Consort Electrochemical analyzer.

4.2.1.7. Determination of Resistivity

Consort Electrochemical analyzer was used to measure the resistivity in water samples in kΩ.cm.

4.2.2. Determination of Chemical parameters

4.2.2.1. Determination of Anions

4.2.2.1.1. Chloride (Cl^-)

Chloride was determined in laboratory by using DR/2800 photospectrometer. While determining chloride first of all chloride programme was selected in DR/2800. One cell was filled with 10 ml of water sample and with deionized water in another cell reserved as blank. Mercuric Thiocynate (0.8ml) of solution was added to each sample cell. Swirled to mix and then add 0.4 ml of ferric ion solution into each sample and mix well. Pressed the timer for two minutes for the completion of reaction. After two minutes put the blank solution in the cell holder and press zero, and then put the water prepared solution in to the cell holder and the reading was noted on the screen in mg/L.

4.2.2.1.2. Nitrate (NO_3^-)

Nitrates are normally present in natural drinking and waste waters. Nitrates enter water supplies from the breakdown of natural vegetation, the use of chemical fertilizers and from the oxidation of nitrogenous compounds in sewages effluents and industrial wastes. The DR/2800 photospectrometer was used to determine the nitrate for all the water samples in the laboratory. The regent used for the nitrate is called Powder Pillow Test (Nitra Ver 5 Regent Powder Pillow). First of all specific programme (No.358) was selected. One glass cell was filled with 10 ml of water sample, and then the content of one Nitra Ver 5 Regent Powder Pillow was added. Cell was shaked for one minute till the time dissolution was complete. Again sample was left for five minutes. Blank sample was prepared with 10 ml double deionized water in the cell and cell was inserted the holder.

Instrument was calibrated at zero with blank and then nitrate concentration in the water samples was noted as mg/L.

4.2.2.1.3. Sulfate (SO_4^{2-})

Sulfate was determined by using DR/2800 photospectrometer. The regent used for sulfate determination is, Sulfa Ver 4 Sulfate Act Vac Ampul. First of all SO_4^{2-} program (No.685) was selected. Water sample was prepared by adding Sulfa Ver 4 Sulfate Act Vac Amopule in 10 ml of square cell containing water sample. Sample cell was left for five minutes. Double deionized water was used as blank sample. It was taken to the cell holder, zero was pressed and then put the water sample cell and press and reading was noted of Sulfate in mg/L.

4.2.2.1.4. Carbonates (CO_3^{-2}) and Bicarbonates (HCO_3^-)

Titration method was used to measure carbonates and bicarbonates in all water samples with 0.1N hdrochloric acid. phenolphthalein and methyl orange were used as indicators for carbonates and bicarbonates respectively. The method of titration was run in such way that 25ml of water sample was taken in 250ml flask and added 3 drops of phenolphthalein, no color changing occurred which clarified the absence of carbonate in the water samples. In the same volume 2-3 drops of methyl orange were added. Light orange color developed in samples which were titrated against 0.1N HCl until color disappeared. The volume of acid used was noted and results were recorded in mg/L in terms of $CaCO_3$ using following formula (Srivastava, 2004).

$$\text{mg/L of } CaCO_3 = \frac{(\text{Volume x N of acid used}) \text{ x } 50{,}000}{\text{Volume of sample}}$$

4.2.2.2. Determination of Light Elements

The analyses for the light elements were performed on the Perkin Elmer Analyst 700 atomic absorption by using absorption mode.

4.2.2.2.1. Determination of Sodium (Na) and Potassium (K)

The stock standard solutions (1000mg/L) for Na and K were prepared by dissolving 2.542g of NaCl and 1.91g KCl in deionized water and the volume was made up to 1000ml in a volumetric flask. Working standards of 2.5, 5 and 10mg/L were prepared from this stock solution. After the preliminary standardization of the atomic absorption by the working standards, the concentration of Na and K were determined in water samples in mg/L. For conformation of instrument calibration and accuracy of analyses, blank and working standards were run after every 10 samples. The atomic absorption spectrometer was calibrated under the following conditions.

Conditions

Element	**Na**	**K**
Mode	Absorption	Absorption
Wavelength	589nm	766.5nm
Energy	57	89 J
Current	8	12 A
Slit width	0.2nm	0.4nm
Air flow	17 L/mi	17L/min
Fuel flow	2L/min	2L/min

4.2.2.2.2. Determination of Ca and Mg

For determination of Ca and Mg, standard solution was prepared by dissolving 2.479gm of $CaCO_3$ and 4.95gm in 50 ml of deionized water, in which 10 ml of conc. HCl was added and after this the solution was made up to 1000 ml in volumetric flask with deionized water. From the stock standard solution 2.5, 5 and 10 mg/L working solutions were prepared. After atomic absorption standardized with these working standards solutions, the concentration of Ca and Mg were determined in water samples in mg/L. For confirmation of instrument calibration blank and working standards were run after every 10 samples. The atomic absorption spectrometer was calibrated with the conditions as mentioned above for Na and K.

4.2.2.3. Determination of heavy metals by using graphite furnace

The heavy and trace elements concentration were determined by the Perkin Elmer Analyst 700 atomic absorption fitted, with HGA graphite furnace and autosampler.

4.2.2.3.1. Determination of Manganese (Mn)

For manganese 1000mg/L standard solution was prepared by dissolving 4.418gm of $MnSO_4.4H_2O$ in deionized water in volumetric flask and diluted to 1L. Working standards of 50, 100 and 200 μg/L were prepared from the stock solution. After the instrument calibrated with above mention prepared standards, the concentration of manganese was determined in μg/L in all water samples. For instrument calibration confirmation standards were run after every 10 water samples.

Conditions

Mode	**Absorption**
Wavelength	279.5nm
Energy	38J
Current	20A
Slit width	0.2nm
Air flow	17L/min
Fuel flow	2L/min

4.2.2.3.2. Determination of Iron (Fe)

First of all, 1000mg/L stock solution was prepared by dissolving 1.15g of Mohr salt [Fe $(NH_4)_2$. $(SO_4)_2$ H_2O] in deionized water and further diluted in volumetric flask to 1L. From same stock solution, working standards of 50, 100, and 200µg/L were prepared. The instrument was calibrated by these working standards under the following calibration conditions.

Conditions

Mode	**Absorption**
Wavelength	248.3nm
Pretreatment temp	1400˚C
Atomization temp	2400˚C
Energy	40J
Current	30mA
Tube/site	pyro/platform
Slit width	0.2nm

4.2.2.3.3. Determination of Copper (Cu)

Stock solution (1000mg/L) was prepared by dissolving 1gm Cu in (1:1) HNO_3 and diluted to 1L with diionozed water in a volumetric flask. Standards of 50,100 and 200µg/L were prepared from this stock solution. Instrument was calibrated with these standards and concentration of copper was determined in µg/L. The conditions under which instrument was calibrated are as following.

Conditions

Mode	**Absorption**
Wavelength	324.8nm
Pretreatment temp	1200˚C
Atomization temp	2300˚C
Energy	23J
Current	15mA
Tube/site	pyro/platform
Slit width	0.7nm

4.2.2.3.4. Determination of Lead (Pb)

The stock solution was prepared by dissolving 1.598gm of $Pb(NO_3)_2$ in 1% of HNO_3 and the volume was made to 1L by adding deionized water. After the calibration of instrument under the given condition, concentration of lead was noted as µg/L. Blank and working standards were run after 10 water samples for the conformation of instrument calibration and accuracy.

Conditions

Mode	**Absorption**
Wavelength	283.3nm
Pretreatment temp	850˚C
Atomization temp	1800˚C
Energy	35
Current	10mA
Tube/site	pyro/platform
Slit width	0.7nm

4.2.2.3.5. Determination of Zinc (Zn)

The stock solution (1000mg/L) was prepared by dissolving 1gm of Zn metal in minimum volume of HCl and the volume was made to 1L by adding deionized water. After getting the calibration of instrument, the concentrations of Zn in water samples were determined in µg/L. The required conditions for Zn determination are as following.

Conditions

Mode	**Absorption**
Wavelength	213.9nm
Pretreatment temp	700˚C
Atomization temp	1800˚C
Energy	22J
Current	15mA
Tube/site	pyro/platform
Slit width	0.7nm

4.2.2.3.6. Determination of Nickel (Ni)

Stock solution of 1000mg/L was prepared by dissolving 1.273gm of Ni_2O_3 in minimum volume of 10% (v/v) HCl and diluted to 1L with deionized water in a volumetric flask. Working standards of 50, 100 and 200µg/l were prepared from stock solution. For the instrument calibration and measuring accuracy, the blank and working standards were run after every 10 water samples. Instrument was calibrated according to the following conditions.

Conditions

Mode	**Absorption**
Wavelength	232nm
Pretreatment temp	1400˚C
Atomization temp	2500˚C
Energy	30J
Current	25mA
Tube/site	pyro/platform
Slit width	0.2nm

4.2.2.3.7. Determination of Chromium (Cr)

Stock solution of 1000mg/L was prepared by dissolving 3.735gm of potassium chromate (K_2CrO_4) in deionized water and diluted to 1L with same water in volumetric flask. From this solution working standards of 50, 100 and 200µg/L were prepared. After proper calibration, samples were run and concentration was noted in µg/L.

Conditions

Mode	**Absorption**
Wavelength	357.9nm
Energy	30J
Current	25A
Slit width	0.7nm
Air flow	17L/min
Fuel flow	2.5L/min

4.2.2.3.8. Determination of cadmium (Cd)

For making 1000mg/L stock solution 1gm of Cd metal was dissolved in minimum volume of HCl and diluted with 1 % HCl upto 1L. Standards of 50, 100 and 200µg/L were prepared from this stock solution. After proper calibration samples were run and concentration was recorded in µg/L. The required conditions for Cd determination are as following.

Conditions

Mode	**Absorption**
Wavelength	228.8nm
Pretreatment temp	700˚C
Atomization temp	1608˚C
Energy	26J
Current	4mA
Tube/site	pyro/platform
Slit width	0.7nm

4.2.2.4. Determination of toxic elements, Mercury (Hg) and Arsenic (As) by Mercury Hydride System (MHS)

Toxic elements like mercury and Arsenic were determined by Atomic Absorption on a MHS mode.

4.2.2.4.1. Determination of Mercury (Hg)

After preparation of stock solution 1000mg/L working standards of 10, 25 and 50µ g/L were prepared from same stock solution. When the instruments were properly calibrated with the standards 10ml of water sample was taken in a reaction flask, and added 10 ml of 1.5% HCl. To initiate the reaction button was pressed for 25 second, and Hg was noted as µg/L. After the post reaction time (40sec) sample was quickly discarded. Various regents required for this method were prepared as follow:

Required Regents

1. Concentrated HCl (15ml) was diluted with deionized water up to 1L for the preparation of 0.15 mol/L.
2. Diluted Nitric Acid of 0.22 mol/L was prepared from the concentrated Nitric Acid by adding deionized water up to 100ml.
3. For 5% $KMnO_4$ solution 5gm Potassium Permanganate was dissolved in deionized water and made up to 100ml.
4. NaOH (0.25 mol/L) was prepared by dissolving 10gm of NaOH in deionized water and made up 1L.

An instrument was calibrated for Hg determination under the following conditions.

Conditions

Mode	**Absorption**
Wavelength	253.6nm
Slit wide	0.7nm
Pre reactions purge time	5 sec oppox
Post reaction purge time	50 sec
Pre reaction purge time	50 sec
Reaction time	25 sec
Post reaction purge time	40 sec

4.2.2.4.2. Determination of Arsenic (As).

From stock solution of 1000mg/L, working standards of 10, 25 and 50µg/L were prepared, and instruments was calibrated with these standards solution under the below mentioned conditions. When the instruments was properly calibrated 10ml of water sample was taken in a reaction flask,10ml of 1.5% HCl and 1ml of KI were added to each water sample. Same procedure was followed for the blank and standards. After 30min, samples were run on MHS and As was noted as µg/L.

Various solutions required for this method were prepared as follow:

1. **NaOH** solution {0.25mol/L (1% w/v)} was prepared by dissolving 10gm NaOH in double deionized water and diluted to 1L. **0.15M (1.5% v/v) HCl.**
2. **HCl** (5mol/L) was prepared by taking 500ml concentrated HCl and diluting up to 1L with double deionized water.
3. **$NaBH_4$** (0.8mol/L) solution was prepared by taking 3gm Sodium borohydride and dissolving it in 100ml of 10% NaOH.

4. Solution of **KI** was prepared by dissolving 3gm KI and 5gm Ascorbic acid in 100ml of deionized water.

Required conditions for As determination are as following.

Conditions

Mode	**Absorption**
Wavelength	193.7nm
Slit wide	0.7nm
Radiation source	Electrodeless discharge lamp for As
Pre reaction Purge time	50 sec
Reaction time	25 sec
Post reaction Purge time	40 sec

4.3. Piper diagram scheme

Piper diagram is a graphical representation of the chemistry of water samples. Generally it consist of two triangles (one for cations and one for anions), and a central diamond-shaped figure. Water analysis plotted on piper diagram scheme cation (such as Ca^{+2}, Na^{+}, K^{+} and Mg^{+2}) percentages in $meqL^{-1}$ plotted on the left triangle, and anions (such as Cl^{-}, SO_4^{2-}, CO_3^{2-} and HCO_3^{-}) percentages in $meqL^{-1}$ plotted on the right triangle. Points on the cations and anions diagram are projected to upward where they intersect on the diamond.

4.4. GIS Maps

For the plotting and digitization of all the maps were constructed and digitized for the study by using the GIS software called as Arc-GIS 9.2.

CHAPTER 5

WATER CHEMISTRY

5.1. Introduction

Water is a major constituent for all living organisms. The human body is containing about 85% of water and vegetative materials are containing about 90% of water. In all the living systems the basic fundamental processes are dependent on the distinctive physical and chemical properties of water. It is the only a substance on the earth that exists in three different states i.e., solid, liquid and gaseous. The vast amounts of water on the surface of earth act as a giant thermostat to moderate the earth's temperature. Due to high specific heat it helps to maintain stable temperatures in living organisms (Soomro, 2004).

There is a fixed amount of water on the planet, (nearly 1388 million km^3) Which can be neither increased nor decreased but only can be polluted by interaction with fresh resources without proper planning. About 70% of the earth's surface is covered by the ocean, which contain about 97.3%.of total water on the earth. A further 2.09% is ice and the rest is found underground (0.60%), in fresh water lakes (0.007%), in saline lake (0.0007%), in soil water (0.005%), in atmosphere (0.0009%), in living bio-mass (0.0002%) and in rivers and streams (0.00007%) (Soomro, 2004).

This small portion of the fresh water on the earth can be used to meet the need of humanity-to quench its thirst, to wash away its wastes and water to its crops. In many countries, this limited supply is polluted by industrial and municipal wastes, agricultural runoff and sediments from eroded land. About 40% of the world's population is dependent upon water from neighbouring countries. In such cases, one country polluted water may become problem of neighbor country. Nevertheless, this small portion should be enough to sustain all forms of life on earth, provided it is more evenly distributed and kept unpolluted (Narayan, 2000).

5.2. Water pollution

Water pollution is a phenomenon that is characterized by the deterioration of the quality of land water (river, lakes, marshes and ground water) or seawater as a result of various geogenic and human activities (Triveddi and Raj, 1992). There are certain pollutants which by both geogenic and anthropogenic activities that enter the water which effect the physical and chemical quality of water and cause water pollution. Water pollution occurs in oceans, rivers, lakes, bays, streams and underground water. It involves the release of toxic substances, inorganic chemical and pathogenic germs, substances that require oxygen to decompose, easy soluble substances and radioactivity. The root causing agents of these pollutants in the water are, synthetic agricultural chemicals, sediments, petroleum products hazardous wastes and excess of organic matter (Botkin, 1995).

High altitude alpine lakes/wetlands are one of the best water resources and suitable habitats to the biodiversity (Hecky and Ohwayo, 1990). These high mountain alpine lakes are good indicators of regional and global pollution, as they are far from human settlements and the variations they undergo are mainly due to atmospheric deposition of pollutants and to climatic change. In general, they are sensitive to changes in atmospheric deposition because of their peculiar characteristics, such as small size, watershed with steep slopes, little land cover and thin soil, low temperature and low weathering rates of their bedrock. Palaeolimnological evidence has shown the sensitivity of alpine lakes to acidification and to temperature change (Marchetto et al., 1995).

Gradually when the human population increases, interruption of human to such highly environmental sensitive areas will be started. Human impacts on lake ecosystem by overexploitation, which leads to a decline in the fish stocks, industrialization and land use, can lead eutrophication and rapid contaminations of the aquatic ecosystem (Hecky and Bugenyi, 1992).

5.2.1. Sources of water pollution

There are two types of sources from which pollutants are usually generated that lead to water pollution. These are (1) point sources from which the pollutants released at one readily identifiable spot such as steel mill, sewer outlet, septic tank and (2) non-point sources from which the pollutants released in diffused form and it is difficult to identify their sources such as fertilizer run off from farmland, acid drainage from an abandoned strip mine, runoff of calcium and sodium chloride salt from either directly off roadway or via storm drains. The point sources of pollution are often easier to identify relative to the non point sources of pollution (Montgomery , 2006).

5.2.2. Types of water pollutants

Water pollutants are the substances that enter the water body from an external source and are responsible to degrade the aquatic ecosystem. Geogenic and anthropogenic activities lead to accelerate the rate of water pollution.

Reven et al. (1993) categorized the pollutants according to their existence which are as follows:

- **a.** Soil erosion which lead to sediments pollution.
- **b.** Diseases causing germ from the infected organism.

c. Mercury compound, salt and acid drainage type of inorganic chemicals from the mines.

d. Sewerage waste water carried off by drain or sewer from the toilets, shower and kitchens.

e. Inorganic plant nutrients such as Nitrogen, Phosphorous originating from animal waste, plant residues and fertilizers.

f. Organic compound in synthetic form that are often toxic to aquatic organisms,

g. Waste from the mining and refinement of radioactive metals, causing radioactive substances pollution.

h. Thermal pollution i.e., heat entering from the industries which is not

only affecting the liquid organisms but are also toxic for variety of wildlife.

5.3. Water chemistry

Chemically pure water is two molecules of hydrogen and one of oxygen (H_2O). Such a substance is not found in nature, not in wild stream lakes, clouds, rain and not in falling snow, or nor polar of ice caps. Pure water can be prepared in laboratory but only with considerable difficulty (Jonathan et al., 1983). Water body has different water chemistry in its different forms (in air, in snow, in river, in lakes and in oceans). During the hydrological cycle of water, fresh water in the form of rain and snow fall on the surface of earth and it started to move downward from the high altitude, it dissolves many substances from the surrounding catchments and water get contaminated on the way. Water accepts and holds foreign matter in various ways that are:

1. Water is a good solvent in nature, therefore, it dissolved organic compound in the form of organomettalic complexes and dissolves inorganic substances such as, minerals and salts which typically consist of negative and positive ions.
2. Insoluble particles, if they are small enough, may settle so slowly that for all practicle purposes they remain in water indefinitely.
3. Nutrients retained in water body as waste product are the nutrient metabolized by living organisms in water.
4. Soluble substances that react with the insoluble contaminants and bring these into solution.
5. Contaminants in the form of floating substances on the surface of water i.e. petroleum and oil spill.

Water chemistry of alpine lakes is influenced by many factors, such as bedrock mineralogy soil and vegetation in the catchments. Bedrock mineralogy influence water chemistry by the dissolution of minerals and solutes by the action of water during weathering and erosional processes (Psenner and Catalan, 1994). Vegetation effect precipitation, transport, and deposition of ions and nutrients while the soil can provide cation exchange complex (Stumm and Margon, 1996). The quantity and quality of water in any place may be degraded or improved by human intervention. This should be our duty as human being to look for the ways and mean for the conservation of clean water for our future generations (Soomro, 2004).

5.4. Water chemistry of the study areas

The quality and property of any water body is depending upon their physiochemical parameters. On the basis of these parameters water can be classified as healthy and polluted. Various physiochemical parameters in 50 representative water samples collected from the nine selected high altitude alpine lakes (i.e., Naltar wetland complex, Uttar lake, Hundrap lake and Baha lake) and their respective streams of the study area have been evaluated for their possible contamination. Their detailed results have been given below.

5.4.1. Physical parameters

Color

The appearance color of water body is dependent on the presence of dissolved and suspended matter, including metallic ions, chemical pollutants, plankton, and plant pigments (polyphenolic compounds) from humus and peat. In case of lakes, reflections of the substrate can also impart color. The true color of water is attributed to dissolve substances only, and can be determined by filtering the water to remove any suspended matter. Color standards have been developed by which dissolved color can be measured using a comparative scale. The color of the water in the study area is generally colorless and odorless.

Temperature

Temperature is one of the most important parameter for aquatic environment because almost all the physical, chemical and biochemical properties of water are governed by it therefore, it has direct and indirect effects on aquatic ecosystems. Variations in water temperature occur both seasonally and daily. In case of daily variation, maximum temperatures usually occur in the afternoon, minimum temperatures are recorded in the early morning hours. Short-term variations are greatest in unshaded, shallow streams and less in deep-water body and near the source of spring-fed streams.

Water has a high heat capacity, it is highly resistant to changes in temperature. However, increases in water temperature may result from the discharge of heated waters, chemical reaction inside the water body and run-off from heated surfaces (e.g., roads, parking lots), and decrease in water temperature can result from snowmelt, shade, and underground springs. As the temperature of water changes chemical and physical properties of the water also change, therefore, it has significant impacts on biological processes.

The values of temperature in the water of lakes and streams of the areas selected for studies (Naltar wetland complex, Uttar, Hundrap and Baha lakes and their respective streams) are given in the Table 5.1 and graphically presented in figures 5.1a, 5.1b, 5.1c, and 5.1d. The recorded temperature in Naltar (wetland complex and their related stream), ranged from 6 ^{o}C to 9 ^{o}C. The maximum temperature of 9 ^{o}C was recorded in sample W29, which was collected from Naltar 4 View Hotel. The average temperature in the region was 6.92 ^{o}C. In Iskoman (Uttar lake and respective stream), the temperature recorded was 7 ^{o}C in all the water samples except in sample W20, collected from the Uttar lake centre where the temperature was measured 8 ^{o}C. The average value of temperature in Iskoman was found 7.11 ^{o}C. Temperature recorded in Hundrap region (Hundrap lake and respective stream), ranged from 6 ^{o}C to 8 ^{o}C. The maximum values of temperature 8 ^{o}C were recorded in samples W38, W39, which were collected from the Hundrap inhabitance. The average temperature in the water of this region was 6.67 ^{o}C. In Khukosh (Baha lake and respective stream), the value of temperature was recorded below 7 ^{o}C in all the water samples having an average value of 6.43 ^{o}C in the region.

pH

Is the –log of hydrogen ion concentration or it is the intensity factor of acidity. pH values can also be defined as the exponent to the base 10 of hydrogen ion concentration. For natural water these values range from 4-9 however, higher values represent bicarbonate and carbonates of alkali and alkaline earth elements (Rajuaidya and Markandey, 2005).

Water is classify on the basis of their pH are as given below.

Concentration of H+ moles/ Liters	Calculation of pH	Types of water
1/10-1	log1/10-1= -1pH = 1	More acidic
1/10,000,000	log1/10,000,000, =log 10-7 = 7	Neutral
1/10,000,000,000	Log1/1000,000,000 =10-9 =9	alkaline

Source, Ahmad (2008).

The values of pH in the water of lakes and steams of the areas studied are given in the Table 5.1 and graphically presented in Figures 5.2a, 5.2b, 5.2c, and 5.2d. The values of pH in Naltar (wetland complex and their related stream), ranged from 7.4 in sample W30, collected from the Naltar steam at Bangalah, to 7.9 in samples W6,W7,W32 and W34, collected from Singo bari outlet, Chakar bari inlet, Naltar home and from the last of Naltar stream at Nomal respectively. The average value of pH in Naltar region was found 7.71. In Iskoman (Uttar lake and respective stream), the values of pH ranged from 7.2 in sample W43, collected from Iskoman stream at Gotolti, to 7.9 in sample W46, collected from the stream at the last of Iskoman population. The average value of pH in Iskoman was 7.62. The values of pH in Hundrap (Hundrap lake and respective stream), ranged from 7.2 in sample W37 collected from the house in Hundrap, to 7.9 in sample W38, collected from another house in the Hundrap. The average value of pH in Hundrap region was found 7.64. In Khukosh (Baha lake and respective stream), the values of pH ranged from 7.5 in samples W25, W48, collected from the Baha lake inlet and Khukosh stream at Longer valley respectively, to 7.9 in sample W50, collected from the Khukosh stream at Barsat. Average value of pH in water of Khukosh region was found 7.69.

Electric Conductivity (EC)

Electric conductivity is the ability of a material to conduct electric current in water, (Rajuaidya and Markandey, 2005). Electric conductivity is determined by measuring the concentration of dissolved salts. More salts dissolved in the water, better will be the conductance electricity. As the temperature of water increases, the velocity of salt ions increase and, in turn, the conductivity of the water also increases. In unpolluted waters, conductance increases by 2 to percent. Conductance values can be used to estimate the total concentration of dissolved and particulate solids (commonly referred to as total dissolved solids (TDS), in a water body. The value of conductivity in water is measured as micro-Siemans (μS) (Sinyukovich, 2001).

The values electrical conductivity in water of lakes and streams of the selected areas are given in Table 5.1 and graphically presented in Figures 5.3a, 5.3b, 5.3c, and 5.3d. The values of EC in Naltar (Naltar wetland complex and their related stream), varied from a minimum of 106 μs/cm in sample W4, collected from the Singo bari inlet, to maximum value of 281 μs/cm in sample W30, collected from Naltar stream at Bangalah. The average value of EC in Naltar region was found 145.76 μs/cm. In Iskoman

(Uttar lake and respective stream), the valus of EC ranged from 128 μs/cm in samples W128, collected from the Uttar stream at Gotolti, to 217 μs/cm in sample W4, collected from the mosque in Iskoman. The average value of EC in Iskoman was found 163.89 μs/cm. In Hundrap (Hundrap lake and respective stream), the values of EC ranged from 90 μs/cm in sample W23, collected from the Hundrap lake centre, to 181 μs/cm in sample W39, collected from the house in Hundrap. The average value of EC in Hundrap was found 123.22 μs/cm. In Khukosh (Baha lake and respective stream) the values of EC ranged from 103 μs/cm in sample W47, collected from the Khukosh stream, to 241 μs/cm in sample W27, collected from the Baha lake outlet. The average value of EC in Khukosh region was found 150.71 μs/cm.

Total Dissolved Solids (TDS)

Total dissolved solids (TDS) comprise inorganic salts and small amounts of organic matter that are dissolved in water and left in water after water filtration, (Sinyukovich, 2001). The principal constituents are usually the cations calcium, magnesium, sodium and potassium and the anions carbonate, bicarbonate, chloride, sulphates and, particularly in groundwater, nitrate (from agricultural use). A concentration of TDS in water varies and it depends upon different mineral solubilities in a different geological regions. The concentration of TDS in water is less than 65 mg/L in a Precambrian rocks while their level is higher in Palaeozoic and Mesozoic sedimentary rock (ranging from 195 to 1100 mg/L), because of the presence of carbonates, chlorides, calcium, magnesium and sulphates, (Singh, et al., 1975). TDS in a water cause hardness, while in the sense of health effect it will be estimated as the individual component dissolved in a water rather than whole TDS.

The values of TDS in the water of lakes and streams of the areas under investigation are given in the Table 5.1 and graphically presented in Figures, 5.4a, 5.4b, and 5.4c 5.4d. The values of TDS in Naltar (Naltar wetland complex and their related stream), ranged from 57 mg/L in sample W7, collected from Chakar bari inlet, to 181 mg/L in sample W29, collected from the Naltar 4view hotel. The average value of TDS in Naltar was found 83 mg/L. In Iskoman (Uttar lake and respective stream), the values of TDS ranged from 65 mg/L in sample W43, collected from the Iskoman stream at Gotolti, to 122 mg/L in sample W45, collected from the mosque in Iskoman. The average value of TDS in Iskoman was found 94.2 mg/L. The values of TDS in Hundrap (Hundrap lake and respective stream), varied from a minimum value of 50 mg/L in sample W23, collected from the Hundrap lake centre, to a maximum of 125 mg/L in sample W40, collected from the Hundrap stream at the end of Hundrap population. The average value of TDS in the Hundrap was found 75 mg/L. In Khukosh (Baha lake and respective stream), the values of TDS ranged from 51 mg/L in sample W47, collected from Khukosh stream just below the Baha lake, to 149 mg/L in sample W49, collected from the Khukosh stream at longer valley. The average value of TDS in Khukosh region was found 88 mg/L.

Turbidity

Turbidity is a cloudiness or haziness in water (or other liquid) caused by individual particles that are too small that cannot be seen without magnification, or it can contain suspended solid matter in large sizes (Schwartz et al., 2000). Therefore, in drinking water, the turbidity is a measure of the cloudiness of the water, which includes inorganic, organic and microbial organisms. Increasing turbidity depends on different weathering processes and inevitable consequences of human activities around the water body. Increasing turbidity in water associated with different problems such as, blocking of light penetrating to the lower substrata of water body and destroying the life of photosynthetic plant inside the water body. The siltation that tends to accompany high turbidity may kill living coral and destroy highly productive grass flats (Cluney, 1975).

As turbidity is one of the most important parameter in water and their values in the water of lakes and streams in the areas studied are given in Table of 5.1 and graphically presented in Figures 5.5a, 5.5b, 5.5c, and 5.5d. The values of turbidity in Naltar (Naltar wetland complex and their related stream), varied from a minimum of 0 NTU, to a maximum of 2.8 NTU with an average value of 0.75 NTU in the region. In Iskoman (Uttar lake and respective stream), the values of turbidity varied from minimum of 0.3 NTU to a maximum of 4.9 NTU with an average value of 3.8 NTU in the region. The values of turbidity in Hundrap (Hundrap lake and respective stream), varied from 0.2 NTU, to 1 NTU with an average value of 0.5 NTU. In Khukosh (Baha lake and respective stream), the values of turbidity varied from 0.7 NTU, to 3.9 NTU with an average value of 2.04 NTU in the region.

Salinity

The acid neutralization capacity of water is called salinity of water. The salinity of water is a function of carbonate, bicarbonates and hydroxide contents dissolved in water body (Sinyukovich, 2001). Salinity was originally defined by the oceanographer as the total amount of solid material in grams contained in one kilogram of seawater when all the carbonate has been converted to oxide, the bromine and iodine replaced by chlorine, and all organic matter completely oxidized (Willams and Sherwood, 1994). Salinity is most important chemical attribute of athalassic salt lake in most chemical, physical and biological studies of these water-bodies. Measurements of salinity in water can be derived directly from full ionic analyses, while indirectly can be derived by determinations of density, conductivity, freezing point depression and total dissolved solids or matter.

The values of salinity in water of lakes and streams of the selected areas are given in Table of 5.1 and graphically presented in figures 5.6a, 5.6b, 5.6c and 5.6d. The values of salinity in Naltar region (Naltar wetland complex and their related stream), were found in the range of 0.1 in samples W2, W4, W5, W7, W10, W13, W30, collected from the centre part of the Bodrok bari, inlet and centre of Singo bari, Chakar bari inlet, Chemo bari inlet, Small bari inlet and Naltar stream at Bangalah respectively, to 3.8 in sample W3, collected from the Bodrok bari outlet. The average value of salinity in Naltar was found 0.51. In Iskoman (Uttar lake and respective stream), the value of salinity was found 0.1 in all the collected water samples with little variation of 0.7 and 0.8 in samples W45 and W42, collected from Iskoman mosque and Iskoman stream at Matintar. The average value of salinity in Iskoman was found 0.26. The value of salinity in Hundrap (Hundrap and respective stream), was found to be <0.4 with an average value of 0.17 in the region. In Khukosh (Baha lake and respective stream) the value of salinity was found to be <0.2 with an average value of 0.16 in the region.

Resistivty

The ability of water to resist the electric current is called resistivity of that water (Paul, 1988). Mostly the resistivity is used to estimate the subsurface water contaminations (Urish, 1983). The surface electric resistivity measurement can also be used to estimate the horizontal flow direction and viscosity of ground water in shallow aquifers as well as the aquifers hydraulic conductivity (Fried, 1975). Any water having high value of resistivity is having less concentration of salts. In contrast when the water is concentrated with different salts it enhances the electric current due to impurities of salts and decrease the value of electric resistivity.

The values of resistivity in the water of lakes and streams of the study areas are given in Table 5.1 and graphically presented in Figures 5.7a, 5.7b, 5.7c, and 5.7d. The values of resistivity in Naltar (Naltar wetland complex and their related stream), ranged from 5 k/Ω in sample W18, collected from the Koto bari outlet, to 10 k/Ω in samples W4, W9, W29, and W34, collected from Singo bari inlet, Chakar bari outlet, Naltar 4view hotel and at the end of Naltar stream at Nomal respectively. The average value of resistivity in Naltar was found 7.73 k/Ω. The calculated values of resistivity in Iskoman (Uttar lake and respective stream), ranged from 5 k/Ω in sample W41, collected from Iskoman stream near the local huts, to 8 k/Ω in samples W42 and W4, collected from Iskoman stream at Matintar and at the end of Iskoman population respectively. The average value of resistivity in Iskoman was found 6.89 k/Ω. In Hundrap (Hundrap lake and respective stream), the values of resistivity ranged from 5 k/Ω in sample W38, collected from the Hundrap stream at Chakurrari, to10.9 k/Ω in sample W23, collected from the central part of Hundrap lake. The average value of resistivity in Hundrap was found 8.43 k/Ω. In Khukosh (Baha lake and respective stream), the values of resistivity ranged from 4 k/Ω in sample W27, collected from the Baha lake outlet, to 8 k/Ω in sample W25, taken from the Baha lake inlet. The average value of resistivity in Khukosh was found 6.54 k/Ω.

5.4.2. Anions

Chloride (Cl^-)

Chloride (Cl^{-1}) is one of the major anions found in water, and are generally combined with calcium, magnesium, or sodium in form of soluble salts. Mostly chlorides entered into the water bodies from several external sources such as rocks, agricultural runoff, industrial waste water, oil well waste, effluent from wastewater treatment plants and salting road (Nollet, 2000). In combination form such as sodium chloride, chloride is essential for life, but in small quantity to a normal cell to perform functions in plant and animal life. At high concentration chloride can corrode metals and affect the taste of food products (WHO, 1996).

The values of chloride in the water of lakes and streams of the study areas are given in the Table 5.2 and graphically presented Figures 5.8a, 5.8b, 5.8c, and 5.8d. The value of chloride in Naltar (Naltar wetland complex and their related stream), was found below the detection level (<0.1mg/L) in samples W6, W7, W10 and W13, collected from Naltar lakes at Singo bari outlet, Chakar bari inlet Chemo bari inlet and Small bar inlet respectively. The values of chloride in rest of the water samples ranged from 0.1 mg/L, to 42.2 mg/L. The average value of chloride in Naltar was found 5.65 mg/L. In Iskoman (Uttar lake and respective stream), the values of chloride were found between 0.2 mg/L to 29.2 mg/L in samples W21-W43, collected from Uttar lake outlet and Iskoman stream at Gotolti respectivelly. The average value of chloride in Iskoman was found 9.2 mg/L. In Hundrap (Hundrap lake and respective stream), the values of chloride were measured from 0.5 mg/L to 23.4 mg/L in samples W2-W36, collected from Hundrap lake centre and Hundrap stream at Hirzdam respectively. The average value of chloride in Hundrap was found 11.87 mg/L. In Khukosh (Baha lake and respective stream), the values of chloride were in the range of 0.7 mg/L 23.2mg/L in in samples W27-W48, collected from the Baha lake outlet and Khukosh stream at Longer valley. The average value of chloride in Khukosh was calculated 9.51 mg/L.

Sulfate (SO_4^{-2})

Sulfate is a naturally occurring substance formed as a result of combination of sulpher and oxygen. In soil sulfate formed various minerals of different elemental groups including, calcium, potassium, sodium etc. Sulfates are found in water as soluble salts of sodium, magnesium and potassium from the leaching of soil, but some of the sulfate salts (calcium and barium) not easily be soluble in water. There are several sources other than soil which bring sulfate in water are, decaying of plant and animal matter, excessive use of fertilizer having the chemical product of ammonium sulfate. Generally sulfate is nontoxic and is consider as integral component of protein, sulfates found in all foods containing protein such as fish, meat or milk products. Sulfates are absorbed by the body only in very small quantities but at high concentration of magnesium and sodium sulfate in water may cause intestinal discomfort, diarrhea and consequently dehydration. High concentration of sulfate in water may interfere the chlorination and some time it increases the corrosive properties of water (Sulfate fact sheet, 2003).

The concentrations of sulfate in the water of lakes and streams of the areas studied are given in Table 5.2 and graphically presented in the Figures 5.9a, 5.9b, 5.9c, and 5.9d. The concentration of sulfate in Naltar (Naltar wetland complex and their related stream), were found between 6 mg/L to 28 mg/L in samplesW9-W31, collected from Chakar bari outlet and Naltar house at cote muhallah respectivelly. The average concentration of sulfate in Naltar was found 14.56 mg/L. In Iskoman (Uttar lake and respective stream), the concentration of sulfate ranged from 15 mg/L to 27 mg/L in samples W20-W43 and W45, and were collected from Uttar lake centre, Iskoman stream at Gotolti and Iskoman mosque respectivelly. The average concentration sulfates in Iskoman was found 20.22 mg/L. The concentration of sulfate in Hundrap (Hundrap lake and respective stream), were in the range of 6 mg/L to 27 mg/L in samples W23-W39, collected from the Hundrap lake centre and Hundrap house respectively. The average concentration of sulfate in Hundrap was measured 16.22 mg/L. In Khukosh (Baha lake and respective stream), the concentration of sulfate ranged from 5 mg/L to 50 mg/L in samples W25-W27, collected from inlet and outlet of Baha lake respectively. The average concentration of sulfate in Khukosh was calculated 22mg/L.

Nitrate (NO_3^-)

Nitrate is a common compound of food, with vegetables usually being the principle in the daily diet. The entrance of nitrate in human body is directly by the intake of contaminated groundwater or indirectly by the uses of different vegetables contaminated with nitrate, Therefore, mostly in vegetarian people high concentration of nitrate are found as compare to non vegetarian (Gray, 2008). The percentage of amount of nitrate leaching from the soil is depend upon the different factors such as, soil structure, plant activities, rain fall and temperature and the rate of fertilizer application. It is difficult to predict that how much amount of nitrate is released from the farmland, but it can be concluded that nitrates are mostly coming from the different agricultural activities because of excessive use of fertilizer in the farmlands. This excessive concentration of nitrate in water may cause nutrients deposition in lakes and pounds, which are responsible for the deficiency of oxygen in the water body and lead to eutrophication. In case of dirking water excessive intake of nitrates can have severe consequences for human health, especially for bottle fed-babies, the high concentration of nitrate in human body may cause blood poisoning, hypertension, gastric cancer and fetal malformations (Narayan, 2000).

The concentrations of nitrate in the water of lakes and streams in the areas under investigation are given in Table 5.2 and graphically presented in the Figures of 5.10a, 5.10b, 5.10c and 5.10d. The concentration of nitrate in Naltar wetland complex and their related stream were found between 0.4 mg/L to 5 mg/L in samples W7-W34, collected from Chakar bari inlet and end of Naltar stream at Nomal respectively. The average concentration of nitrate in Naltar was found 1.61 mg/L. The concentration of nitrate in Iskoman (Uttar lake and respective stream), was found below the detection level (<0.3) in sample W20, collected from the Uttar lake centre, while in rest of the water samples the concentration of nitrate were ranged from 0.4 mg/L to 2.9 mg/L. The average concentration of nitrate in Iskoman was found 1.49 mg/L. In Hundrap (Hundrap Lake and respective stream) the concentration of nitrate were found less than 2.1 mg/L in all the water samples having an average concentration of 0.89 mg/L. In Khukosh (Baha lake and respective stream), the concentration of nitrate were found less than 3 mg/L in all collected water samples, with an average concentration of 1.19 mg/L.

Carbonates (CO_3^{-2}) and Bicarbonates (HCO_3^-)

Carbonates and bicarbonates imparts alkalinity to the water, which is the ability of water to neutralize acid. The function of alkalinity is due to the carbonate, bicarbonates and hydroxyl ions. Measuring of these parameters are important in the interpretation and control of the water and wastewater treatment processes. Generally soft waters are prone to the acid however, the presence of the carbonate and bicarbonate ions help in buffering the system (Nolett, 2000).

The concentrations of carbonate were found in negligible amount in all the representative water samples of the study areas and, therefore not presented in the Table.5.1 however, the concentration bicarbonates in the water of lakes and streams in the study areas are given in Table 5.2 and graphically presented in the Figures 5.11a, 5.11b, 5.11c, and 5.11d. The concentration of bicarbonates in Naltar (Naltar wetland complex and their related stream), were found between 60 mg/L to 320 mg/L in samples W5-W31, collected from the Singo bari centre and Naltar house at cote muhallah respectively. The average concentration of bicarbonates in Naltar was calculated 163.2 mg/L. The concentration of bicarbonates in Iskoman (Uttar Lake and respective stream), were in the range of 80 mg/L to 360 mg/L in samples W21-W43, collected from the Uttar lake outlet and Iskoman stream at Gotolti respectivelly. The average concentration of bicarbonates in Iskoman was found 170 mg/L. In Hundrap (Hundrap lake and respective stream), the concentration of bicarbonates ranged from 23 mg/L to 360 mg/L in samples W37-W39, which were collected from the Hundrap houses at different place. The average concentration of bicarbonates in Hundrap was found 168.11 mg/L. The concentration of bicarbonates in Khukosh (Baha lake and respective stream), were ranged from 140 mg/L to 210 mg/L in samples W47-W49 and W50 and were collected from Khukosh stream just below the Baha lake, longer valley and Barsad respectivelly to The average concentration of bicarbonates in Khukosh was calculated 178.57 mg/L.

5.4.3. Light elements

Sodium (Na^+)

Sodium is silvery-white metallic element with a symbol Na, and is most abundant element of the earth crust (about 2.6% by weight of the Earth's crust). It is a highly reactive metal, therefore, it is found in nature only as a compound and never as the free element. Sodium is found in many different minerals, in which, ordinary salt (sodium chloride), amphibole, cryolite, soda niter and zeolite. In water sodium ion is soluble in nearly all of its compounds, therefore, it is present in greater quantities in oceans, lakes and other stagnant water bodies. Sodium is an essential element for the living of plants and animals. In animals, sodium ion is used in opposition to potassium ions, to allow the organism to build up an electrostatic charge on cell membranes, and allow transmission of nerve impulses. In its metallic form sodium can be used to refine some reactive metals, such as potassium, and zirconium from their compounds, while as an alkali metal, sodium ion is vital to animal life. Sodium in water in the form of sodium hypochloride is highly corrosive to metal and it damages all the living tissues except keratinized epithelia (Roger and Alex, 1998). In highly sodium concentrated water reservoir there occurs a change in the fresh water chemistry, and hence resist the survival of fresh living organisms.

Sodium concentrations in the water of lakes and streams in the study areas are given in Table 5.3 and graphically presented in Figures 5.12a, 5.12b, 5.12c, and 5.12d. The concentration of sodium in water samples collected from Naltar area (Nalatr wetland complex and their related stream) ranged from 0.5 mg/L to 35.03 mg/L in samples W11-W31, with an average concentration of sodium 2.98 mg/L. The concentration of sodium in Iskoman (Uttar Lake and respective stream), were found between 1.27 mg/L to 123.88

mg/L in samples W42-W46, with average concentration of sodium 1.56 mg/L. Water samples collected from Hundrap area (Hundrap lake and respective stream), the concentration of sodium ranged from 1.65 mg/L to 33.67 mg/L samples W23-W37, with an average concentration of sodium 5.52 mg/L in the area. Water samples collected from Khukosh region (Baha lake and respective stream), the concentration of sodium were in the range of 1.31mg/L to 140.75mg/L in samples W47-W50, with an average concentration of sodium of 57.25 mg/L in the region.

Potassium (K^+)

Potassium is silver white metal and it exists in water with low concentration, because of its low solubility in water. Potassium is found in water from the mineral like feldspar. Potassium in $KMnO_4$ form in water affects the chemical oxygen demand and affects the fish living pattern. Generally potassium is an essential element for life when its concentration level is low in body it causes muscle vascular disease (American Clinical Nutrition, 2000).

The concentrations of potassium in the water of lakes and streams of the areas under investigation are given in Table 5.3, and graphically presented in the Figures 5.13a, 5.13b, 5.13c, and 5.13d. The concentration of potassium in water samples collected from Naltar wetland complex and their related stream were in the range of 1.97 mg/L to 5.27 mg/L in samples W14-W30, with an average concentration of potassium 2.78mg/L. Water samples collected from Iskoman area (Uttar lake and respective stream), the concentration of potassium were found between 2.41 mg/L to 5.4 mg/L in samples W20-W45, with an average concentration of potassium 3.39mg/L in the area. Water samples collected from Hundrap region (Hundrap lake and respective stream), the concentration of potassium were in the range of 0.86 mg/L to 4.3 mg/L in samples W24-W0, with an average concentration of potassium 2.44 mg/L. The calculated concentration of potassium in water samples collected from Khukosh region (Baha lake respective stream), ranged from 0.92 mg/L to 4.72 mg/L in samples W26-W48, with an average concentration of potassium 2.78 mg/L.

Calcium (Ca^{+2})

Calcium is consider as a major component of mineralized tissues and is required for normal growth and maintenance of bone. Generally it is agreed that an adequate calcium intake is necessary for the maintenance of life. From most of the epidemiologic studies, it clarified that most of the population fail to meet the recommended optimal calcium intake (American Clinical Nutrition, 2000). Calcium is found in water as carbonate or chloride which are due to limestone, gypsum, and gypsiferous. Calcium is essential element for life. It helps to cellular permeability and the maintenance of the intact cellular membranes in a body. When calcium level is low in water, and its use is for long time, it will lead to cardiovascular disease; chronic renal failure and coronary artery disease in body (Heaney and Dowell, 1994).

The concentrations calcium in the water of lakes and stream of the study area are given in Table 5.3 and graphically presented in the Figures 5.14a, 5.14b, 5.14c, and 5.14d. The concentration of calcium in water samples collected from Naltar region (Naltar wetland complex and their related stream) ranged from 16.36 mg/L to 57.1 mg/L in samples W7-W31, with an average concentration of calcium 24.36 mg/L in the area. Water samples collected from Iskoman area (Uttar Lake and respective stream), the concentration of calcium were found between 19.35 mg/L to 74.29 mg/L in samples

W21-W43 with an average concentration of calcium 39.53mg/L. The measured concentration of Calcium in water samples collected from Hundrap region (Hundrap Lake and respective stream) were in the range of 11.83 mg/L to 62.9 mg/L in samples W23-W36, with an average concentration of calcium 40.67 mg/L. The calculated concentration of calcium in water samples collected from Khukosh area (Baha lake and respective stream) were ranged from 15.88 mg/L to 50.85 mg/L in samples W49-W26. The average concentration of calcium in Khukosh region was found 33.34 mg/L.

Magnesium (Mg^{+2})

Magnesium is a second most abundant element after sodium found in water. A large number of minerals contain magnesium, among these most common are dolomite and magnetite. Magnesium also enters the water bodies in different ways, such as it can be introduced by the weathering mafic and ultramafic rocks and also from the fertilizer application and from cattle feed. Industrial sectors which are using the magnesium in different proposes also act a magnesium sources for pollution. Presence of magnesium in water is a dietary mineral for living organism such as insects. It is a central atom of the chlorophyll molecule, and is, therefore, a requirement for plant photosynthesis, but excessive amount of magnesium in water will lead to hardness to the water (Mordike and Ebert, 2001).

Concentrations of magnesium in water of lakes and streams of the study area are given in Table 5.3 and graphically presented in the Figures 5.15a, 5.15b, 5.15c, and 5.15d. The concentration of magnesium in water samples collected from Naltar (Naltar wetland complex and their related stream) were found between 0.05 mg/L to 38.66 mg/L in samples W12-W34. The average concentration of magnesium in Naltar was found 5.82

mg/L. The concentration of magnesium in water samples collected from Iskoman area (Uttar lake and respective stream), were in the range of 2.16 mg/L to 29.68 mg/L in samples W41-W46. The average concentration of magnesium in Iskoman was found 14 mg/L. Water samples collected from the Hundrap region (Hundrap lake and respective stream), the concentration of magnesium ranged from 0.28 mg/L to 25.51 mg/L in samples W22-W39 with an average concentration of magnesium 14.82 mg/L in the area. The concentration of magnesium in water samples collected from the Khukosh area (Baha lake and respective stream) were found in the range of 1.19 mg/L to 27.69 mg/L in samples W47-W48, with an average concentration of magnesium 12.43 mg/L in the region.

5.4.4. Classification of water

For identification and characterization of high altitude alpine lakes and their respective streams in the study areas (Naltar wetland complex, Uttar, Hundrap and Baha lakes with their respective streams), a typical method of classification was used on the basis of anions and light elements data through piper diagrams (Fig Nos. 5.25, 5.26, 5.27 and 5.28). The Piper diagram (Fig.5.25), for Naltar wetland complex and their related stream showed that, all the lakes and stream water samples fell toward the Ca^+ and HCO_3^-, suggested that all the water samples had higher concentration of Ca^+ as compare to Na^+, K^+ and Mg^+ and HCO_3^- as compare to Cl^- SO_4^{2-} and NO_3^-. Therefore, water of the Naltar wetland complex and their related stream were found as $CaHCO_3^-$ type (Field.11) in the piper diagram (Fig.5.25). In Iskoman (Uttar lake and respective stream), all the lake's water samples were having higher concentration of Ca^+, while stream samples were having higher concentration of Na^+ (Fig.5.26). The concentrations of bicarbonates were also found higher in all the water samples in this region as compared to Cl^-, SO_4^- and NO_3^-. Therefore the water of Uttar lake and respective stream was classified as bicarbonate type such as $CaHCO_3$ (Field.11) and $NaHCO_3$ (Field.1V) in the piper diagram (Fig.5.26). In Hundrap (Hundrap lake and respective stream), all the water samples have higher concentration of Ca^+ and HCO_3^-, therefore, water of the Hundrap was found as $CaHCO_3$ type (Field.11) in the piper diagram (Fig.5.27). In Khukosh (Baha lake and respective stream), all the lake's water were showing higher concentration of Ca^+ while the stream samples were showing higher concentration of Na^+ in the piper diagram (Fig.5.28). These water samples also showed higher concentration of HCO_3^-. Therefore the water of the Khukosh fell in the (field.11) and (field.111) and was therefore, classified as $CaHCO_3$ and $NaCaHCO_3$ in the piper diagram scheme (Fig.5.28).

5.4.5. Heavy metals

Heavy metals selected for the present study, includes, manganese (Mn), iron (Fe), copper (Cu), lead (Pb), zinc (Zn), nickel (Ni), chromium (Cr), cadmium (Cd), mercury (Hg) and arsenic (As). Brief description, their possible concentrations and GIS based maps showing the distribution pattern of these elements in the water of lakes and stream of the study area are as given below.

Manganese (Mn^{+2})

Manganese is present in ores and rocks in higher concentration. It is introduced in the surface and groundwater due to reducing conditions in soil and rocks to bringing it in soluble forms. In the presence of oxygen, manganese oxidized to form insoluble component and precipitate in black color at the bottom of water storage tanks, and pipes, while in the absence of oxygen it turns up to soluble indirect, therefore, most of the lakes and underground water are mainly contaminated by manganese. The major sources which bring the manganese into the human body are food, intake of water and tea. It is estimated that on average a cup of tea is containing between 400-1300 μg/L of Mn. With the toxic point of view manganese is considered as nontoxic within the permissible limit but it is present in higher amount than the permissible limit, it induces taste problem in the water and also health related problems such as physiological and particularly neurological disorder (Criddle, 1992).

The concentrations of manganese in the water of lakes and streams of the study areas are given in Table 5.4 and graphically presented in Figures, 5.16a, 5.16b, 5.16c and 5.16d. The GIS based maps showing the distribution of Mn in the study areas are shown in Figures 5.29, 5.30 5.31 and 5.32. The concentration of manganese in Naltar (Nalatr wetland complex and their related stream), was found below detection level (<0.5 μg/L) in samples W11, W12, W13, W17, and W28, collected from the centre and outlet of Chemo bari, Small bari inlet, Koto bari centre and Naltar stream at Bieshgeri respectively. The calculated concentration of Mn in rest of the water samples in the region ranged from 10 μg/L in samples W14, W15, W16, W18, W29, and W28, collected from centre and outlet part of Naltar lake5 (Small bari), inlet and outlet part of Naltar lake6 (Koto bari), Naltar 4view hotel and Naltar home at Daas mullah respectively to110 μg/L, in samples W9 and W10, taken from the Chakar bari out, and Chemo bari inlet. The average concentration of Mn in Naltar was found 44 μg/L. In Iskoman (Uttar lake and respective stream), the concentration of manganese was found below the detection level (<0.5 μg/L) in three samples W42, W43 and W46, collected from the Iskoman stream at Matintar, at Gotolti and at the end of Iskoman population respectively. The measured concentration of manganese in rest of the water samples ranged from 10 μg/L in samples W19, W21 and W44, collected from the inlet and outlet of Uttar lake and Iskoman Jamatkhanah respectively, to 30 μg/L in sample W41, taken from Iskoman stream near local huts. The average concentration of Mn in Iskoman was found 12 μg/L. The concentration of Mn in Hundrap (Hundrap lake and respective stream), was found below the detection level (<0.5 μg/L) in all lake's water samples, while in stream samples the concentration of Mn ranged from 10 μg/L in sample W39, collected from home in Hundrap, to 40 μg/L in sample W35, taken from the Hundrap stream at Chukarrari. The average concentration of Mn in Hundrap was found 16 μg/L. The concentration of manganese in Khukosh (Baha lake and respective stream), was found below the detection level (<0.5 μg/L) in two lake's water samples W25 and W27, taken from the inlet and outlet part of the Baha lake. The concentration of manganese in rest of all the water samples were found 30 μg/L except sample W48, collected from Khukosh stream at Longer valley showed the concentration of 10 μg/L. The average concentration of Mn in Khukosh was found 19 μg/L.

Manganese distribution GIS based maps (Fig.5.29, 5.30, 5.31 and 5.32.) of the study areas indicated that the Mn concentration was found in relative higher amount in the upstream of Beishgri in the Naltar wetland complex and its related stream (Fig.5.29). In the Uttar lake and related stream (Fig.5.30), the Mn concentration at the outlet of the lake, at shepherd hut and stream at the end of Iskoman had high concentration of Mn.

The distribution of Mn in Hundrap lake and related stream (Fig.5.31) indicated that Hundrap lake showed minimum concentration of Mn while the downstream the Hundrap lake showed relatively high concentration. Mn distribution map of the Baha lake and related stream (Fig.5.32) showed that the middle part of Baha lake and most of the samples downstream were having relatively high concentration of Mn.

Iron (Fe^{+3})

Iron an extremely common metal is found in insoluble form in large amount in soil and rocks but in some cases due to the number of complex reactions it also form soluble compounds (Gray, 2008). Therefore, excess amount of iron is a common phenomenon on the ground. Iron generally occurring in ferrous state in soluble form while it also occurs in ferric state as insoluble form during oxidizing state. During the hydrological cycle, irons usually enter the water body from surrounding environment. Iron is an essential element with the recommended minimum daily requirement but unlikely cause threats to the health when its concentration occasionally found above the permissible limit in water. Iron cause taste effect and coloration in water and vegetables, especially tomatoes. In human body when the amount of iron is exceeding it will lead genetic disorder (WHO, 2006).

The concentrations of iron in the water of lakes and streams of the study areas are given in the Table 5.4, and graphically presented in Figures, 5.17a, 5.17b, 5.17c and 5.17d. The GIS based maps showing the distribution of iron are presented in Figures.5.33, 5.34, 5.35 and 5.36. The concentration of iron in Naltar (Naltar wetland complex and their related stream), was found below the detection level (<0.5µg/L) in samples W32 and W34, collected from Naltar house at Galieng and Naltar stream at Nomal respectively. The calculated concentration of iron in rest of the water samples in the region ranged from 7 µg/L in sample W9, collected from Chakar bari outlet to 877 µg/L in sample W3, taken from the Bodorok bari outlet. The average concentration of iron in Naltar was found 114 μg/L. In Iskoman (Uttar lake and respective stream), the concentration of iron was found below the detection level (<0.5μg/L) in sample W44, collected from the mosque in Iskoman, while in rest of the water samples the concentration of iron were in the range of 5 μg/L in sample W44, collected from Jamatkhana in Iskoman, to 783 μg/L in sample W21 collected from Uttar lake outlet. The average concentration of iron in Iskoman was found 259 μg/L. The concentration of iron in Hundrap (Hundrap lake and respective stream), ranged from 6 μg/L in sample W36, collected from the Hundrap stream at Hirzdam, to 629 μg/L in sample W40, which was taken from the Hundrap stream at the end of population. The average concentration of iron in Hundrap was calculated 165 μg/L. In Khukosh (Baha lake and respective stream), the concentration of Iron was found below the detection level in samples W49 and W50, collected from the Khukosh stream just below the longer valley and at Barsat respectively. While in rest of the water samples, the concentration of iron in the range of 5 μg/L in sample W48, collected from Khukosh stream at longer valley to 333 μg/L in sample W50, collected from Baha lake inlet. The average concentration of iron in the Khukosh region was found 84 μg/L.

Iron distribution GIS based maps (Fig.5.33, 5.34, 5.35 and 5.36.) of the study areas indicated that the Fe concentration was found in higher amount at Naltar lake1 (Bodorok bari), in the upstream of Dalaan, and at Khayout in the Naltar wetland complex and its related stream (Fig.5.33). In the Uttar lake and respective streams (Fig.5.34), the distribution of Fe was found in relatively higher amount in the Uttar lake as compared to downstream of the lake. The distribution of Fe in the Hundrap lake and related stream in the map (5.35) indicated that the Hundrap lake showed minimum concentration of Fe while the water samples of downstream of the lake at the end Hundrap population showed relative high. Fe distribution map of Baha lake and respective streams at Khukosh (Fig.5.36) indicated that Baha lake showed relatively higher amount of Fe while the water samples of downstream the Baha lake showed relatively low concentration.

Copper (Cu^{+2})

Copper is a heavy metal often used as anti-corrosion and decorative coatings on metal alloys. In drinking water copper is present as, ionizable copper (mostly divalent) and as copper complexes with organic and inorganic legends, some of these complexes are insoluble and are, therefore, not likely to show be bioavailability. At high concentration of copper in water is toxic to a variety of living organisms from humans to bacteria, especially fish and also even in low exposures can have impact on respiration, and also affect cell walls of microorganisms. Generally drinking water having high concentration of copper will show the sign of nausea, vomiting, diarrhea and gastrointestinal diseases (Fitzgerald, 1998).

The concentrations of copper in the water of lakes and stream of the study areas are given in the Table 5.4 and graphically presented in the Figures.5.18a, 5.18b 5.18c and 5.18d. The GIS based maps showing the distribution of copper concentration in the study areas are given in Figures.5.37, 5.38, 5.39 and 5.40. The concentration of copper in Naltar (Naltar wetland complex and their related stream), was found below the detection level (<0.5 μg/L) in samples W15, W17 and W18, collected from the outlet of Naltar lake5 (Small bari), centre and outlet parts of the Naltar lake6 (Koto bari) respectively. In rest of the water samples the calculated concentration of copper ranged from 1 μg/L in samples W10 and W14, collected from the Chemo bari inlet and Small bari centre to 84 μg/L in sample W1, collected from Bodorok bari inlet. The average concentration of copper in Naltar was found 9 μg/L. The concentration of copper in Iskoman (Uttar lake and respective stream) was found below the detection level (<0.5 μg/L) in samples W20 and W45, collected from the Uttar lake centre and mosque of Iskoman. The concentration of copper in rest of the water sample ranged from 1 μg/L in sample W19, collected from the Uttar lake inlet to 31 μg/L in sample W21, collected from Uttar lake outlet. The average concentration of copper in Iskoman was found 8 μg/L. In Hundrap (Hundrap lake and respective stream), the concentration of copper ranged from 2 μg/L in sample W38, collected from the house in Hundrap to 8 μg/L in sample W35, collected from the Hundrap stream at Chukarrari. The average concentration of copper in Hundrap was measured 4 μg/L. The concentration of Copper in Khukosh region (Baha lake and respective stream), was found below the detection level (<0.5 μg/L) in sample W50, collected from the end of Khukosh stream at Barsad. In rest of the water samples the concentrations of copper were found in the range of 1 μg/L in samples W25 and W49, collected from Baha lake inlet and Khukosh stream just below the Longer to 4 μg/L in samples W26 and W27, taken from the centre and outlet parts of the Baha lake. The average concentration of copper in Khukosh was found 2 μg/L.

Copper distribution GIS based maps (Fig.5.37, 5.38, 5.39 and 5.40.) of the study areas indicated that the Cu concentration was found in relative higher amount in Naltar lakes, downstream the lakes at the Galieng, and at the end of stream at Nomal in the Naltar wetland complex and it related streams (Fig.5.37). In Uttar lake and its related streams (Fig.5.38) the Cu contents at the outlet of the lake, downstream the lake at Shepherd huts, Marig musk and the stream at the end of Iskoman population had high concentration of Cu. The distribution of Cu in the Hundrap lake and its related stream in the map (5.39) indicated that, the inlet and middle parts of the Hundrap lake and downstream the lake at Chukarrari showed relatively higher concentration of Cu as compared to rest of the water samples at Hundrap. Cu distribution map of the Baha lake and its related stream (Fig.5.40) showed that the middle and outlet parts of the Baha lake, downstream just below the lake and at the Longer valley were having relatively high concentration of Cu.

Lead (Pb^{+2})

Lead is one of the most toxic elements because of its accumulative effect. Due to their toxicity it is considering as environmental priority pollutants. In some areas natural water is contaminated with lead from industrial activities and also from natural influx. The main sources which are responsible for lead generates in water are, mining, refining and smelting processes as well as the various lead-treatment industries. Beside these burning of fossil fuels containing lead additives is another source for lead (Andrzej. et al., 2004). Lead mostly causing biological effect that are nervous system disorder, kidney and brain damage. Since lead has accumulative behavior, therefore, lead is accumulated in the body tissue, especially fetus and growing children (Goyer, 1990).

The concentrations of lead in the water of lakes and stream of the areas selected for study are given in the Table 5.4 and graphically shown in Figures.5.19a, 5.19b, 5.19c and 5.19d. The GIS based maps showing the distribution of lead concentrations in the study areas are presented in Figures.5.41, 5.42, 5.43 and 5.44. The concentration of lead in Naltar wetland complex and their related stream was found below the detection level (<0.5 μg/L) in nine water samples W3, W8, W9, W16, W17, W18 W28, W29 and W34, collected from Bodorok bari outlet, centre and outlet parts of Chakar bari (Lake3), inlet, centre and outlet parts of Koto bari (Lake6), Naltar stream at Beishgiri, Naltar 4view hotel and at the end Naltar stream at Nomal respectively. In rest of the water samples the concentration of lead ranged from 1 μg/L in samples W6, W7, W11 and W30, collected from the Singo bari outlet, Chakar bari inlet, Chemo bari centre and Naltar stream at Bangalah respectively to 10 μg/L in sample W13, taken from small bari inlet. The average concentration of lead in Naltar region was found 3 μg/L. The concentration of lead in Iskoman (Uttar lake and respective stream), was found below the diction level (<0.5 μg/L) in samples W19, W20, W44 and W45, collected from the inlet, outlet of Uttar lake, Iskoman mosque, and Iskoman Jamatkhana respectively. The concentration of lead in rest of the water samples ranged from 1 μg/L in sample W41, collected from Iskoman stream near local huts to 7 μg/L in sample W43, collected from the Iskoman stream at Gotolti. The average concentration of lead in Iskoman was measured 2 μg/l. In Hundrap (Hundrap lake and respective stream), the concentration of lead was found below the detection level (<0.5 μg/L) in all the lake's water samples along with sample W38, collected from home in Hundrap. The concentration of lead in Hundrap stream water samples ranged from 1 μg/L, in sample W37, collected from a house in Hundrap to 7μg/L in sample W40, taken from stream at the end of Hundrap population. The average concentration of lead in the Hundrap was calculated 2 μg/L. In Khukosh (Baha lake and respective stream), the concentration of lead was found below the detection level (<0.5 μg/L) in all the water samples, except samples W26 and W47, having the concentrations of 7 μg/L and 3 μg/L respectively, collected from Baha lake centre, and Khukosh stream just below the lake. The average concentration of lead in Khukosh was found 1 μg/L.

Lead distribution GIS based maps (Fig.5.41, 5.42, 5.43 and 5.44.) of the study areas indicated that the Pb concentration was found in relative higher amount in Naltar lakes, and downstream of the lakes at Galeing in the Naltar wetland complex and their related streams (Fig.5.41). In Uttar lake and its related streams (Fig.5.42), the Pb contents at the outlet of the lake, downstream the lake at Matintar, Marig mushk and at the end of Iskoman stream had relatively higher concentration. The distribution of Pb in the Hundrap lake and its related stream in the map (5.43) indicated that, Hundrap lake showed minimum concentration of Pb while the stream water downstream the lake showed relatively high. Pb distribution map of the Baha lake and related stream (Fig.5.44) showed that the inlet and middle parts of Baha lake along with water sample downstream just below the lake were having relatively high concentration of Pb.

Zinc (Zn^{+2})

Zinc is a metal that is normally found in small amounts in nature. It is an essential nutrient needed for body growth, metabolism, bones development, and wound-healing. Although naturally zinc is occurring every where, in air in soil and in water but their rate of concentration are enhanced by different human activities. Therefore, mining, smelting metals (like zinc, lead and cadmium) and steel production, as well as burning coal and certain wastes from the industries are the main sources of zinc to find it way to the environment. Soil is contaminated with high level of zinc due to improper disposal of zinc-containing wastes from metal manufacturing industries and electric utilities. Water is contaminated with zinc when it flows through such region and water supply pipes which are coated with zinc metals. Zinc can be entered in to the body through breathing, food and intake of zinc contaminated water (Gabe et al., 2006). Ingestion of too much zinc in short period of the time will effected the body by stomach cramps, nausea and vomiting, whiles it long term use will cause, anemia, nervous system disorders, damage to the pancreas (Elinder, 1986).

The concentrations of Zinc in the water of lakes and streams of the study areas are given in the Table 5.4 and graphically presented in Figures.5.20a, 5.20b 5.20c and 5.20d. The GIS based maps showing the distribution of zinc in the study areas are presented in Figures.5.45, 5.46, 5.47 and 5.48. The concentration of Zinc in Naltar (Naltar wetland complex and their related stream), was found below the detection level (<0.5 μg/L) in samples W6, W8, W9 and W10, collected from the Singo bari outlet, centre and outlet of Chakar bari and Chemo bari inlet respectively. In rest of the water samples in Naltar, the calculated concentration of zinc ranged from 2 μg/L in samples W7 and W18, collected from Chakar bari inlet and Koto bari outlet to 602 μg/L, taken from Naltar stream at the end population at Nomal. The average concentration of Zinc in the Naltar was found 47 μg/L. The concentration of Zinc in Iskoman (Uttar lake and respective stream) are ranging from 8 μg/L in sample W42, collected from Iskoman stream at Matintar to 1283 μg/L in sample W43, which is collected from the Iskoman stream at Gotolti. The average concentration of Zinc Iskoman was found 257 μg/L. In Hundrap (Hundrap lake and respective stream), the concentration of Zinc ranged from 17 μg/L in sample W24, collected from the Hundrap lake outlet to 929 μg/L in sample W38, collected from the House in Hundrap. The average concentration of Zinc in Hundrap areas was found 362 μg/L. The concentration of Zinc in Khukosh (Baha lake and respective stream), were in the range of 20 μg/L, in sample W25, collected from Baha lake inlet to 623 μg/L, in sample W49, taken from the Khukosh stream just below the Longer valley. The average concentration of Zinc in Khukosh was found 171 μg/L.

Zinc distribution GIS based maps (Fig.5.45, 5.46, 5.47 and 5.48.) of the study areas indicated that the concentration of Zn was found in relative higher amount in Naltar lake1 (Bodorok bari), downstream the lakes at Galeing and at the end of stream at Nomal in the Naltar wetland complex and its related streams (Fig.5.45). In Uttar lake and its related stream (Fig.5.46), the Zn contents at the inlet and outlet of the lake, downstream the lake at Marig mushk, main Iskoman population and the stream at the end of catchments had high concentration of Zn. The distribution of Zn in the Hundrap and its related streams in the maps (Fig.5.47) indicated that Hundrap lake showed minimum concentration of Zn while the stream water downstream the Hundrap lake showed relatively high. Zn distribution map of Baha lake and its related stream (Fig.5.48) showed that the outlet part of the Baha lake and most of the water samples downstream the lake were having relatively high concentration of Zn.

Nickel (Ni^{+2})

Nickel is a nutritionally essential trace metal for several animal species, micro-organisms and plants which has widespread distribution in the environment. Nickel is a naturally occurring element that can exist in various mineral forms. It resists to corrosion by air, water and alkali because it is a member of the transition metal series, readily dissolves in dilute oxidizing acids. Although nickel is widely distributed element found in all segment of environments (air, water and soil) but its concentration is enhance by both natural (weathering of rock and soil, volcanoes emission wind blown dust and forest fire), and anthropoginically (industrial sectors, automobiles and mining activities). Nickel is generally considered as nutritionally essential element within the permissible limit but when the body is exposed to excess of nickel it will cause nasal cavity, larynx and lungs cancer and some of allergy problems (Cempel and Nikel, 2006).

The concentrations of nickel in the water of lakes and streams of the areas studied are given in the Table 5.4 and graphically presented in Figures.5.21a, 5.21b 5.21c and 5.21d. The GIS based maps showing the distribution of nickel in the study areas are presented in Figures.5.49, 5.50, 5.51 and 5.52. The concentration of nickel in Naltar (Naltar wetland complex and its stream), was found below the detection level (<0.5 μg/L) in most of the Naltar lakes water samples. In rest of the water samples, the concentration of nickel ranged from 1 μg/L in samples W5, W7, W16 and W30, collected from Singo bari centre, Chakar bari inlet, Koto bari inlet and Naltar stream at Bangalah respectively to 29 μg/L in sample W1, collected from the Bodorok bari inlet. The average concentration of nickel in Naltar was found 4 μg/L. In Iskoman (Uttar lake and respective stream), the concentration of nickel was found below the diction level (<0.5 μg/L) in samples W19, W20, W44 and W45, collected from the inlet and centre of Uttar lake, Iskoman Jamatkhana and Iskoman mosque. While in rest of the water samples the concentration of nickel was found within the value of 17 μg/L with an average concentration of 4 μg/L in the region. In Hundrap (Hundrap lake and respective stream), the concentration of nickel was found below the detection level (<0.5μg/L) in all the water samples except W35, W36, W39 and W40, having the concentrations of 4 μg/L, 1 μg/L, 1 μg/L and 3 μg/L respectively, collected from the Hundrap stream at Chukarrari, Hirzdam, Hundrap home and at the end of Hundrap population respectively. The average concentration of nickel in Hundrap was found 1 μg/L. The concentration of nickel in

Khukosh (Baha lake and respective stream), was found below the detection level (<0.5 μg/L) in all the water samples except samples W27 and W47, collected from the Baha lake outlet and Khukosh stream just below the lake having the concentration of 5 μg/L and 2 μg/L respectively. The average concentration of nickel in Khukosh region was found 1 μg/L.

Nickel distribution GIS based maps (Fig.5.49, 5.50, 5.51 and 5.52.) of the study areas indicated that the Ni concentration was found in relative higher amount in the Naltar lakes, downstream the lakes at Beishgiri, at Galeing and at the end of stream at Nomal in Naltar wetland complex and it related stream (Fig.5.49). In the Uttar lake and related stream (Fig.5.50), the Ni contents at the outlet of the lake, at local shepherd huts and at Matintar had high concentration of Ni. The distribution of Ni in Hundrap lake and related stream (Fig.5.51), indicated that Hundrap lake showed minimum concentration of Ni while the stream water downstream the Hundrap lake showed relatively high concentration. Ni distribution map of Baha lake and its related stream (Fig.5.52), showed that the outlet part of the Baha lake and stream sample just below the lake were having relatively high concentration of Ni.

Chromium (Cr^{+3})

Chromium and its salts are used in the leather tanning industry, the manufacturing of catalysts, paints, pigments, cosmetics, glass industry and in photography. Chromium salts are also used in chrome plating and corrosion control (USEPA, 1984). The distribution compound containing chromium-iii and chromium-vi are dependent upon redox potential, the pH, the presence of oxidizing or reducing compound the kinetic of the redox reactions, the formation of chromium (iii) complexes and total concentration of total chromium. Because chromium is widely distributed element, therefore, it is present in all segment of environment (air, soil, and in water). The concentration of chromium in surface water is approximately 0.52μg/L (Shiller and Boyle, 1987). Although chromium is an essential element in limited amount to body for normal glucose metabolism, but when the concentration of chromium exceeded from the permissible limit it will causes a nephritis and glycosuria disease. Chromatic dusts produce skin ulcer and nasal mucosum (Javied et al., 2009)

The concentrations of Chromium in water of lakes and streams of the areas under investigation are given in the Table 5.4 and graphically presented in Figures.5.22a, 5.22b 5.22c and 5.22d. The GIS based maps showing the distribution of chromium in the study areas are shown in Figures.5.53, 5.54, 5.55 and 5.56. The concentration of chromium in Naltar (Naltar wetland complex and their related stream), was found below the detection level (<0.5 μg/L) in samples W9, W10, W14 and W15, collected the Chakar bari oulet, Chemo bari inlet, centre and outlet of Small bari respectively. The measured concentration of chromium in remaining water samples ranged from 0.52 μg/L in sample W13, collected from the Small bari inlet to 8 μg/L in sample W1, collected from Bodorok bari inlet (Naltar Lake1). The average concentration of chromium in Naltar was found 2 μg/L. The concentration of chromium in Iskoman (Uttar lake and respective stream), was found between 0.6 μg/L, in sample W42, collected from Iskoman stream at Matintar to 3 μg/L, in sample W21, taken from Uttar lake outlet. The average concentration of chromium in Iskoman was found 1 μg/L. In Hundrap (Hundrap lake and respective stream), the concentration of chromium ranged from 0.6 μg/l, in sample W24, collected from Hundrap lake outlet to 3 μg/L, in sample W23, which is taken from Hundrap lake centre. The average concentration of chromium in Hundrap was calculated 2 μg/L. In Khukosh (Baha lake and respective stream), the concentration of chromium was found below the detection level (<0.5 μg/L) in samples W27 and W48, collected from Baha lake outlet and Khukosh stream at Longer valley. The concentrations of chromium in rest of the all water samples collected from Khukosh region were found less than 1.29 μg/L, with an average value of 0.86μg/l in the area.

Chromium distribution GIS based maps (Fig.5.53, 5.54, 5.55 and 5.56) of the study areas indicated that the Cr concentration was found in relative higher amount in the Naltar lake1, downstream the lakes at Khayout, at Galeing and at the end of stream at Nomal in the Naltar wetland complex and it related stream (Fig.5.53). In the Uttar lake and related stream (Fig.5.54), the Cr contents at the outlet of the lake, water samples downstream the lake at Marig musk and upper Iskoman had high concentration of Cr. The distribution of Cr in Hundrap lake and related stream (Fig.5.55), indicated that the middle part of the Hundrap lake, downstream the Hundrap lake at Hirzdam, and at the end of Hundrap population were having relatively high concentration of Cr. The chromium distribution map of the Baha lake and related stream (Fig.5.56), showed that the inlet and middle parts of Baha lake and most of the downstream the lake except Longer valley, were having relatively high chromium concentration.

Cadmium (Cd^{+2})

Cadmium is a silver white metal occurring in the earth crust. It is not found as pure cadmium but in an environment cadmium is always present in oxide, chloride and sulfur. Cadmium in the form of chloride and sulfate can easily dissolved in water. It may change forms by dissolution but cadmium metal itself not disappear from the environment. Cadmium contamination may be caused by disposal of waste from photographic, metal plating or pesticide manufacturing industries (Gunnar and Nordberg, 1974). Food and cigarette smoke are the biggest sources of cadmium exposure for people in the general population. Besides that, inhalation of air, drinking water from the contaminated sites are also sources of cadmium exposure. The potential harmful nature of cadmium depends on the form and amount of cadmium present in body. Since cadmium tends to accumulate in the body, therefore, long-term effects may occur which include intestinal, lung and kidney damage (Barrento et al., 2009).

The concentrations of cadmium in the water of lakes and streams of the study areas are given in the Table 5.4 and graphically presented in Figures.5.23a, 5.23b 5.23c and 5.23d. The GIS based maps showing the distribution of cadmium in the study areas are presented in Figures.5.57, 5.58, 5.59 and 5.60. The concentration of cadmium in Naltar (Naltar wetland complex and their related stream), was found below the detection level (<0.5 μg/L) in samples W15 and W33, collected from the Small bari outlet and Naltar house at Daas. In rest of the water samples the concentration of cadmium ranged from 0.5 μg/L in sample W13 collected from small bari inlet to 5 μg/L in sample W3, taken from Bodrok bari outlet. The average concentration of cadmium in Naltar was found 2 μg/L. The concentration of cadmium in Iskoman (Uttar lake and respective stream), ranged from 0.5 μg/L in sample No.W45, collected from Iskoman mosque to 5 μg/L in sample No.W43, taken from Iskoman stream at Gotolti. The average concentration of cadmium in Iskoman was found 2 μg/L. In Hundrap (Hundrap lake and respective stream), the concentration of cadmium ranged from 1 μg/L in sample W35, collected from Hundrap stream at Chukarrari to 4 μg/L, in sample W37, taken from the house of Hundrap. The average concentration of cadmium in Hundrap was found 3 μg/L. In Khukosh (Baha lake and respective stream), the concentration of cadmium was found of below the detection level (<0.5 μg/L), in sample W49, collected from Khukosh stream just below the Longer valley. The concentration of cadmium in rest of the water samples ranged from 0.6 μg/L in sample W26 collected from the Baha lake centre to 3 μg/L, in sample W50, taken from the end of Khukosh stream at Barsat. The average concentration of cadmium in Khukosh was found 1 μg/L.

Cadmium distribution GIS based maps (Fig.5.57, 5.58, 5.59 and 5.60.) of the study areas indicated that the Cd concentration was found in relative higher amount in the Naltar lakes, downstream the lakes at Khayout and at Bangalah in the Naltar wetland complex and it related stream (Fig.5.57). In the Uttar lake and related stream (Fig.5.58), the Cd contents at the middle and outlet parts of the lake, water samples downstream the lake at local huts, and Marig musk had high Cadmium concentration. The Cadmium distribution in Hundrap lake and related stream (Fig.5.59), indicated that at the inlet of the Hundrap lake, downstream the lake at main Hundrap population were having relatively high Cd concentration. The distribution map of Cd of the Baha lake and related stream (Fig.5.60), showed that the inlet and outlet parts of the Baha lake and most of the samples downstream the lake were having relatively high Cd concentration.

Mercury (H^{+2})

Mercury is a heavy, silvery-white metal found in various forms including elemental mercury, inorganic mercury compounds, and organic mercury compounds such as methyl mercury. Although mercury is present everywhere in primary nature minute amount but their concentration will increase by natural processes including volcanoes, forest fires, cinnabar (ore) and fossil fuels such as coal and petroleum, and anthropogenically by, mining, pulp, hydroelectric, paper industries, and municipal and medical wastes. Mercury concentrations in water resources are generally vary low, between 0.005 and 0.1μg/L with an average concentration in drinking water of 0.025ug/L. Occasionally, concentration >2μg/L are repotted in shallow well (Gray, 2008). Mercury is highly toxic to humans, and exposure to even small amounts of methylmercury can lead to irreversible neurological damage. Children and the developing fetus are particularly sensitive to mercury. The Environmental Protection Agency (EPA) estimates that there are 630,000 children born annually with unsafe blood mercury levels based on the reference dose set by the agency (Catherine, 2004). In an excessive amount of mercury in human body will lead to chronic effects to the nervous system, kidney or intestines.

The concentration of the Mercury in all the representative water samples collected from the lakes and streams of the study areas was found below the detection level (<0.05 ug/L), therefore not presented in graphs and GIS maps for the study area. (See table. 5.4).

Arsenic (As^{+2})

Highly carcinogenic element arsenic is widely distributed and commonly found in nature as arsenic sulfide and other arsenate metals. The major inorganic forms of arsenic found in drinking water are trivalent (arsenic III) and pentavelent (arsenic V) compounds which are most toxic in their nature and caused poisoning in million of people around the world, while organically arsenic is formed as monomethylarsonic acid (MMA) which is comparatively less toxic (Gray, 2008). Arsenic commercially has been used as a rodenticide, insecticide, and weed killer, as well as a way of assassinating enemies.

Arsenic concentration in water caused naturally by weathering of rocks and ores and or by different human activities. As arsenic can not be metabolized or excreted from the body, therefore, it accumulates in hair and fingernail, where it can be detected long after death (William, 2005).

The concentrations of arsenic in the water of lakes and stream of the study area areas are given in the Table 5.4, and graphically presented in Figures.5.24a, 5.24b 5.24c and 5.24d. The GIS based maps showing the distribution of arsenic in the study areas are shown in Figures.5.61, 5.62, 5.63 and 5.64. The concentration of arsenic in Naltar (Naltar wetland complex and their related stream), ranged from 0.76 μg/L, in sample W30, collected from Nalatr stream at Bangalah to 4.13 μg/L, in sample W33, collected from the house of Naltar at Daas. The average concentration of arsenic in Naltar was found 2.30 μg/L. In Iskoman (Uttar lake and respective stream), the concentration of arsenic varied from a minimum of 0.32 μg/L, in sample W43, collected from Iskoman stream at Gotolti to a maximum of 5.21 μg/L, in sample W21, taken from the Uttar lake outlet. The average concentration of arsenic in Iskoman was found 1.95 μg/L. In Hundrap (Hundrap lake and respective stream), the concentration of arsenic ranged from 0.78 μg/L, in sample W35, collected from Hundrap stream at Chukarrari to 5.52 μg/L in sample W22, taken from the Hundrap lake Inlet. The average concentration of arsenic in Hundrap region was found 3.01 μg/L. In Khukosh (Baha lake and respective stream), the concentration of arsenic ranged from 0.47 μg/L, in sample W27, collected from Baha lake outlet, to 5.64 μg/L in sample W25, which is also Baha lake water sample taken from the lake inlet part. The average concentration of arsenic in Khukosh was found 2.28 μg/L.

Arsenic distribution GIS based maps (Fig.5.61, 5.62, 5.63 and 5.64) of the study areas indicated that the As concentration was found in relative higher amount in the upstream of Beishgri in Naltar lakes and downstream the lakes at Galieng in the Naltar wetland complex and it related stream (Fig.5.61). In the Uttar lake and respective stream (Fig.5.62), the As concentration at Uttar lake, downstream the lake at shepherds huts and at the end of Iskoman stream had high As concentration. The distribution of As in Hundrap lake and related stream (Fig.5.63) indicated that Hundrap lake and downstream the lake at main Hundrap population have relatively high As concentration. Arsenic distribution map of the Baha lake and related stream (Fig.5.64) showed that the inlet and middle parts of Baha lake, and most of downstream water samples except Longer valley had relatively higher As concentration.

Table.5.1. The physical parameters in the water of study area (Naltar wetland complex, Uttar, Hundrap and Baha lake with their respective streams)

Samples No.	source	Temp- (^oC)	pH	Electric Conductivity (µs/cm)	TDS (mg/L)	Turbidity (NTU)	Salinity	Resestivity (k/Ω)
	Site.1 Naltar (Naltar wetland complex)							
W1	Lake.1 (Bodorok bari) inlet	6	7.73	160	91	0.5	0.5	6
W2	centre	7	7.75	150	76	0.4	0.1	6.8
W3	outlet	7	7.7	152	77	0.6	3.8	6.7
W4	Lake 2 (Singo bari) inlet	6	7.63	106	82	0.1	0.1	10
W5	centre	6	7.8	108	79	0	0.1	8.4
W6	outlet	6	7.9	129	69	0.1	0.2	7.6
W7	Lake 3 (Chakar Bari) inlet	7	7.9	107	57	0.2	0.1	9.4
W8	centre	7	7.8	115	63	0.3	0.3	8.3
W9	outlet	6	7.7	115	60	0.6	1.1	10
W10	Lake 4 (Chemo bari) inlet	6	7.6	132	71	0.1	0.1	6.9
W11	centre	8	7.5	165	80	1.2	0.4	6.5
W12	outlet	7	7.8	130	80	1.5	0.3	7.6
W13	Lake 5 (Small bari) inlet	6	7.7	119	62	0.9	0.1	8.4
W14	centre	6	7.8	110	77	0	0.2	8.6
W15	outlet	6	7.7	110	57	0.3	0.2	9
W16	Lake 6 (Koto Bari) inlet	7	7.5	170	90	0.2	0.4	6
W17	centre	8	7.6	165	87	0.1	0.2	6
W18	outlet	7	7.7	184	99	0	0.2	5
	Naltar Streams							
W28	Nalatar stream at Beshgiri.	7	7.8	178	89	1.5	0.3	8
W29	Naltar 4 View Hotel	9	7.7	165	181	0.9	0.2	10
W30	Nalatar stream at Beshgiri.	7	7.4	281	92	2.8	0.1	7
W31	Naltar home 1 at Cote muhallah.	8	7.5	170	95	1.7	0.9	6
W32	Naltar home 2 at Galieng.	8	7.9	122	72	0.8	0.8	7
W33	Naltar home 3 at Daas muhallah.	8	7.8	119	95	2.8	1	8
W34	Nomal	7	7.9	182	102	1.1	1.1	10
	Minimum	**6**	**7.4**	**106**	**57**	**0**	**0.1**	**5**
	Maximum	**8**	**7.9**	**281**	**181**	**2.8**	**3.8**	**10**
	Average	**6.92**	**7.71**	**146**	**83**	**0.75**	**0.51**	**7.73**
	WHO, permissible values	**No limit listed**	**6.5-8.5**	**1400**	**1200**	**5**	**No limit listed**	**No limit listed**
	USEPA, permissible values	**No limit listed**	**6.5-8.5**	**No limit listed**	**500**	**0.5- 5**	**No limit listed**	**No limit listed**

	Site.2 Iskoman (Utter lake)	Temp- (^{o}C)	pH	Electric Conductivity (µs/cm)	TDS (mg/L)	Turbidity (NTU)	Salinity	Resestivity (k/Ω)
W19	Utter lake inlet	7	7.7	166	87	3.9	0.1	6
W20	centre	8	7.6	153	87	5	0.1	6.5
W21	outlet	7	7.7	156	83	4.9	0.2	6.1
	Iskoman Stream							
W41	Iskoman stream at local huts.	7	7.8	158	90	4.8	0.1	5
W42	Iskoman stream at Matintar.	7	7.6	142	97	3.2	0.8	9
W43	Iskoman stream at Gotolti.	7	7.2	128	65	1.7	0.1	8
W44	Iskoman Jamatkhana	7	7.5	197	122	0.3	0.1	6
W45	Iskoman Masjid	7	7.6	217	114	1.1	0.7	6.4
W46	At the end of Iskoman stream.	7	7.9	158	103	2.8	0.1	9
	Minimum	**7**	**7.2**	**128**	**65**	**0.3**	**0.1**	**5**
	Maximum	**8**	**7.9**	**217**	**122**	**4.9**	**0.8**	**8**
	Average	**7.11**	**7.62**	**164**	**94**	**3.08**	**0.26**	**6.89**
	WHO, permissible values	**No limit listed**	**6.5-8.5**	**1400**	**1200**	**5**	**No limit listed**	**No limit listed**
	USEPA, permissible values	**No limit listed**	**6.5-8.5**	**No limit listed**	**500**	**0.5-5**	**No limit listed**	**No limit listed**
	Site.3 Hundrap (Hundrap lake)	**Temp- (^{o}C)**	**pH**	**Electric Conductivity (µs/cm)**	**TDS (mg/L)**	**Turbidity (NTU)**	**Salinity**	**Resestivity (k/Ω)**
W22	Hundrap lake inlet	6	7.6	110	54	0.3	0.1	10
W23	centre	6	7.8	90	50	0.2	0.2	10.9
W24	outlet	6	7.5	104	51	0.2	0.2	10
	Hundrap Stream							
35	Hundrap stream at Chukarrari.	6	7.7	125	61	7	0.1	10
36	Hundrap stream at Hirzdam.	6	7.9	102	98	0.4	0.1	8
37	Hundrap home 1	7	7.2		68	0.6	0.2	6
38	Hundrap home 2	8	7.9	92	79	0.6	0.1	5
39	Hundrap home 3	8	7.8	117	90	0.8	0.1	8
40	At the end of Hundrap stream.	7	7.4	181	125	0.2	0.4	8
	Minimum	**6**	**7.2**	**90**	**50**	**1**	**0.1**	**5**
	Maximum	**8**	**7.9**	**181**	**125**	**0.59**	**0.4**	**10.9**
	Average	**6.67**	**7.64**	**124**	**75**	**5**	**0.17**	**8.43**
	WHO, permissible values	**No limit listed**	**6.5-8.5**	**1400**	**1200**	**0.5-5**	**No limit listed**	**No limit listed**
	USEPA, permissible values	**No limit listed**	**6.5-8.5**	**No limit listed**	**500**		**No limit listed**	**No limit listed**

	Site.4 Khokus (Baha lake)	**Temp- (^oC)**	**pH**	**Electric Conductivity (µs/cm)**	**TDS (mg/L)**	**Turbidity (NTU)**	**Salinity**	**Resestivity (k/Ω)**
W25	Baha lake inlet	6	7.5	125	69	1.4	0.1	7.8
W26	centre	7	7.7	131	75	1.3	0.1	8
W27	outlet	6	7.8	241	129	2.5	0.2	4
	Khukosh Stream							
W47	Khokus stream just below the lake	6	7.7	103	51	0.7	0.2	7
W48	Khokus stream at longer valley.	6	7.5	130	77	1.7	0.2	6
W49	Khokus stream below the longer.	7	7.7	187	149	3.9	0.1	7
W50	Barsad	7	7.9	138	65	2.8	0.2	6
	Minimum	**6**	**7.5**	**103**	**51**	**0.7**	**0.1**	**4**
	Maximum	**7**	**7.9**	**241**	**149**	**3.9**	**0.2**	**8**
	Average	**6.43**	**7.69**	**151**	**88**	**2.04**	**0.16**	**6.54**
	WHO, permissible values	**No limit listed**	**6.5- 8.5**	**1400**	**1200**	**5**	**No limit listed**	**No limit listed**
	USEPA, permissible values	**No limit listed**	**6.5- 8.5**	**No limit listed**	**500**	**0.5- 5**	**No limit listed**	**No limit listed**

Table.5.2. The concentration of anions in the water of the study area (Naltar wetland complex, Uttar, Hundrap and Baha lakes with their respective streams)

Samples No.	**source**	**Chloride (Cl) mg/L**	**Sulfate (SO_4) mg/L**	**Nitrate (NO_3) mg/L**	**Bicarbonate (HCO_3) mg/L**
	Site.1 Naltar (Naltar wetland complex).				
W1	Lake.1 (Bodorok bari) inlet	0.2	18	0.5	130
W2	centre	0.5	12	1.1	100
W3	outlet	6	15	1.2	220
W4	Lake 2 (Singo bari) inlet	0.4	7	1.1	90
W5	centre	0.2	9	0.8	60
W6	outlet	<0.1	10	1	160
W7	Lake 3 (Chakar Bari) inlet	<0.1	9	0.4	90
W8	centre	0.1	7	2	120
W9	outlet	0.3	6	1.4	70
W10	Lake 4 (Chemo bari) inlet	<0.1	12	1	140
W11	centre	0.6	10	0.9	110
W12	outlet	0.8	17	1.5	130
W13	Lake 5 (Small bari) inlet	<0.1	10	0.8	140
W14	centre	0.2	11	2	200
W15	outlet	0.5	10	0.9	190
W16	Lake 6 (Koto Bari) inlet	1.3	16	1.2	130
W17	centre	0.8	24	3	110
W18	outlet	1.4	22	0.9	170
	Naltar Streams				
W28	Nalatar stream at Beshgiri.	3.5	19	2	220
W29	Naltar 4 View Hotel	15.3	22	0.7	240
W30	Nalatar stream at Beshgiri.	10.7	15	3.2	190
W31	Naltar home 1 at Cote muhallah.	42.2	28	2.7	320
W32	Naltar home 2 at Galieng.	16.6	11	1.9	300
W33	Naltar home 3 at Daas muhallah.	24.2	18	3	200
W34	Nomal	15.4	26	5	150
	Minimum	**0.1**	**6**	**0.4**	**60**
	Maximum	**42.2**	**28**	**5**	**320**
	Average	**6.72**	**14.56**	**1.61**	**163.2**

	WHO, permissible values	**250**	**500**	**50**	**250**
	USEPA, permissible values	**250**	**250**	**10**	**250**
	Below diction level (BDL)	**<0.1**	**<2**	**<0.3**	**No level listed**
	Site. 2 Iskoman (Utter lake)	**Chloride (Cl) mg/L**	**Sulfate (SO_4) mg/L**	**Nitrate (NO_3) mg/L**	**Bicarbonate (HCO_3) mg/L**
W19	Utter lake inlet	0.9	17	1	90
W20	centre	0.4	15	<0.3	110
W21	outlet	0.2	19	0.4	80
	Iskoman Stream				
W41	Iskoman stream at local huts.	0.8	19	1	130
W42	Iskoman stream at Matintar.	17.7	18	2.5	180
W43	Iskoman stream at Gotolti.	29.2	27	0.7	360
W44	Iskoman Jamatkhana	18.3	17	1.9	190
W45	Iskoman Masjid	9.9	27	2.9	140
W46	At the end of Iskoman stream.	5.4	23	1.5	250
	Minimum	**0.2**	**15**	**0.4**	80
	Maximum	**29.2**	**23**	**2.9**	360
	Average	**9.2**	**20.22**	**1.49**	170
	WHO, permissible values	**250**	**500**	**50**	250
	USEPA, permissible values	**250**	**250**	**10**	250
	Below diction level (BDL)	**<0.1**	**2**	**0.3**	**No level listed**
	Site.3 Hundrap (Hundrap lake)	**Chloride (Cl) mg/L**	**Sulfate (SO_4) mg/L**	**Nitrate (NO_3) mg/L**	**Bicarbonate (HCO_3) mg/L**
W22	Hundrap lake inlet	0.6	11	0.6	150
W23	centre	0.5	6	0.7	130
W24	outlet	0.9	10	0.1	190
	Hundrap Stream				
35	Hundrap stream at Chukarrari.	21.8	20	0.5	110
36	Hundrap stream at Hirzdam.	23.4	15	2	150
37	Hundrap home 1	15.4	17	0.9	23
38	Hundrap home 2	13.9	25	0.3	210
39	Hundrap home 3	17.9	27	0.8	360
40	At the end of Hundrap stream.	12.4	15	2.1	190
	Minimum	**0.5**	**6**	**0.1**	**23**
	Maximum	**23.4**	**27**	**2.1**	**360**

	Average	**11.87**	**16.22**	**0.89**	**168.11**
	WHO, permissible values	**250**	**250**	**10**	**250**
	USEPA, permissible values	**<0.1**	**2**	**<0.3**	**No level listed**
	Below diction level (BDL)	**Chloride (Cl) mg/L**	**Sulfate (SO_4) mg/L**	**Nitrate (NO_3) mg/L**	**Bicarbonate (HCO_3) mg/L**
	Site.4 Khokus (Baha lake)				
W25	Baha lake inlet	1.8	5	<0.3	160
W26	centre	1.4	7	0.9	170
W27	outlet	0.7	50	3	190
	Khukosh Stream				
W47	Khokus stream just below the lake	2.5	47	2	140
W48	Khokus stream at longer valley.	23.2	13	0.9	170
W49	Khokus stream below the longer.	17.2	16	0.9	210
W50	Barsad	19.8	16	0.5	210
	Minimum	**0.7**	5	**0.5**	**140**
	Maximum	**23.2**	50	**3**	**210**
	Average	**9.51**	22	**1.19**	**178.57**
	WHO, permissible values	**250**	**500**	**50**	**250**
	USEPA, permissible values	**250**	**250**	**10**	**250**
	Below diction level (BDL)	**<0.1**	**2**	**<0.3**	**No level listed**

Table.5.3. The concentration of light elements in the water of the study area (Naltar wetland complex, Uttar, Hundrap and Baha lakes with their respective streams)

Samples No.	**source**	**Sodium (Na) mg/L**	**Potacium (K) mg/L**	**Calcium (Ca)mg/L**	**Magnesium (Mg) mg/L**
	Site.1 Naltar (Naltar wetland complex).				
W1	Lake.1 (Bodorok bari) inlet	1.31	2.83	27.11	4.05
W2	centre	0.87	2.09	18.12	5.5
W3	outlet	1.36	3.01	27.33	4.09
W4	Lake 2 (Singo bari) inlet	0.48	2.06	19.4	1.03
W5	centre	0.49	2.08	18.1	0.9
W6	outlet	0.52	2.19	18.28	1.15
W7	Lake 3 (Chakar Bari) inlet	0.56	2.65	16.36	0.54
W8	centre	0.6	2.92	18.08	0.54
W9	outlet	0.73	2.92	19.23	5.31
W10	Lake 4 (Chemo bari) inlet	0.55	2.18	21.48	0.43
W11	centre	0.5	2.03	19.35	1.08
W12	outlet	0.49	1.98	20.86	0.05
W13	Lake 5 (Small bari) inlet	0.49	1.99	18.36	0.34
W14	centre	0.47	1.97	17.94	4.07
W15	outlet	0.47	2	18.49	0.89
W16	Lake 6 (Koto Bari) inlet	1.99	2.74	25.89	5.33
W17	centre	1.71	2.91	24.05	5.02
W18	outlet	1.33	2.84	25.45	4.41
	Naltar Streams				
W28	Nalatar stream at Beshgiri.	1.36	2.8	30.33	3.92
W29	Naltar 4 View Hotel	1.3	2.73	26.14	3.8
W30	Nalatar stream at Beshgiri.	4.64	5.27	18.75	6.89
W31	Naltar home 1 at Cote area	35.03	3.96	57.1	25.78
W32	Naltar home 2 at Galieng area.	12.35	4.34	49.44	18.64

W33	Naltar home 3 at Daas area	1.05	2.29	18.77	3.11
W34	Nomal	3.73	4.75	34.66	38.66
	Minimum	**0.5**	**1.97**	**16.36**	**0.05**
	Maximum	**35.03**	**5.27**	**57.1**	**38.66**
	Average	**2.98**	**2.78**	**24.36**	**5.82**
	WHO, permissible values	**200**	**15**	**75**	**50**
	USEPA, permissible values	**No limit listed**	**No limit listed**	**No limit listed**	**No limit listed**
	Site. 2 Iskoman (Utter lake)	**Sodium (Na) mg/L**	**Potacium (K) mg/L**	**Calcium (Ca) mg/L**	**Magnesium (Mg) mg/L**
W19	Utter lake inlet	1.31	2.44	19.78	7.95
W20	centre	1.29	2.41	21.26	8.04
W21	outlet	1.3	2.54	19.35	8.07
	Iskoman Stream				
W41	Iskoman stream at local huts.	3.06	3.93	46.93	2.16
W42	Iskoman stream at Matintar.	1.27	2.49	30.42	12.71
W43	Iskoman stream at Gotolti.	11.46	4.56	74.29	25.67
W44	Iskoman Jamatkhana	48.35	2.48	45.26	26.13
W45	Iskoman Masjid	2.14	5.4	42.77	5.62
W46	At the end of Iskoman stream.	123.88	4.23	55.7	29.68
	Minimum	**1.27**	**2.41**	**19.35**	**2.16**
	Maximum	**123.88**	**5.4**	**74.29**	**29.68**
	Average	**21.56**	**3.39**	**39.53**	**14.00**
	WHO, permissible values	**200**	**15**	**75**	**50**
	USEPA, permissible values	**No limit listed**	**No limit listed**	**No limit listed**	**No limit listed**
	Site.3 Hundrap (Hundrap lake)	**Sodium (Na) mg/L**	**Potacium (K) mg/L**	**Calcium (Ca) mg/L**	**Magnesium (Mg) mg/L**
W22	Hundrap lake inlet	1.76	0.92	12.23	0.28
W23	centre	1.65	0.88	11.83	1.17
W24	outlet	1.78	0.86	12.15	0.31
	Hundrap Stream				
35	Hundrap stream at Chukarrari.	8.01	2.14	59.9	15.88
36	Hundrap stream at Hirzdam.	10.9	2.88	62.9	24.96
37	Hundrap home 1	33.66	3.08	53.05	22.28
38	Hundrap home 2	26.15	2.95	45.04	21.13

39	Hundrap home 3	30.95	3.93	51.35	25.51
40	At the end of Hundrap stream.	24.78	4.3	57.6	21.9
	Minimum	**1.65**	**0.86**	**11.83**	**0.28**
	Maximum	**33.66**	**4.3**	**62.9**	**25.51**
	Average	**15.52**	**2.44**	**40.67**	**14.82**
	WHO, permissible values	**200**	**15**	**75**	**50**
	USEPA, permissible values	**No limit listed**	**No limit listed**	**No limit listed**	**No limit listed**
	Site.4 Khokus (Baha lake)	**Sodium (Na) mg/L**	**Potacium (K) mg/L**	**Calcium (Ca) mg/L**	**Magnesium (Mg) mg/L**
W25	Baha lake inlet	2.19	1.22	16.48	4.55
W26	centre	2.05	0.92	15.88	4.48
W27	outlet	2.95	3.94	46.63	2.29
	Khukosh Stream				
W47	Khokus stream just below the lake	1.31	1.68	29.7	1.19
W48	Khokus stream at longer valley.	124.24	4.72	44.9	27.69
W49	Khokus stream below the longer.	127.25	4.6	50.85	24.43
W50	Barsad	140.75	2.4	28.95	22.35
	Minimum	**1.31**	**0.92**	**15.88**	**1.19**
	Maximum	**140.75**	**4.72**	**50.85**	**27.69**
	Average	**57.25**	**2.78**	**33.34**	**12.43**
	WHO, permissible values	**200**	**15**	**75**	**50**
	USEPA, permissible values	**No limit listed**	**No limit listed**	**No limit listed**	**No limit listed**

Table.5.4. The concentrations heavy metals in the water of the study area (Naltar wetland complex, Uttar, Hundrap and Baha lakes with their respective streams)

Samples No.	**source**	**Magnese (Mn) µg/L**	**Iron (Fe) µg/L**	**Copper (Cu) µg/L**	**Lead (Pb) µg/L**	**Zinc (Zn) µg/L**	**Nickle (Ni) µg/L**	**Chromium (Cr) µg/L**	**Cadmium (Cd) µg/L**	**Mercury (Hg) µg/L**	**Arsanic (As) µg/L**
	Site.1 Naltar (Naltar wetland complex).										
W1	Lake.1 (Bodorok bari) inlet	100	105	84	6	22	29	8.4	3.37	<0.05	1.56
W2	centre	80	479	11	2	54	11	5.39	4.2	<0.05	2.27
W3	outlet	100	877	10	<0.5	32	9	6.13	4.78	<0.05	1.93
W4	Lake 2 (Singo bari) inlet	90	14	7	5	11	4	2.25	2.28	<0.05	3.46
W5	centre	100	52	3	4	3	1	1.64	2.89	<0.05	3.61
W6	outlet	80	20	2	1	<0.5	<0.5	1.06	2.31	<0.05	3.55
W7	Lake 3 (Chakar Bari) inlet	90	18	3	1	2	1	0.56	4.07	<0.05	3.83
W8	centre	90	150	2	<0.5	<0.5	<0.5	0.54	2.33	<0.05	1.69
W9	outlet	110	7	2	<0.5	<0.5	<0.5	<0.5	2.59	<0.05	1.66
W10	Lake 4 (Chemo bari) inlet	110	98	1	7	<0.5	<0.5	<0.5	2.24	<0.05	2.53
W11	centre	<0.5	54	28	1	16	10	1.17	1.41	<0.05	2.82
W12	outlet	<0.5	25	5	6	12	<0.5	0.69	2.45	<0.05	2.46
W13	Lake 5 (Small bari) inlet	<0.5	30	3	10	14	<0.5	0.52	0.53	<0.05	2.91
W14	centre	10	27	1	6	16	<0.5	<0.5	0.76	<0.05	2.53
W15	outlet	10	43	<0.5	2	19	<0.5	<0.5	<0.5	<0.05	2.76
W16	Lake 6 (Koto Bari) inlet	10	29	2	<0.5	43	1	1.45	2.57	<0.05	1.34
W17	centre	<0.5	16	<0.5	<0.5	12	<0.5	0.91	4.41	<0.05	2.41
W18	outlet	10	33	<0.5	<0.5	2	<0.5	0.72	0.86	<0.05	2.25
	Naltar Streams										
W28	Nalatar stream at Beshgiri.	<0.5	298	5	<0.5	25	5	1.17	1.4	<0.05	1.77
W29	Naltar 4 View Hotel	10	301	3	<0.5	16	2	1.93	3.29	<0.05	1.66
W30	Nalatar stream at Beshgiri.	10	78	2	1	16	1	0.94	2.71	<0.05	0.76
W31	Naltar home 1 at Cote area	30	69	32	5	222	19	2.71	1.3	<0.05	2.12
W32	Naltar home 2 at Galieng area.	20	<0.5	4	3	17	6	1.89	1.62	<0.05	0.77
W33	Naltar home 3 at Daas area	10	24	3	4	20	3	2.57	<0.5	<0.05	4.13

W34	Nomal	20	<0.5	8	<0.5	602	3	2.48	1.24	<0.05	0.79
	Minimum	**10**	**7**	**1**	**1**	**2**	**1**	**0.52**	**0.53**	**<0.05**	**0.76**
	Maximum	**110**	**877**	**84**	**11**	**602**	**29**	**8.4**	**4.78**	**<0.05**	**4.13**
	Average	**44**	**114**	**9**	**3**	**47**	**4**	2	**2.32**	**<0.05**	**2.30**
	WHO, permissible values	**500**	**300**	**2000**	**10**	**3000**	**20**	**50**	**3**	**1**	**10**
	USEPA, permissible values	**50**	**300**	**1300**	**5**	**5000**	**100**	**100**	**5**	**2**	**5**
	Below diction level	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.05**	**<0.05**
	Site. 2 Iskoman (Utter lake)	**Magnese (Mn) µg/L**	**Iron (Fe) µg/L**	**Copper (Cu) µg/L**	**Lead (Pb) µg/L**	**Zinc (Zn) µg/L**	**Nickle (Ni) µg/L**	**Chromium (Cr) µg/L**	**Cadmium (Cd) µg/L**	**Mercury (Hg)µg/L**	**Arsanic (As) µg/L**
W19	Utter lake inlet	10	595	1	<0.5	93	<0.5	0.62	0.55	<0.05	2.92
W20	centre	20	753	<0.5	<0.5	25	<0.5	0.94	3.77	<0.05	4
W21	outlet	10	783	31	4	109	13	3.04	2.72	<0.05	5.21
	Iskoman Stream										
W41	Iskoman stream at local huts.	30	100	28	1	39	17	1.31	2.21	<0.05	0.67
W42	Iskoman stream at Matintar.	0	45	2	5	8	3	0.54	1.63	<0.05	2.39
W43	Iskoman stream at Gotolti.	0	29	3	7	1283	2	2.07	4.96	<0.05	0.32
W44	Iskoman Jamatkhana	10	5	3	<0.5	362	<0.5	1.98	1.14	<0.05	0.53
W45	Iskoman Masjid	20	0	<0.5	<0.5	12	<0.5	0.84	0.48	<0.05	0.43
W46	At the end of Iskoman stream.	0	21	6	3	381	2	1.43	1.72	<0.05	1.04
	Minimum	**10**	**5**	**1**	**1**	**8**	**2**	**0.54**	**0.5**	**<0.05**	**0.32**
	Maximum	**30**	**783**	**31**	**7**	**1283**	**17**	**3.04**	**4.96**	**<0.05**	**5.21**
	Average	12	**259**	**8**	**2**	**257**	**4**	**1.41**	**2.12**	**<0.05**	**1.95**
	WHO, permissible values	**500**	**300**	**2000**	**10**	**3000**	**20**	**50**	**3**	**1**	**10**
	USEPA, permissible values	**50**	**300**	**1300**	**5**	**5000**	**100**	**100**	**5**	**2**	**5**
	Below diction level	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.05**	**<0.05**
	Site.3 Hundrap (Hundrap lake)	**Magnese (Mn) µg/L**	**Iron (Fe) µg/L**	**Copper (Cu) µg/L**	**Lead (Pb) µg/L**	**Zinc (Zn) µg/L**	**Nickle (Ni) µg/L**	**Chromium (Cr) µg/L**	**Cadmium (Cd) µg/L**	**Mercury (Hg)µg/L**	**Arsanic (As) µg/L**
W22	Hundrap lake inlet	<0.5	163	8	<0.5	53	<0.5	0.83	4.06	<0.05	5.52
W23	centre	<0.5	156	4	<0.5	31	<0.5	2.55	1.54	<0.05	5.7
W24	outlet	<0.5	103	2	<0.5	17	<0.5	0.6	2.73	<0.05	2.95

	Hundrap Stream										
35	Hundrap stream at Chukarrari.	40	82	8	3	401	4	1.79	1.37	<0.05	0.78
36	Hundrap stream at Hirzdam.	20	6	2	3	425	1	2.12	2.19	<0.05	1.88
37	Hundrap home 1	20	24	3	1	859	<0.5	1.73	4.23	<0.05	3.28
38	Hundrap home 2	20	22	2	<0.5	930	<0.5	1.58	3.64	<0.05	2.24
39	Hundrap home 3	10	298	2	5	490	1	2.44	1.67	<0.05	2.22
40	At the end of Hundrap stream.	30	629	3	6	49	3	2.5	3.12	<0.05	2.25
	Minimum	**10**	**6**	**2**	**1**	**17**	**1**	**0.6**	**1.37**	**<0.05**	**0.78**
	Maximum	**40**	**629**	**8**	**5**	**929**	**4**	**3**	**4.23**	**<0.05**	**5.52**
	Average	**16**	**165**	**4**	**2**	**362**	**2**	2	**2.74**	**<0.05**	**3.01**
	WHO, permissible values	**500**	**300**	**2000**	**10**	**3000**	**20**	**50**	**3**	**1**	**10**
	USEPA, permissible values	**50**	**300**	**1300**	**5**	**5000**	**100**	**100**	**5**	**2**	**5**
	Below detection level	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.05**	**<0.05**
	Site.4 Khokus (Baha lake)	**Magnese (Mn) µg/L**	**Iron (Fe) µg/L**	**Copper (Cu) µg/L**	**Lead (Pb) µg/L**	**Zinc (Zn) µg/L**	**Nickle (Ni) µg/L**	**Chromium (Cr) µg/L**	**Cadmium (Cd) µg/L**	**Mercury (Hg)µg/L**	**Arsanic (As) µg/L**
W25	Baha lake inlet	<0.5	333	1	<0.5	20	<0.5	1.01	2.05	<0.05	5.64
W26	centre	30	149	4	7	31	<0.5	0.84	0.63	<0.05	3.13
W27	outlet	<0.5	93	4	<0.5	42	5	0	1.31	<0.05	0.47
	Khukosh Stream										
W47	Khokus stream just below the lake	30	9	3	3	241	2	0.46	1.39	<0.05	4.02
W48	Khokus stream at longer valley.	10	5	3	<0.5	204	<0.5	0.26	1.29	<0.05	0.88
W49	Khokus stream below the longer.	30	0	1	<0.5	623	<0.5	1.3	<0.5	<0.05	0.52
W50	Barsad	30	0	<0.5	<0.5	33	<0.5	1.29	2.73	<0.05	1.31
	Minimum	**10**	**5**	**1**	**3**	**20**	**2**	**0.26**	**0.6**	**<0.05**	**0.47**
	Maximum	**30**	**333**	**4**	**7**	**623**	**5**	**1.29**	**2.73**	**<0.05**	**5.64**
	Average	**26.00**	**84**	**2**	**3**	**171**	**1**	**0.86**	**1.16**	**<0.05**	**2.28**
	WHO, permissible values	**500**	**300**	**2000**	**10**	**3000**	**20**	**50**	**3**	**1**	**10**
	USEPA, permissible values	**50**	**300**	**1300**	**5**	**5000**	**100**	**100**	**5**	**2**	**5**
	Below Detection level	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.5**	**<0.05**	**<0.05**

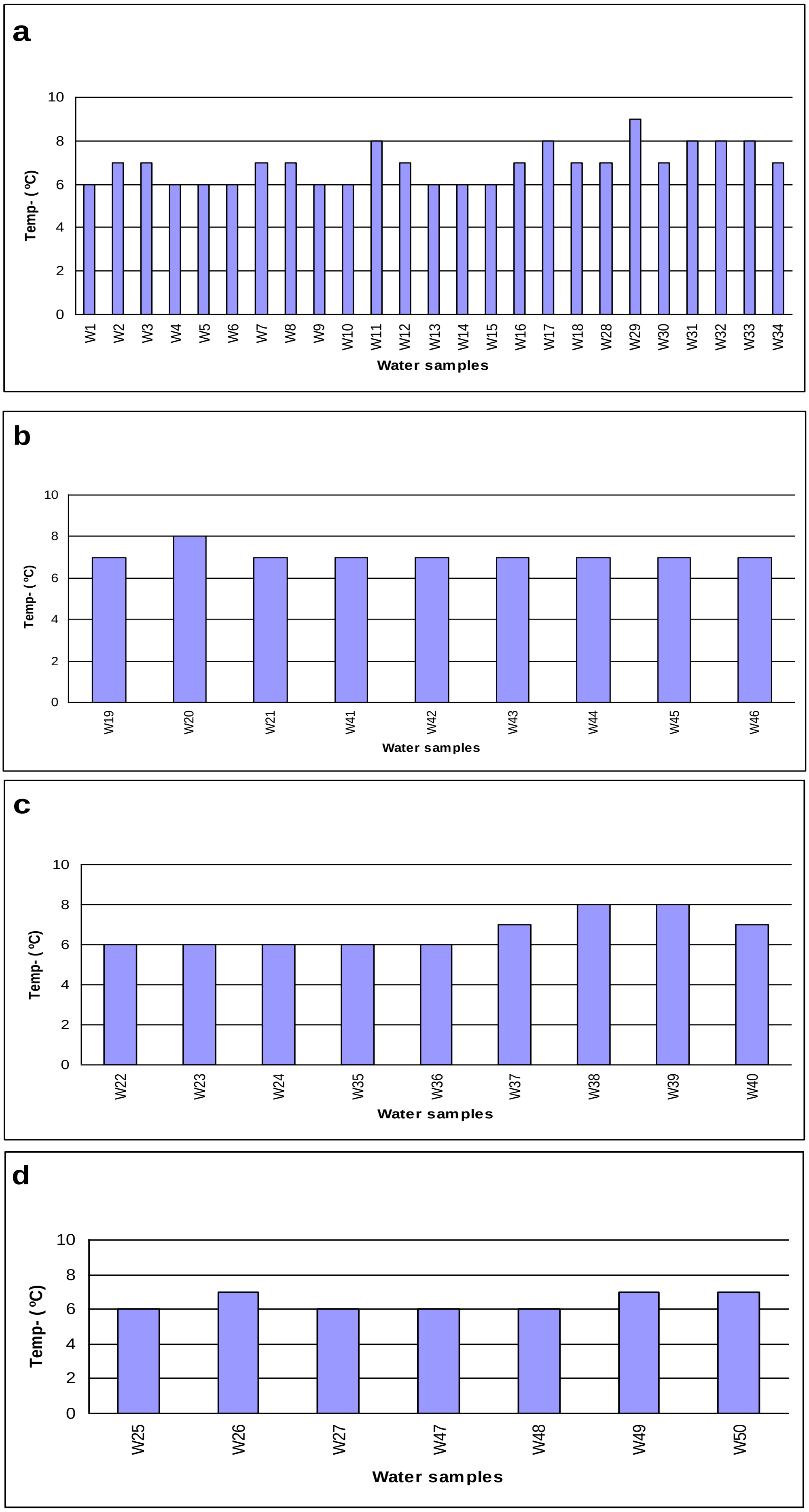


Fig.5.1. Variations in temperature in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

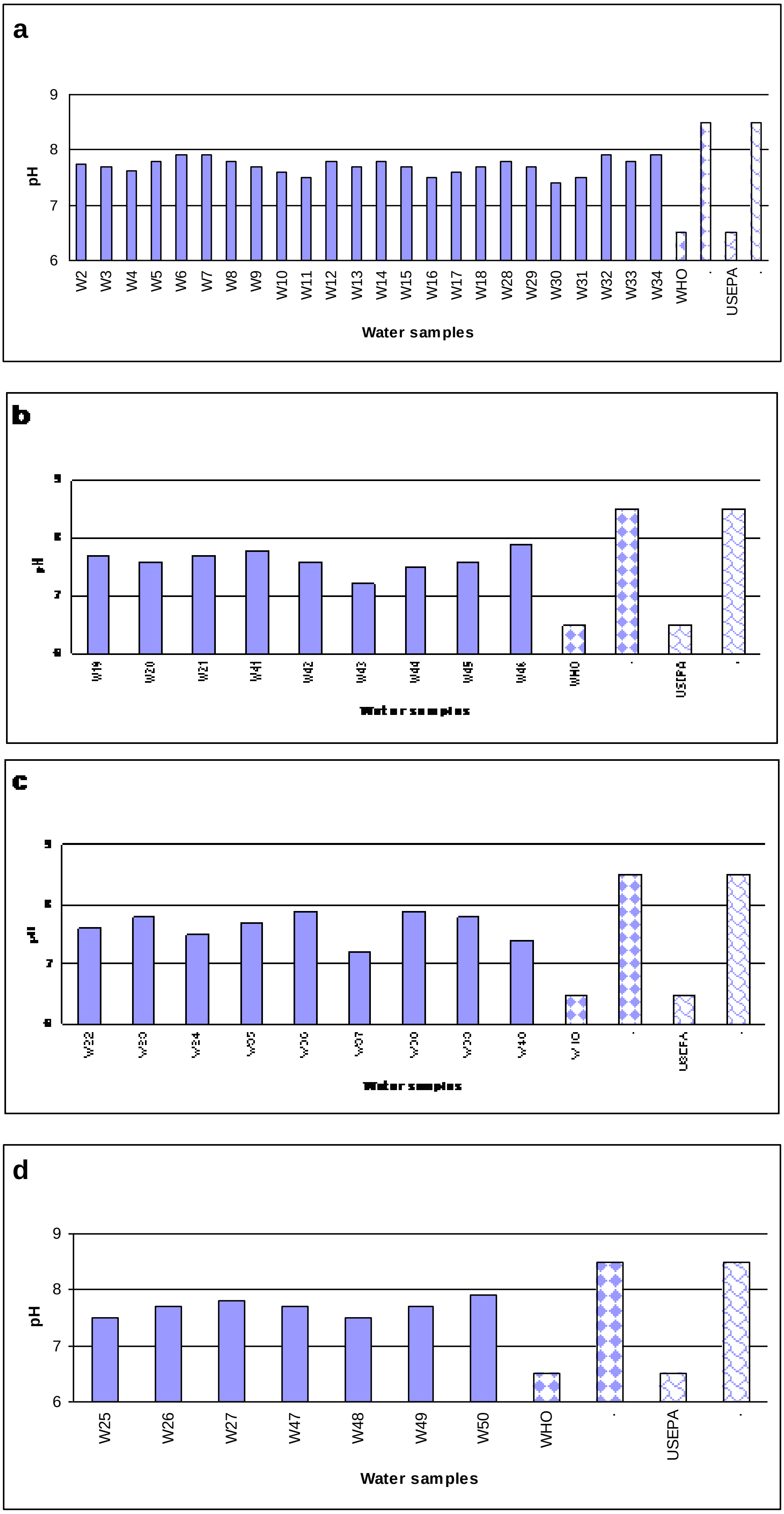


Fig.5.2.Variations in pH in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

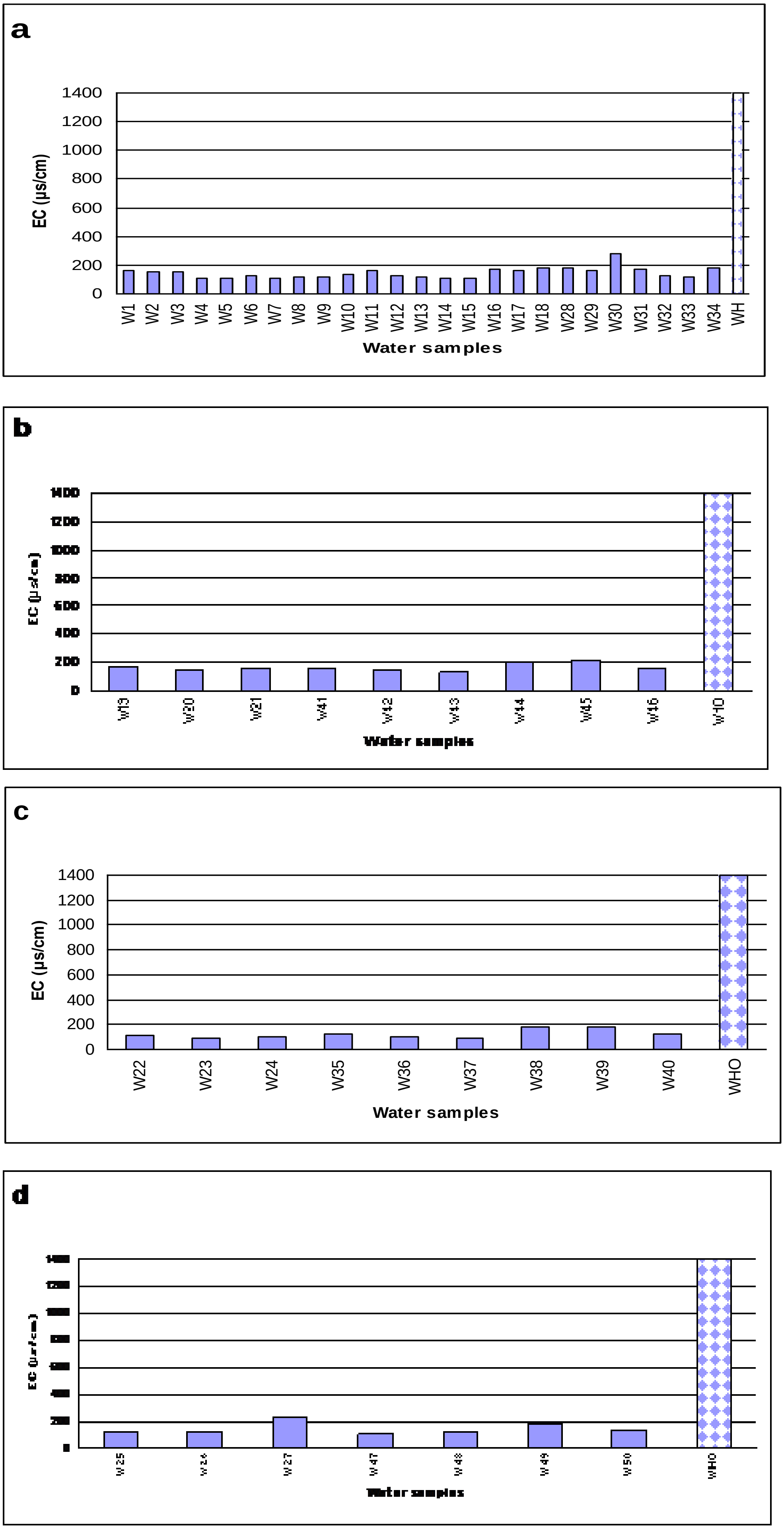


Fig.5.3. Variations in electric conductivity in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

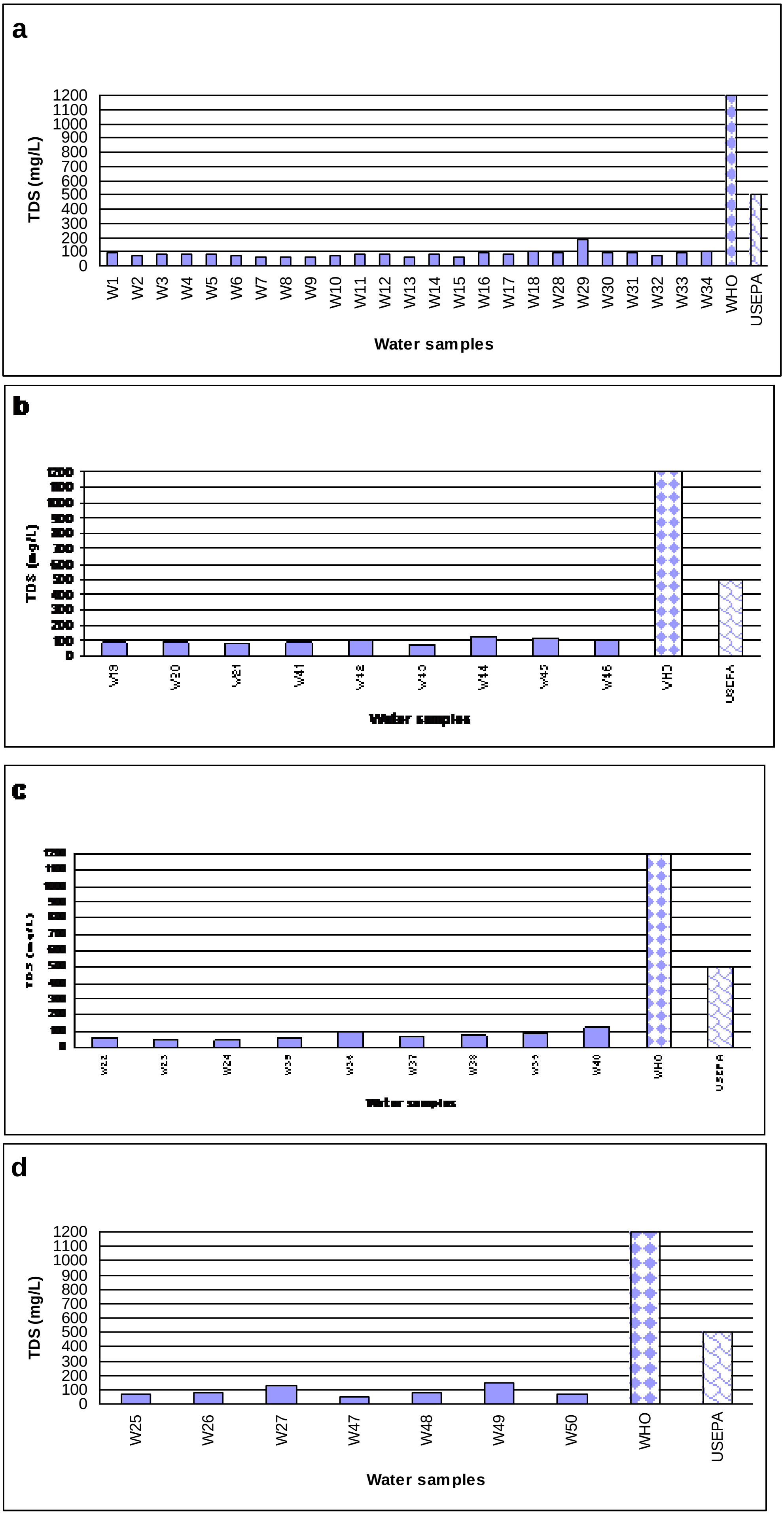


Fig.5.4. Variations of the total dissolved solid in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

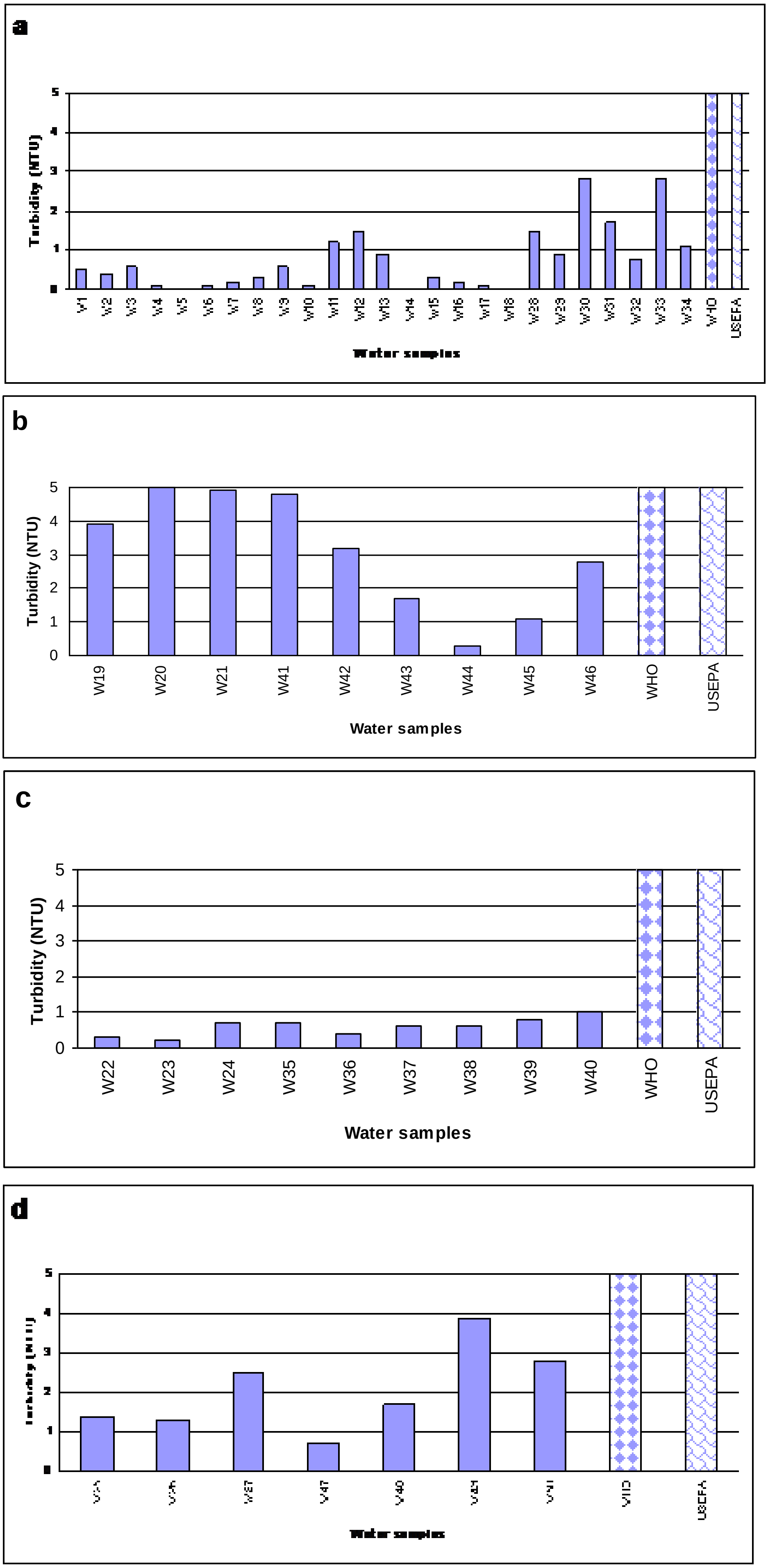


Fig.5.5. Variations in turbidity in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

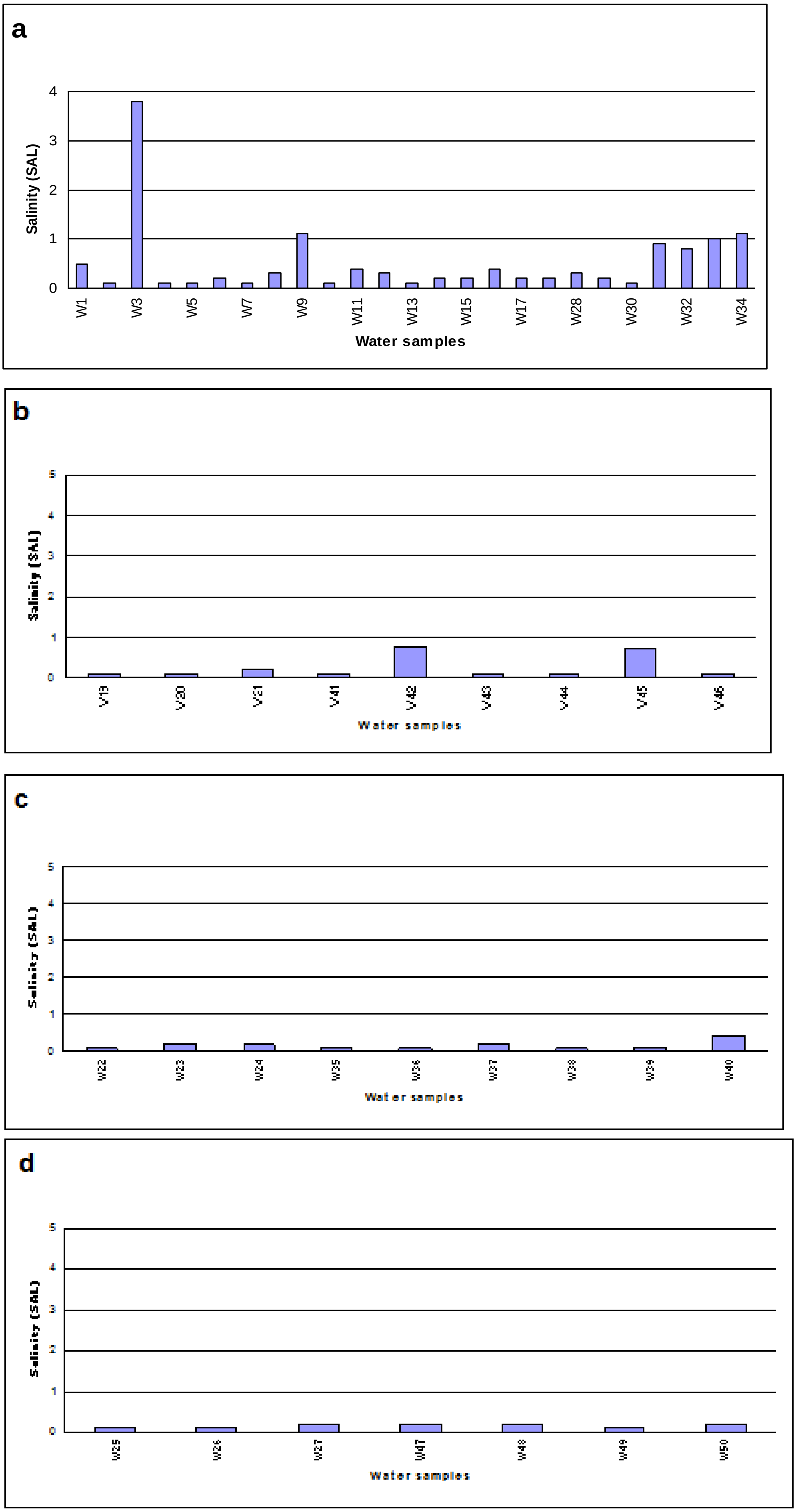


Fig.5.6. Variations in salinity in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

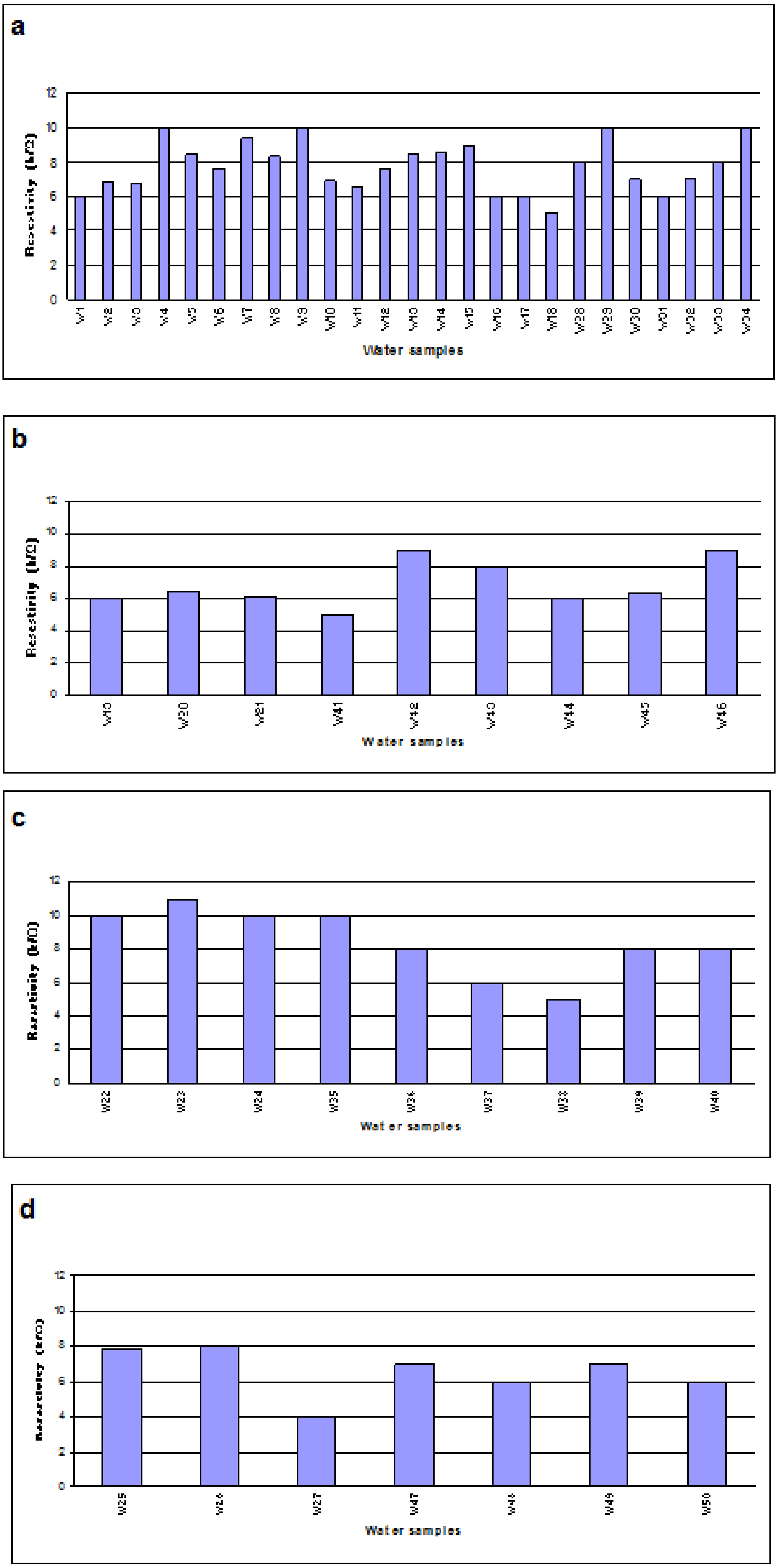


Fig.5.7. Variations in resistivity in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

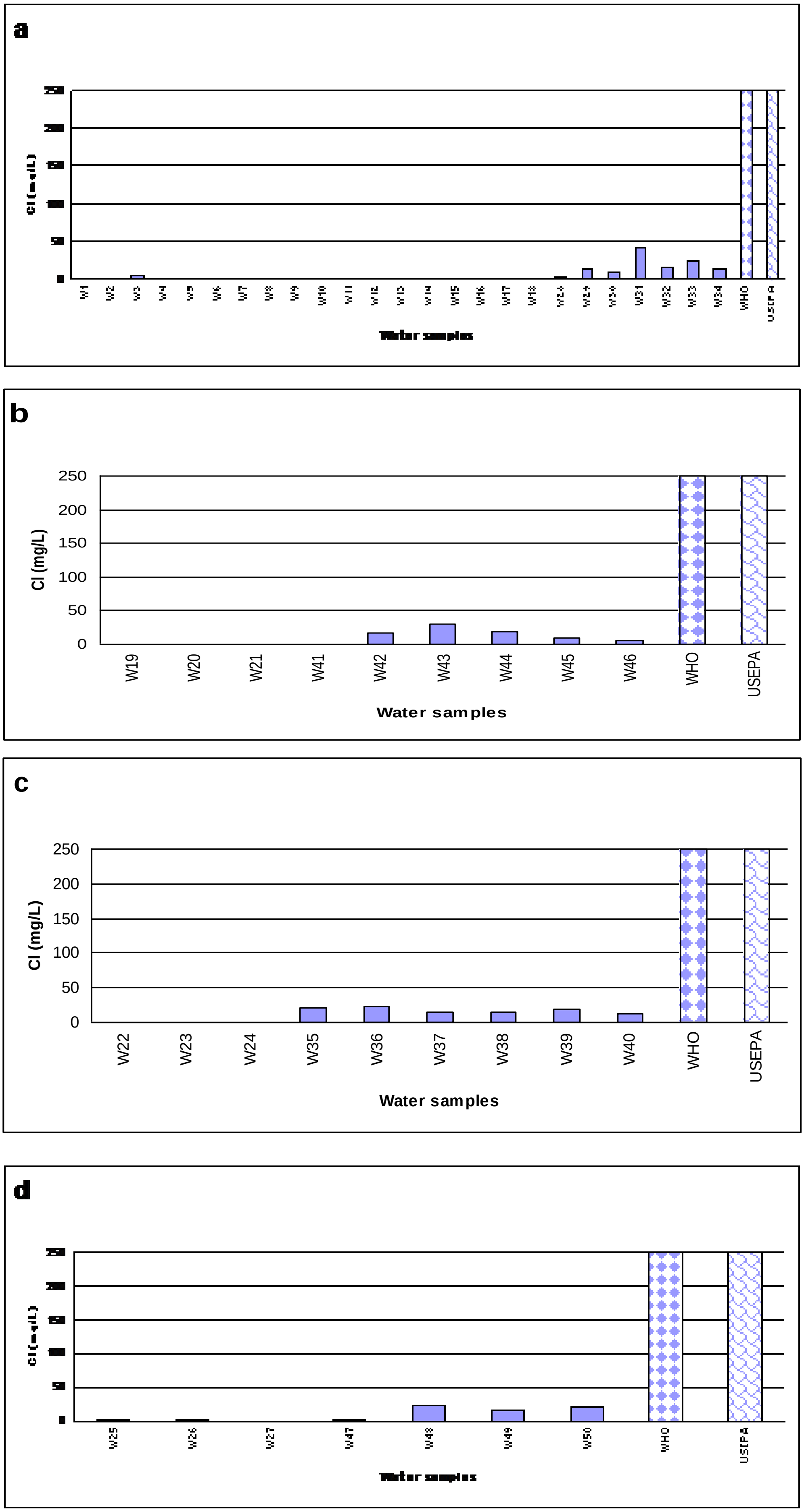


Fig.5.8. Concentrations of chloride in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

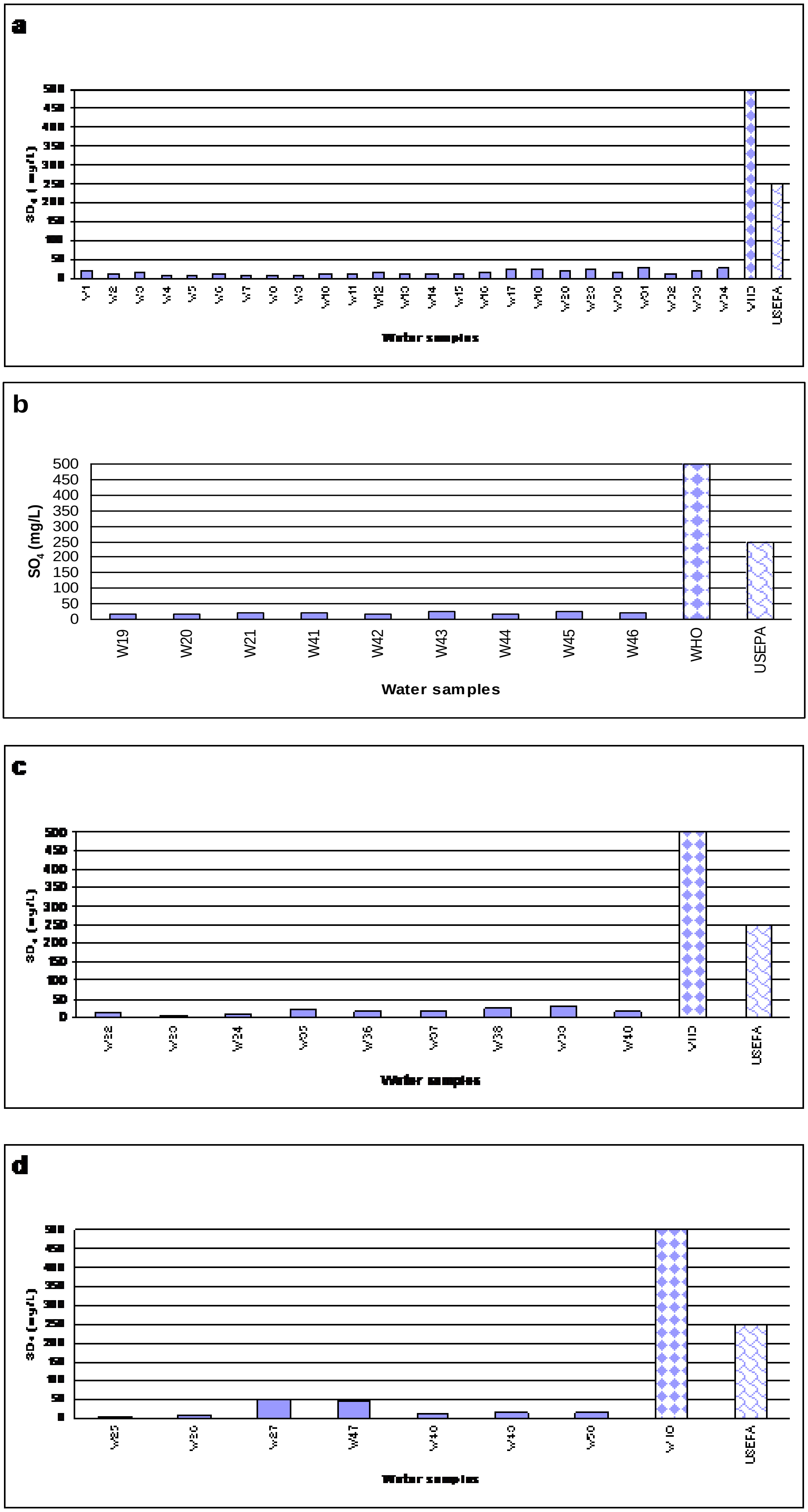


Fig.5.9. Concentration of sulfate in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

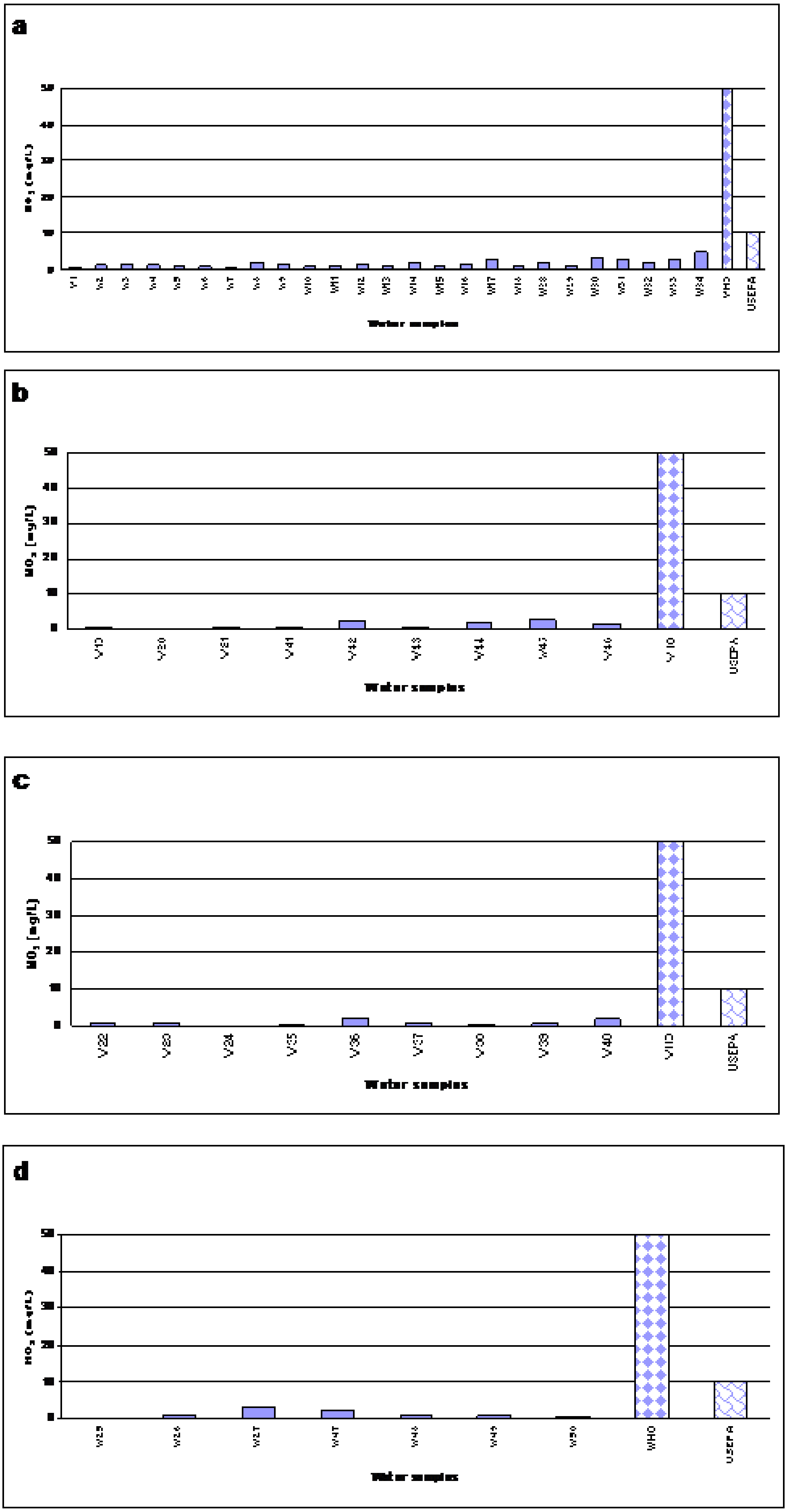


Fig.5.10. Concentrations of nitrate in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

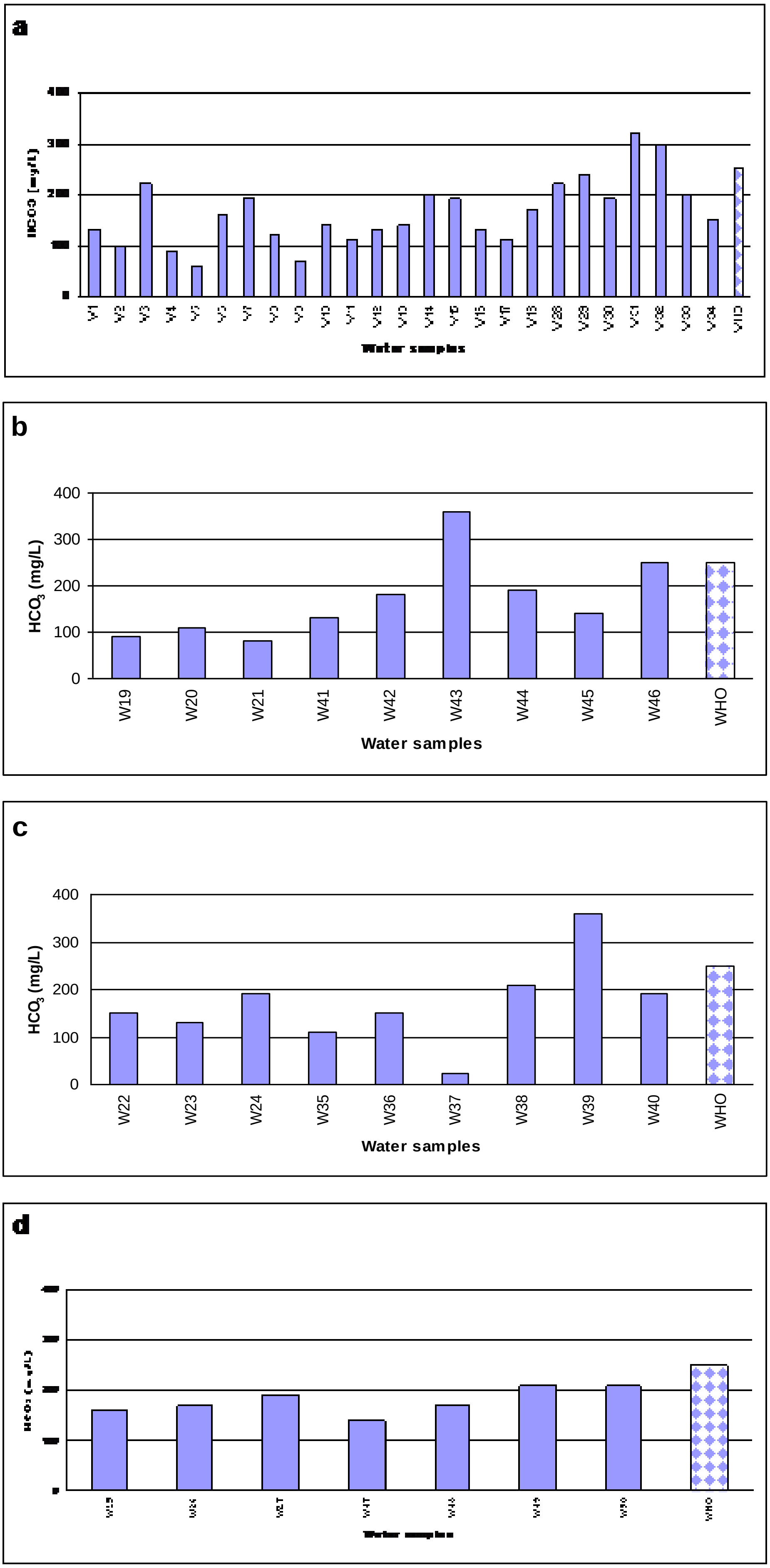


Fig.5.11. Concentrations of bicarbonate in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

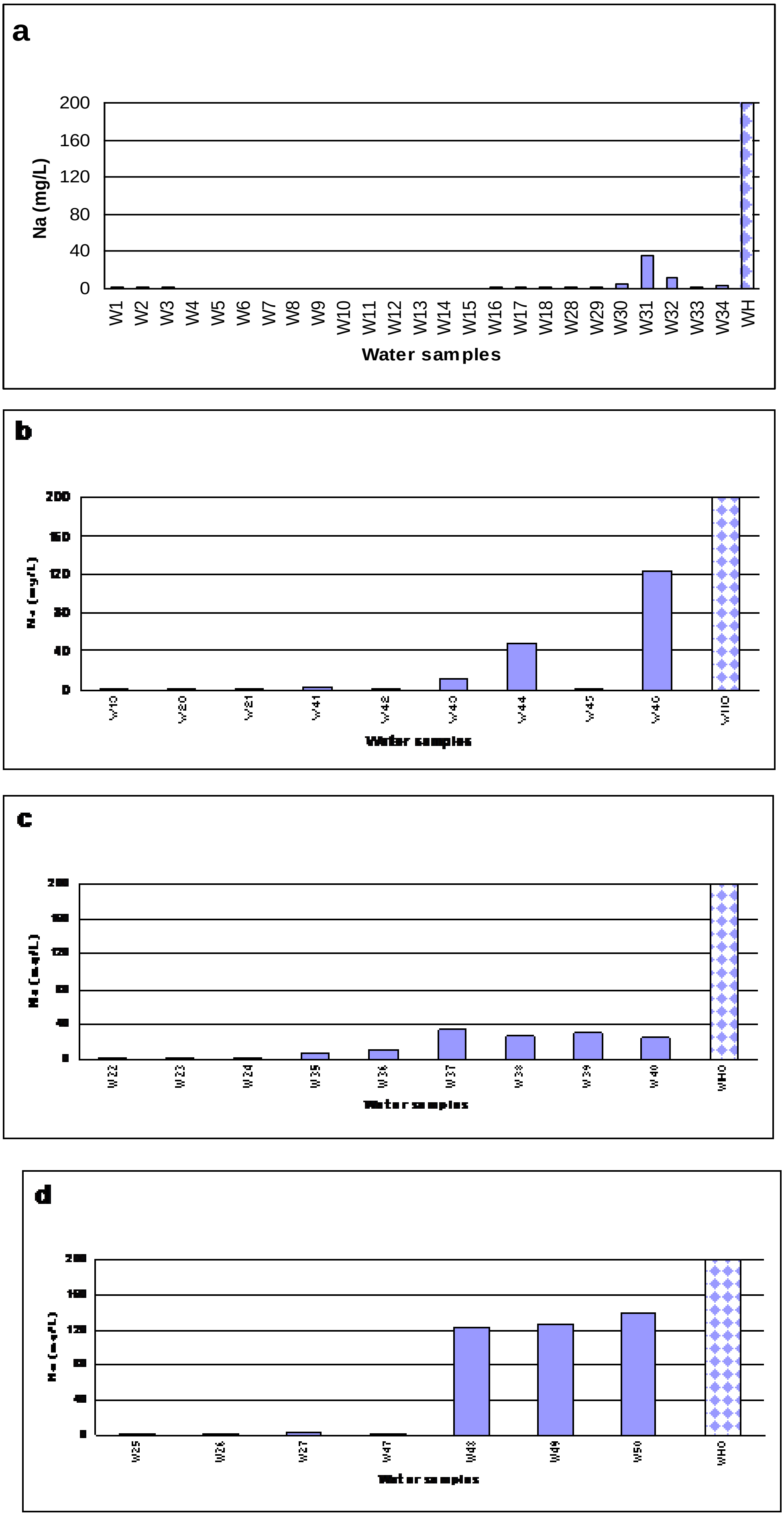


Fig.5.12. Concentrations sodium in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

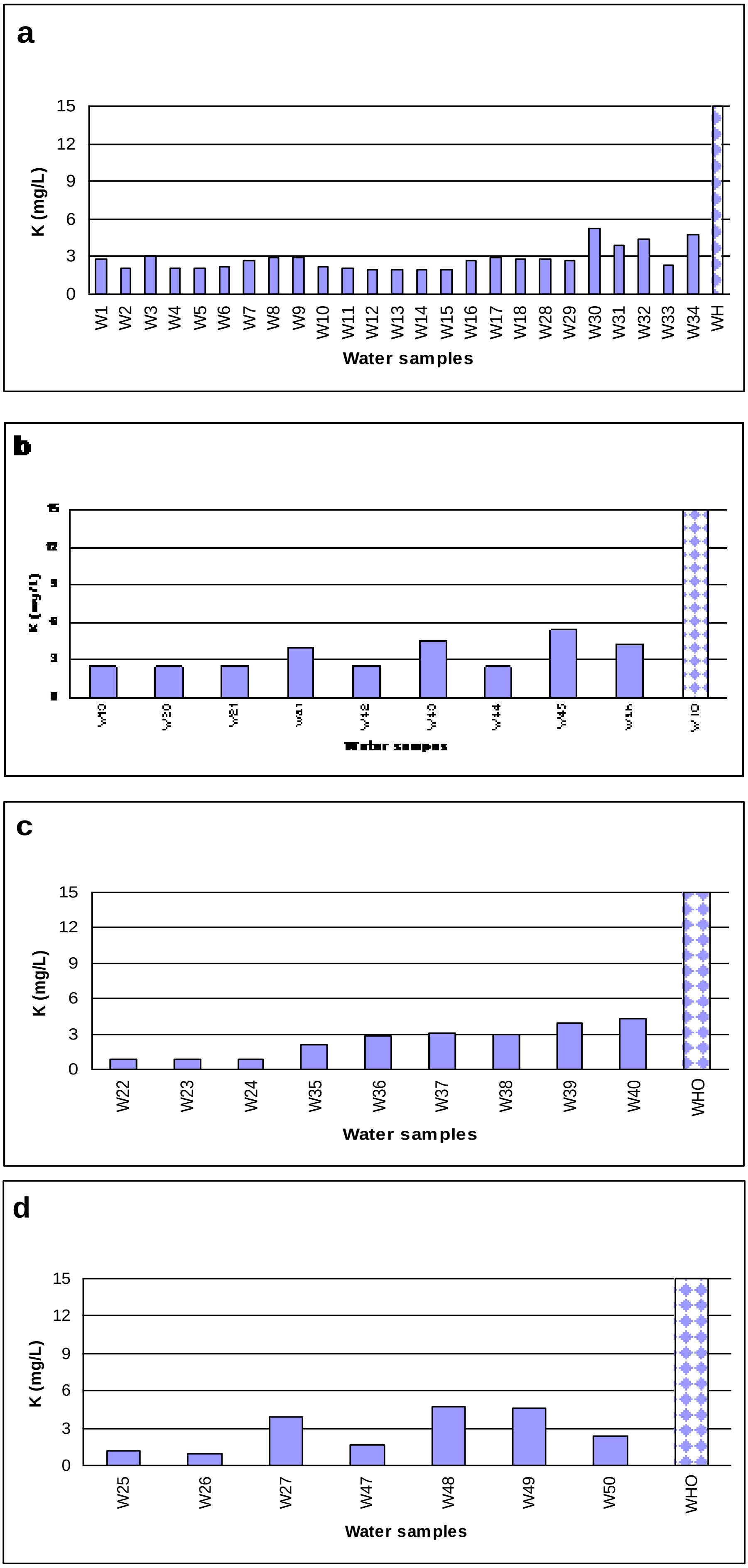


Fig.5.13. Concentrations of potassium in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

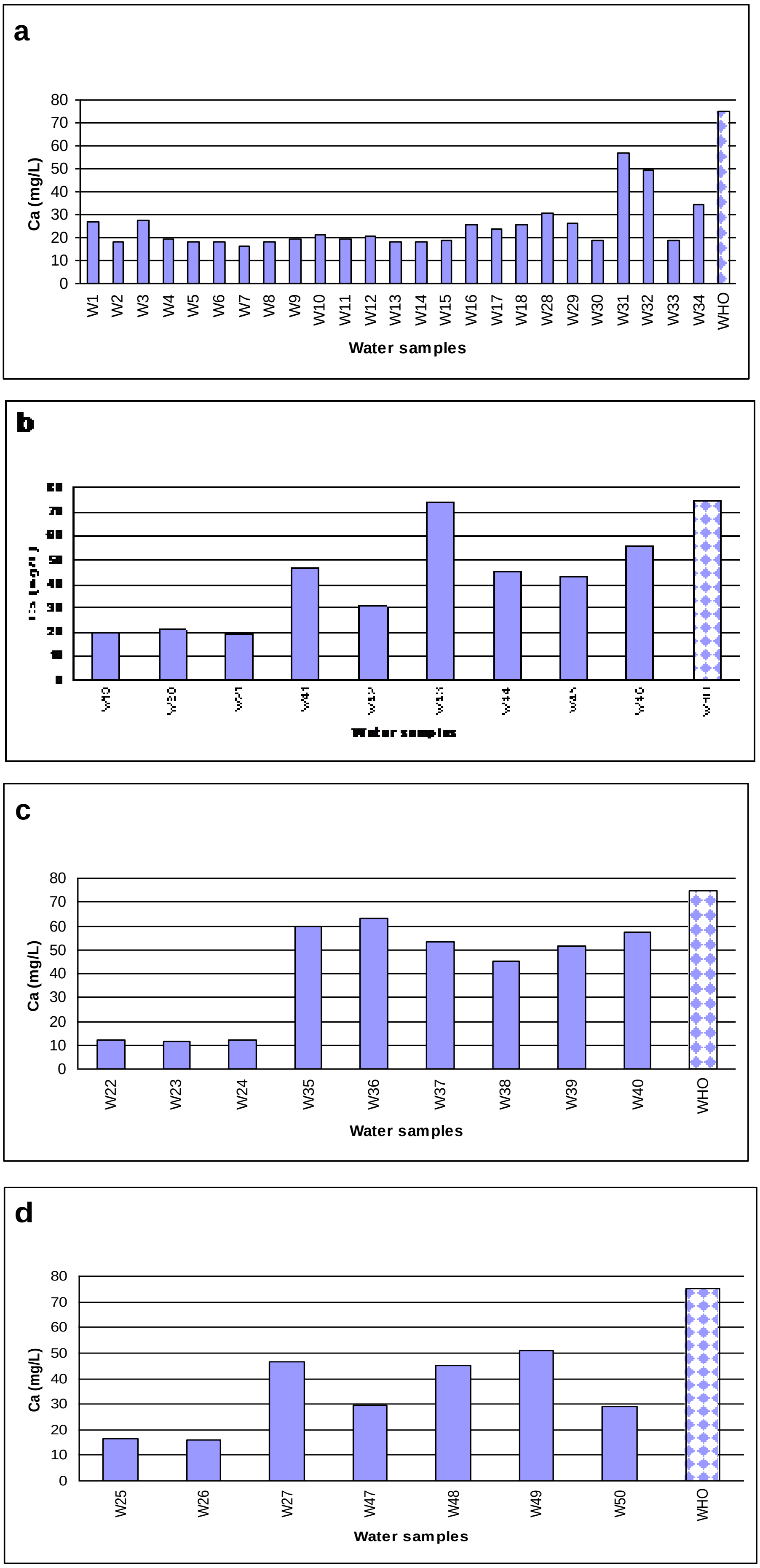


Fig.5.14. Concentrations of calcium in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

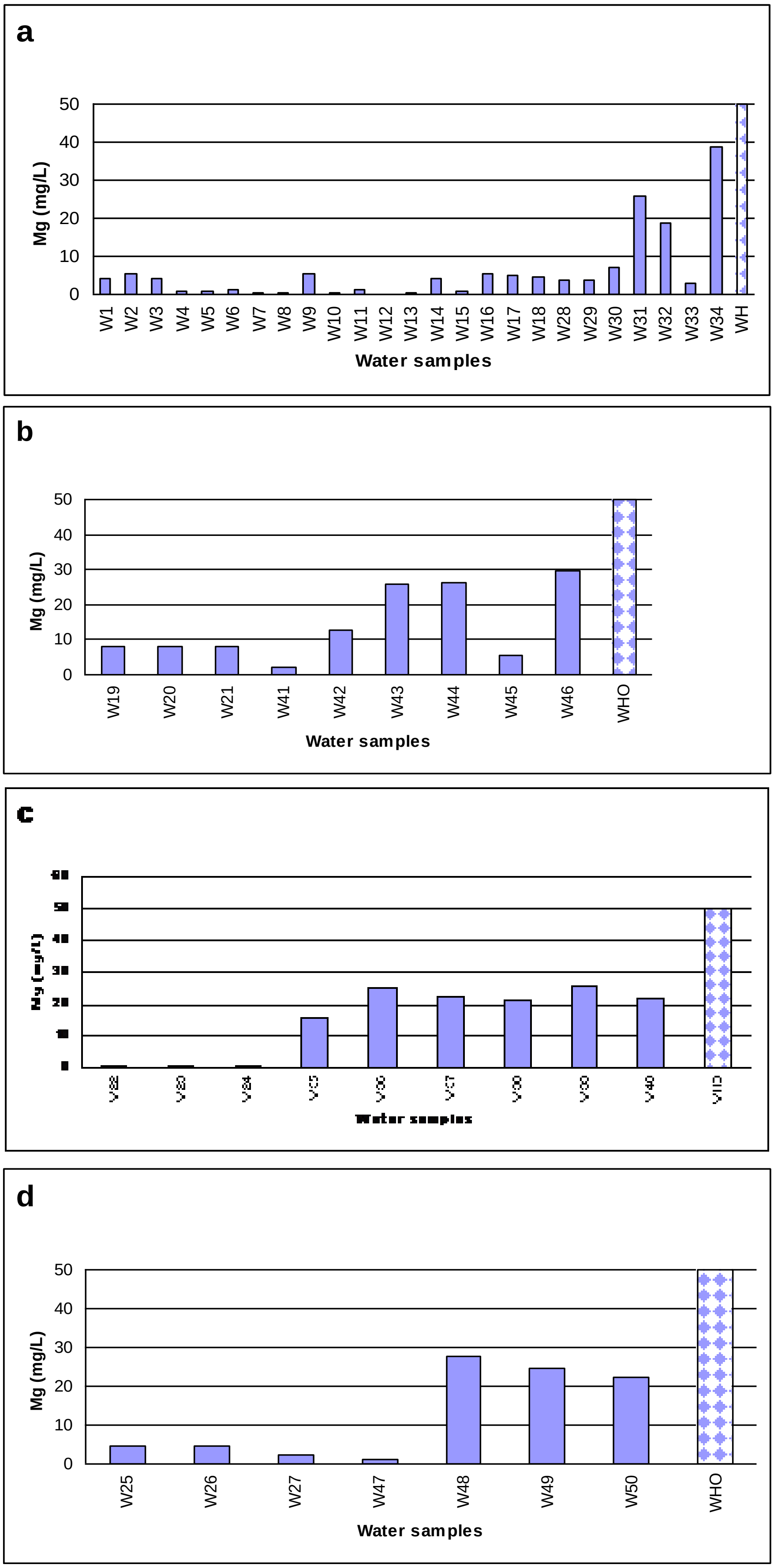


Fig.5.15. Concentrations of magnesium in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

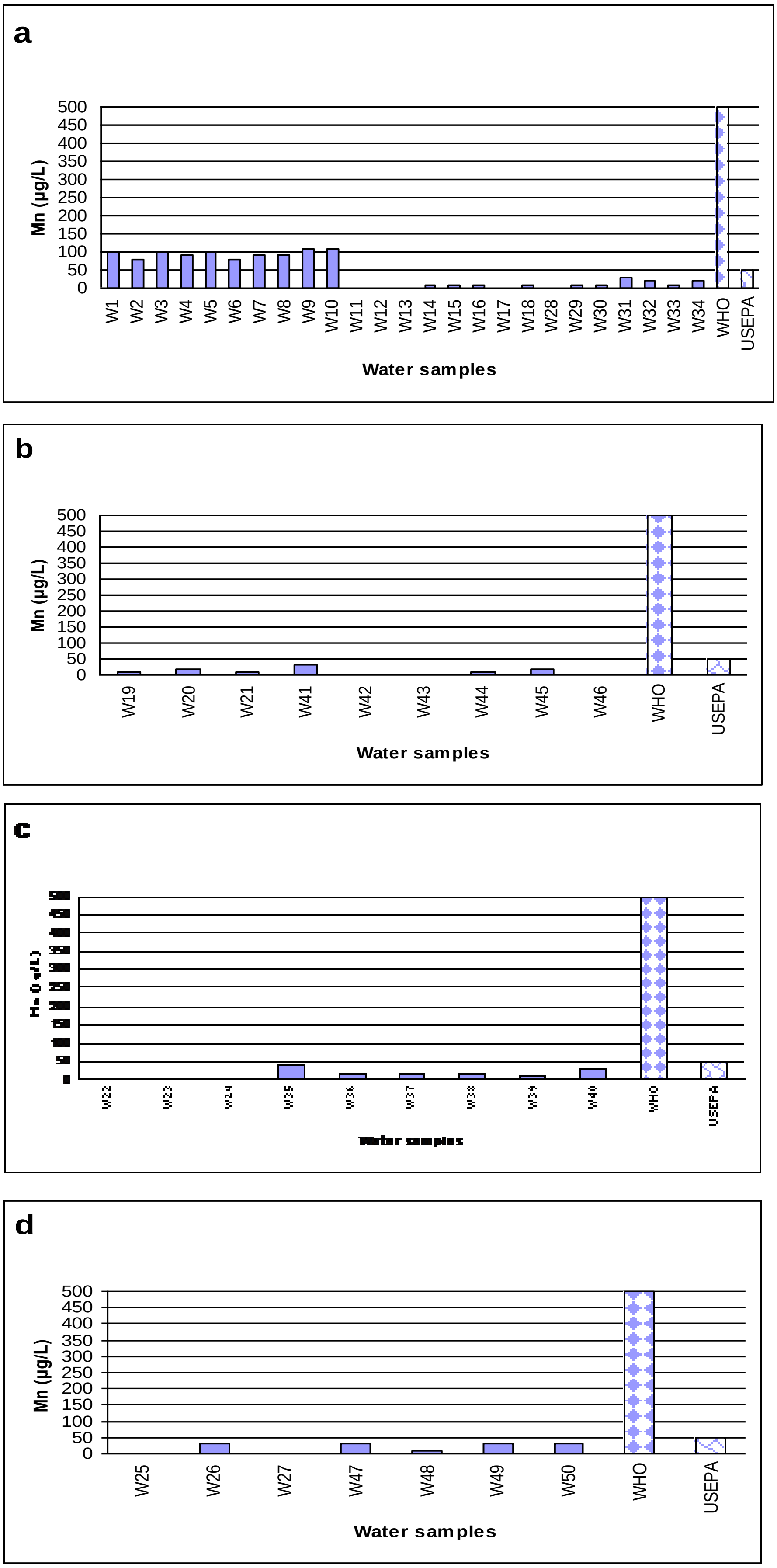


Fig.5.16. Concentrations of manganese in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

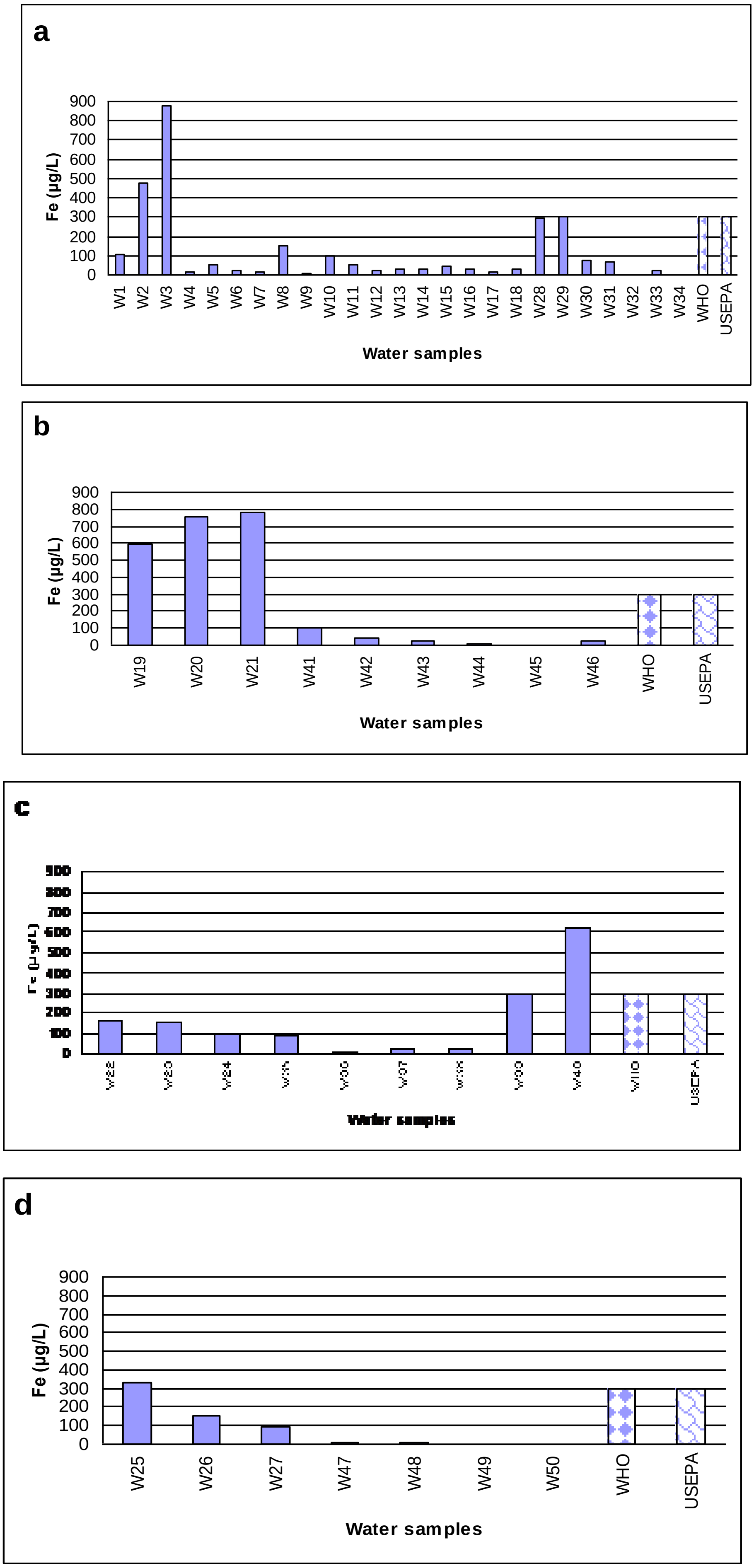
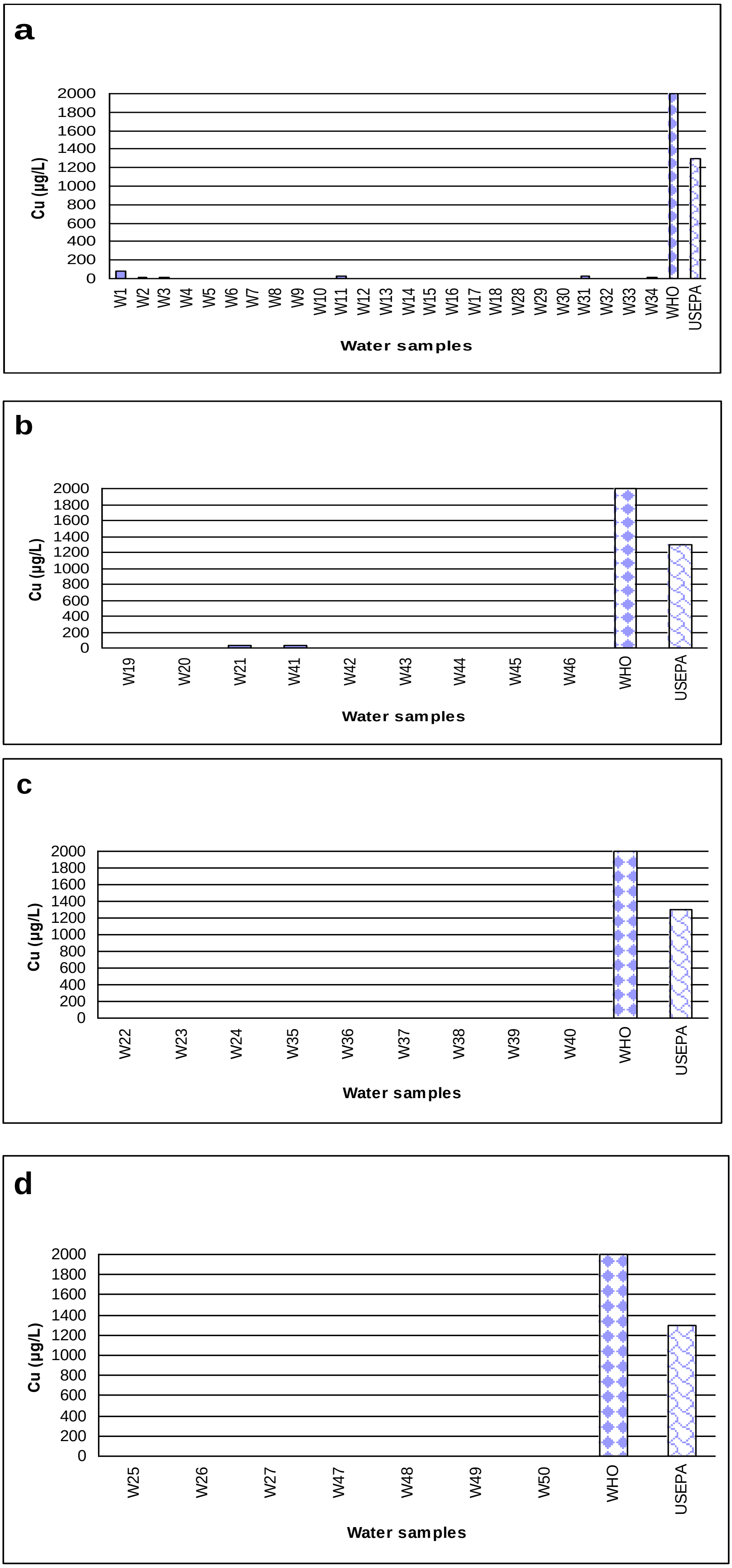


Fig.5.17. Concentrations of iron in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.



Fg.5.18. Concentrations of copper in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

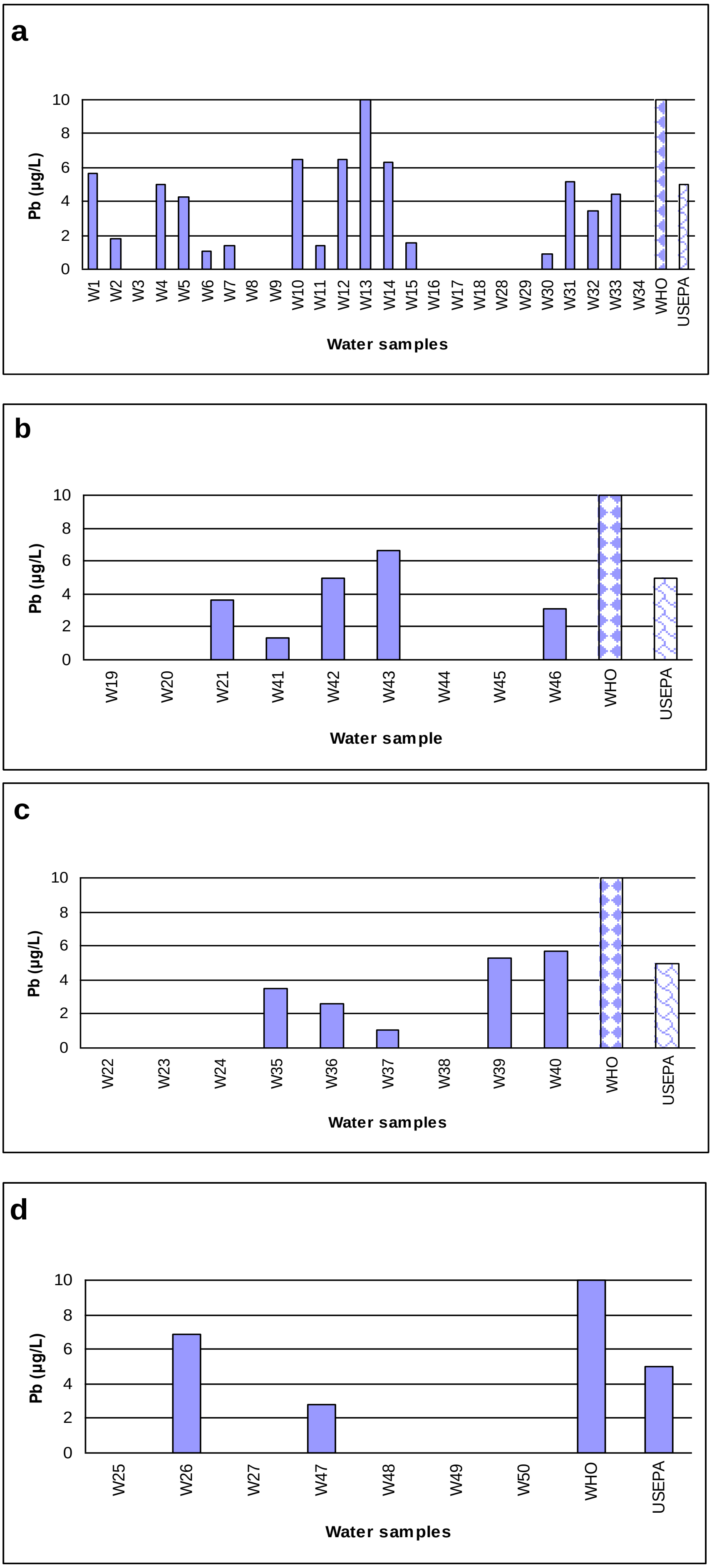


Fig.5.19. Concentrations of lead in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

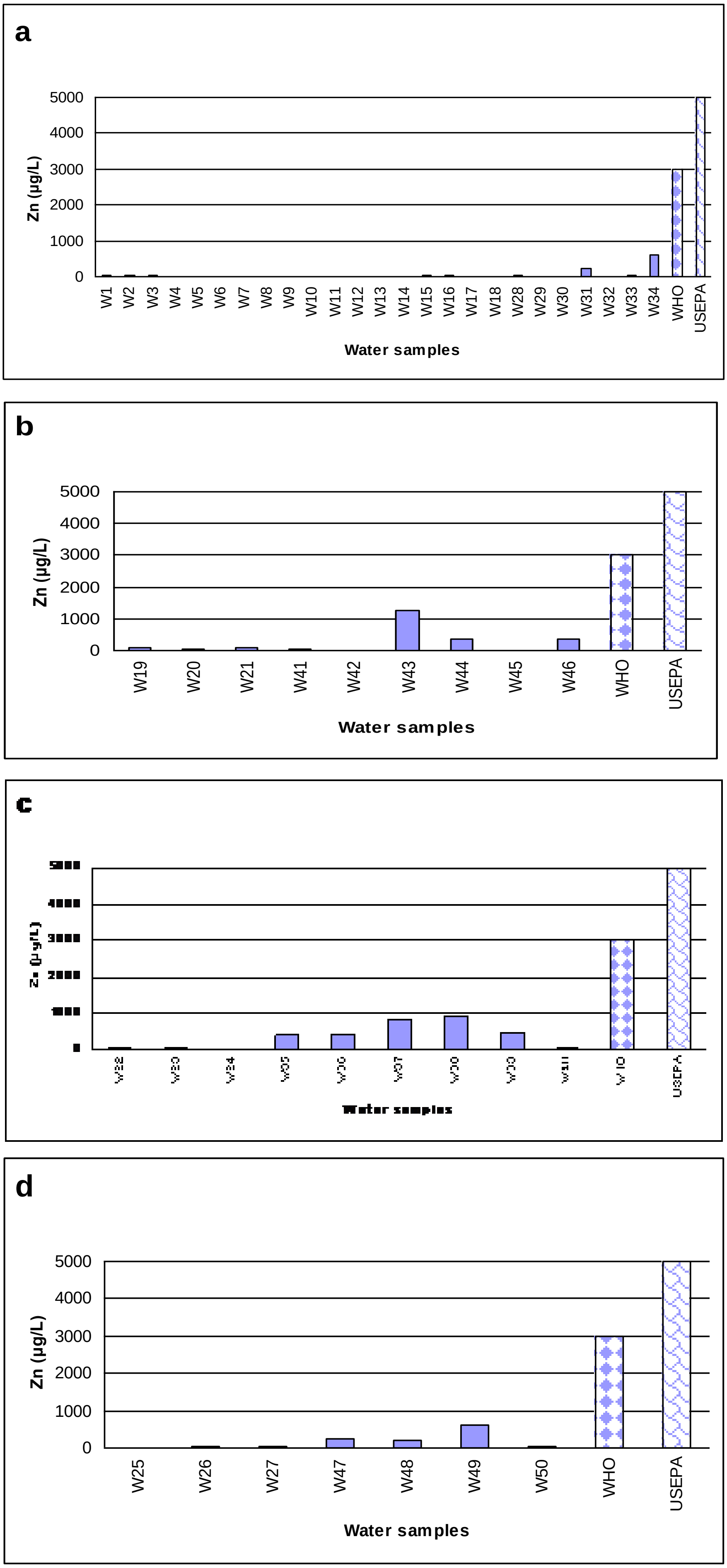


Fig.5.20. Concentrations of zinc in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

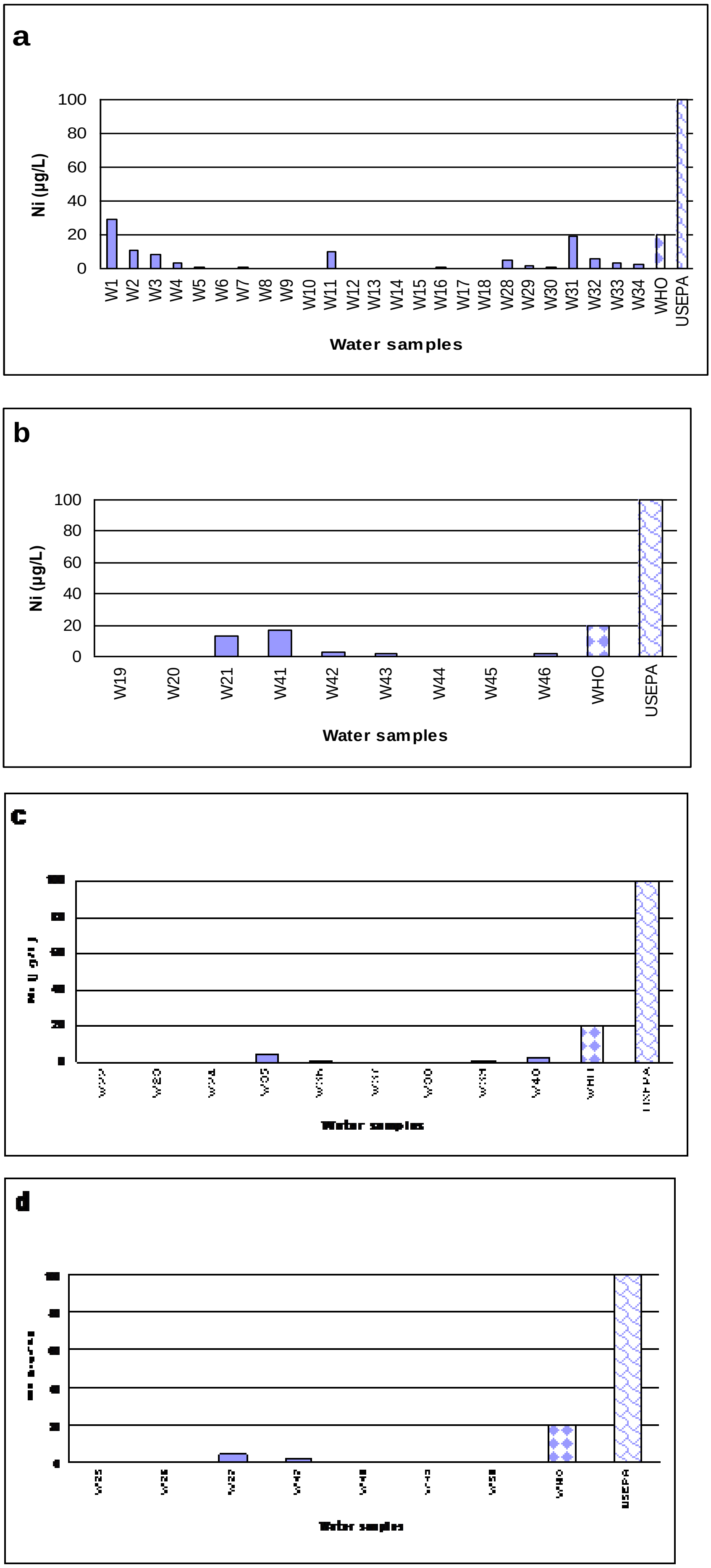


Fig.5.21. Concentrations of nickel in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

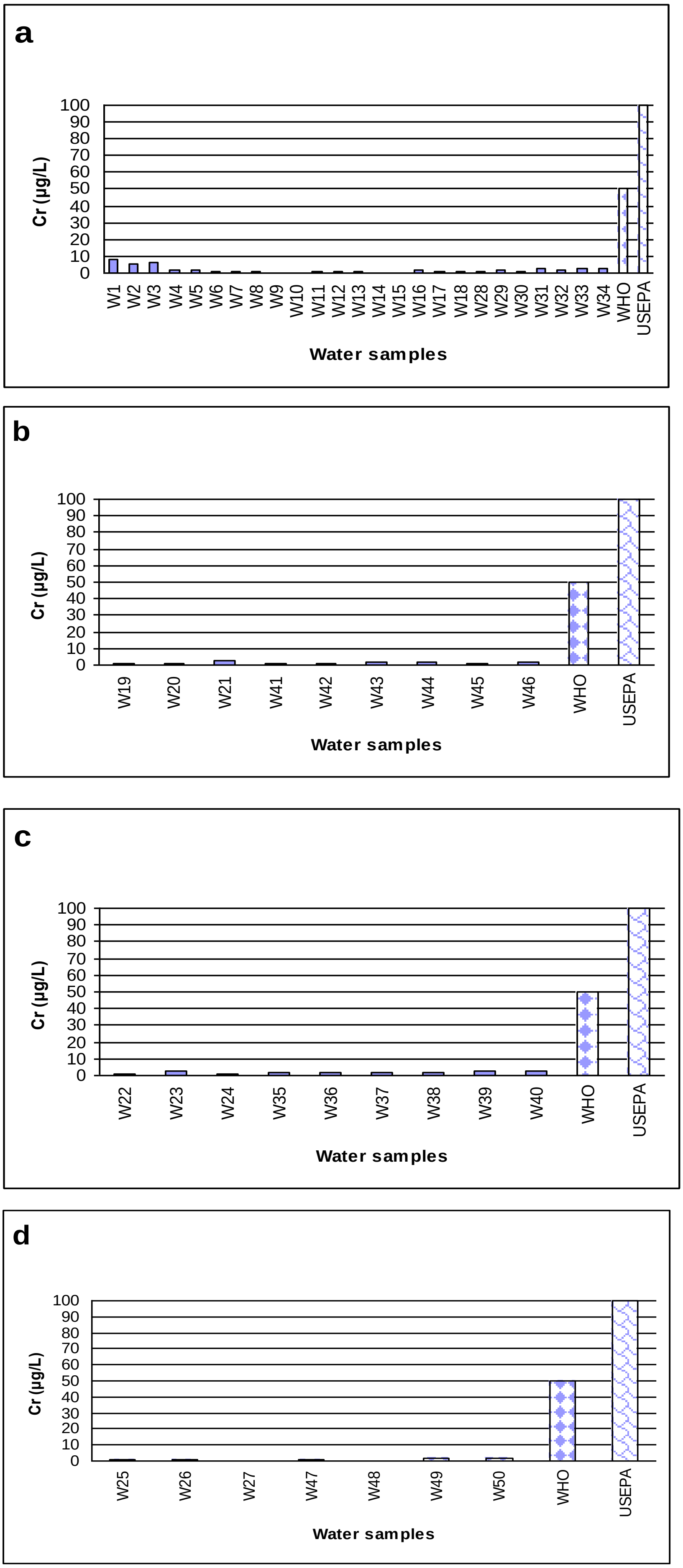


Fig.5.22. Concentrations of chromium in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

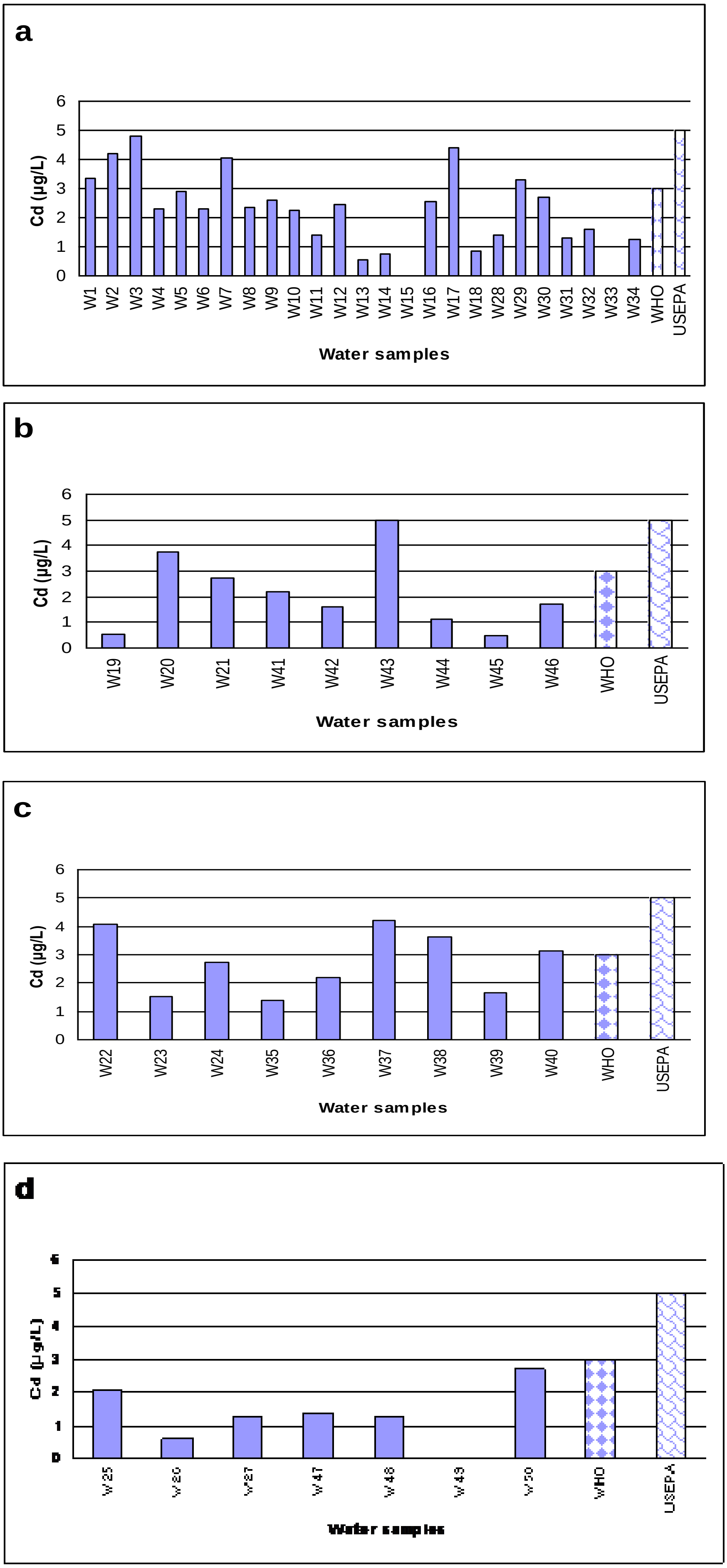
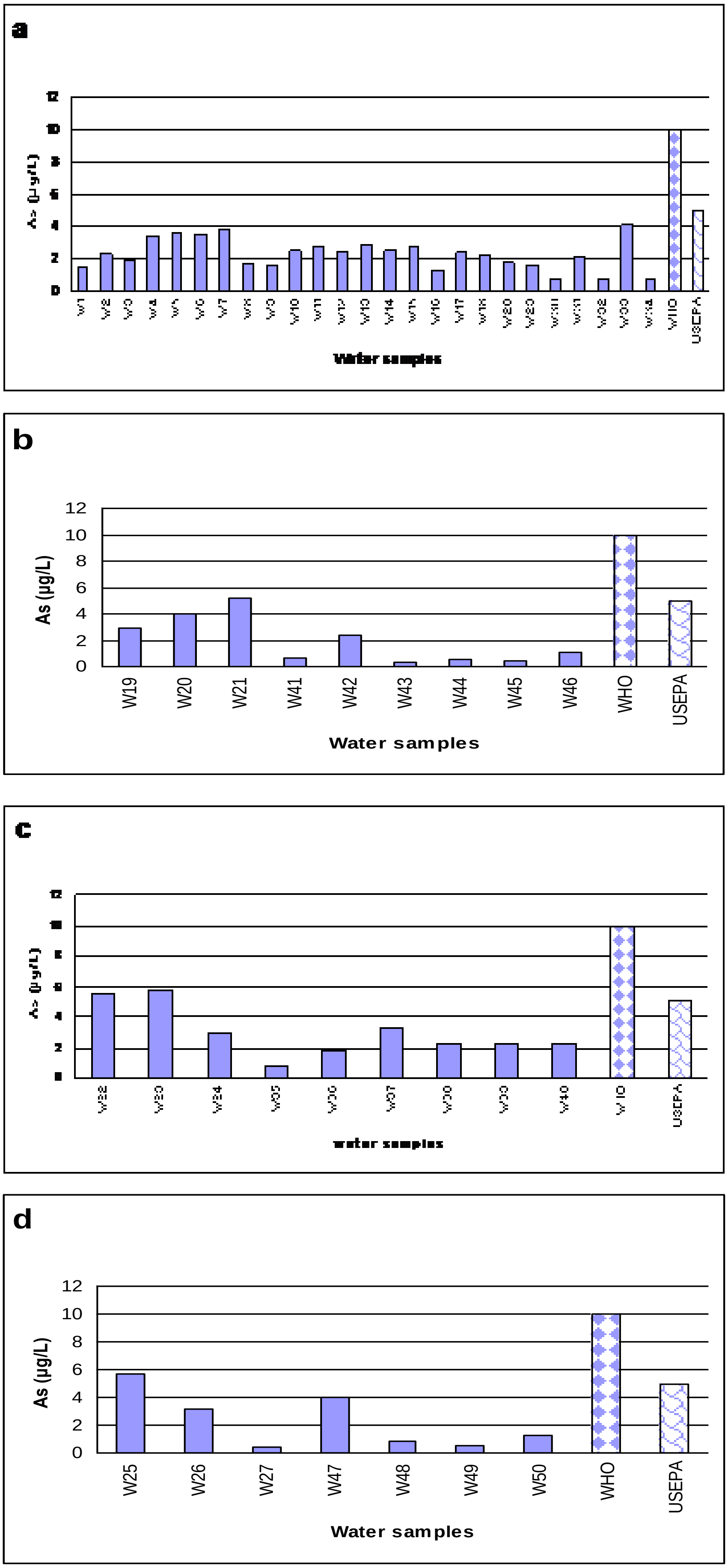


Fig.5.23. Concentrations of cadmium in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.



Fi.g.5.24. Concentrations of arsenic in the water of study area. a= Nalatr wetland complex, b= Iskoman lake, c= Hundrap lake, d= Baha lake.

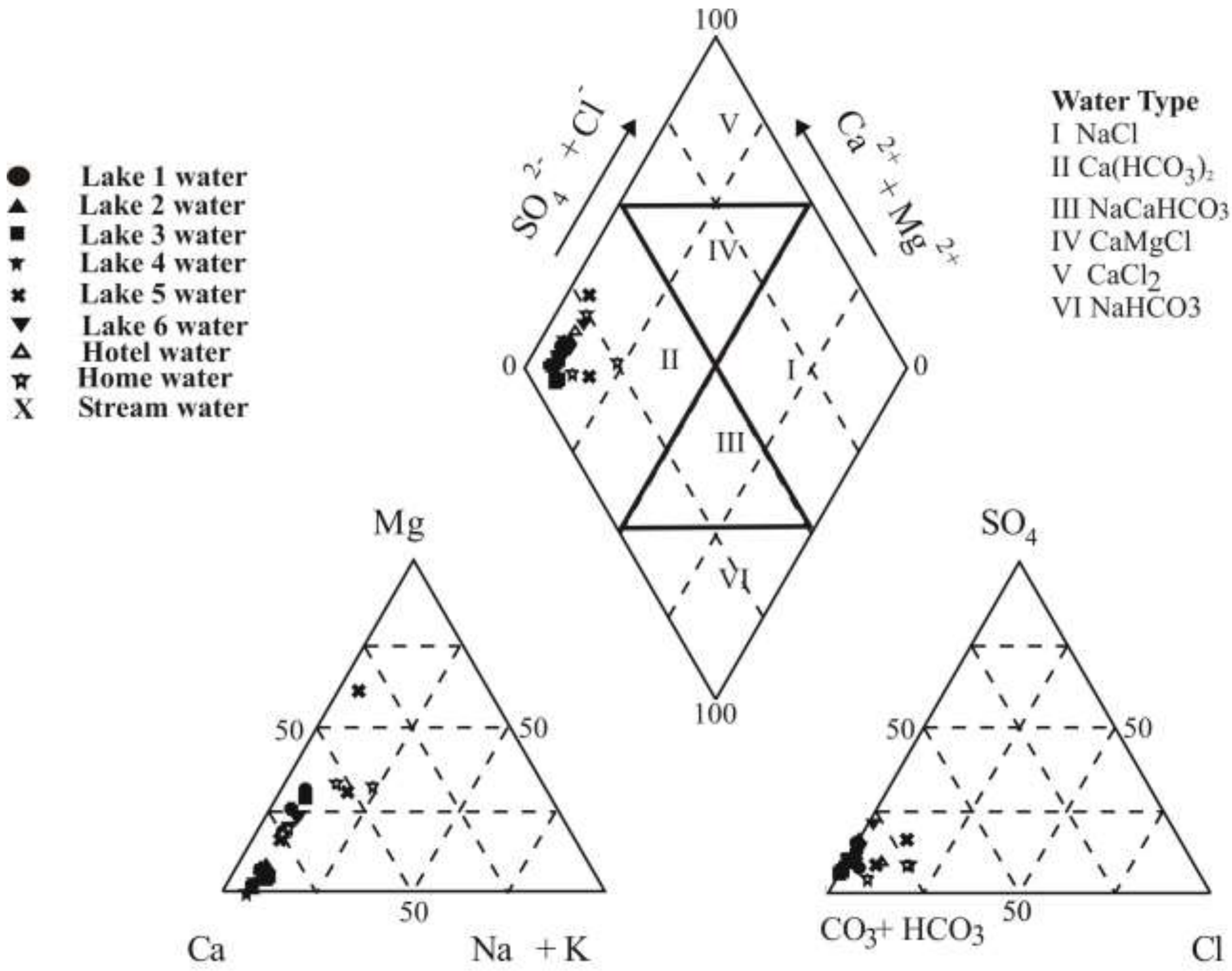


Fig.5.25. The composition of water of the Naltar lakes and its stream in the Piper diagram.

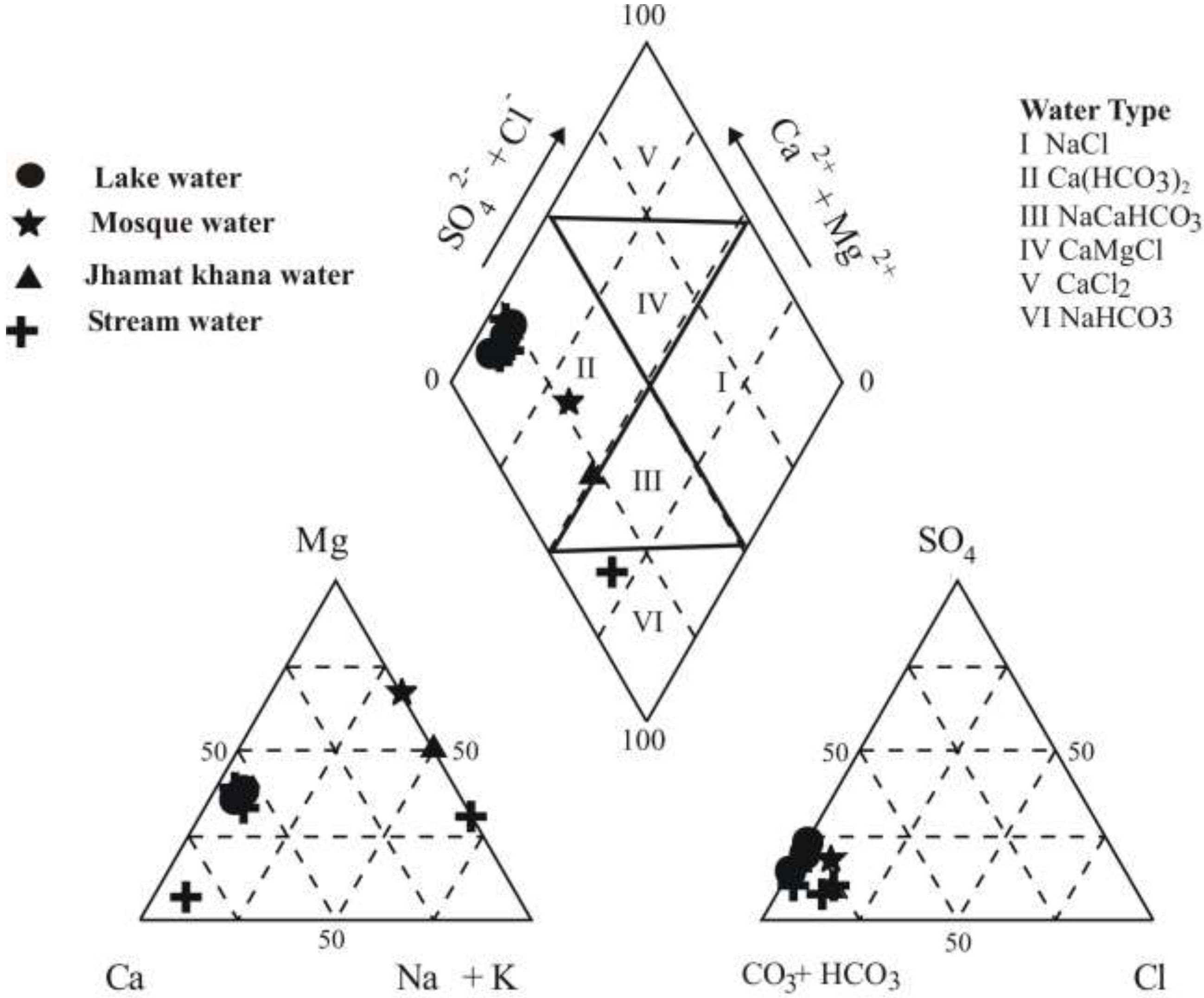


Fig.5.26. The composition of water of the Uttar lake and its stream in the Piper diagram.

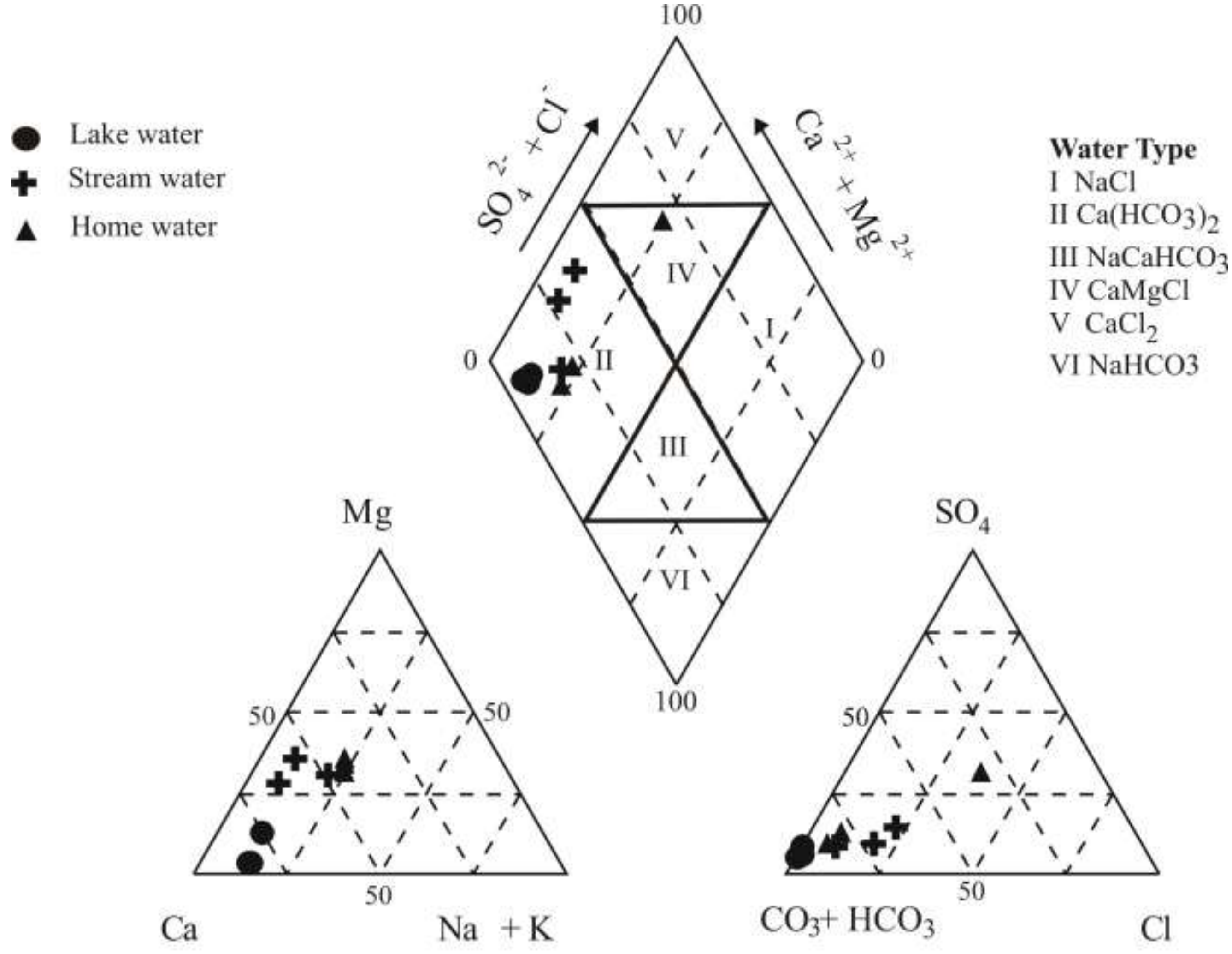


Fig.5.27. The composition of water of the Hundrap lake and its stream in the Piper diagram.

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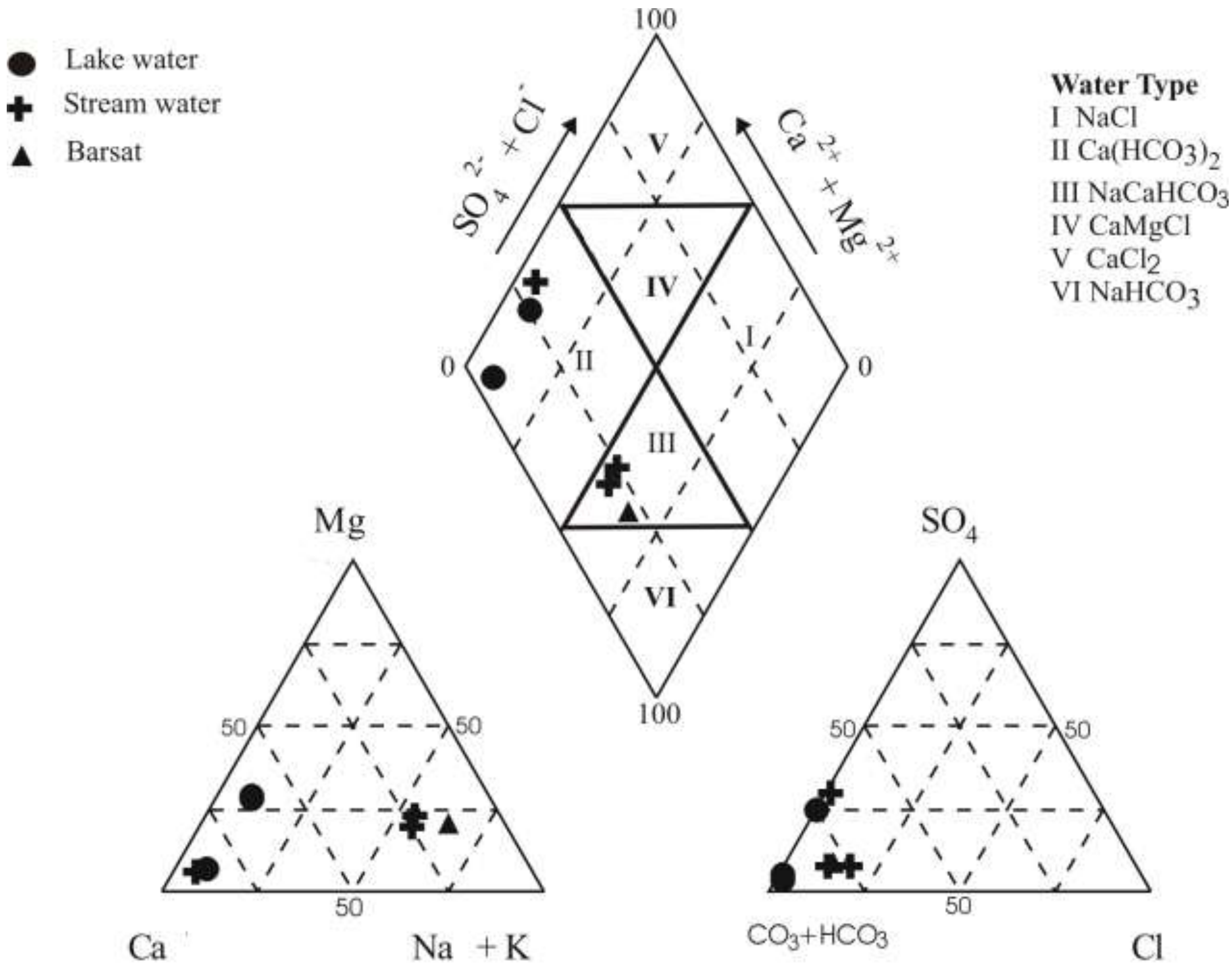

Fig.5.28. The composition of water of the Baha lake and its stream in the Piper diagram

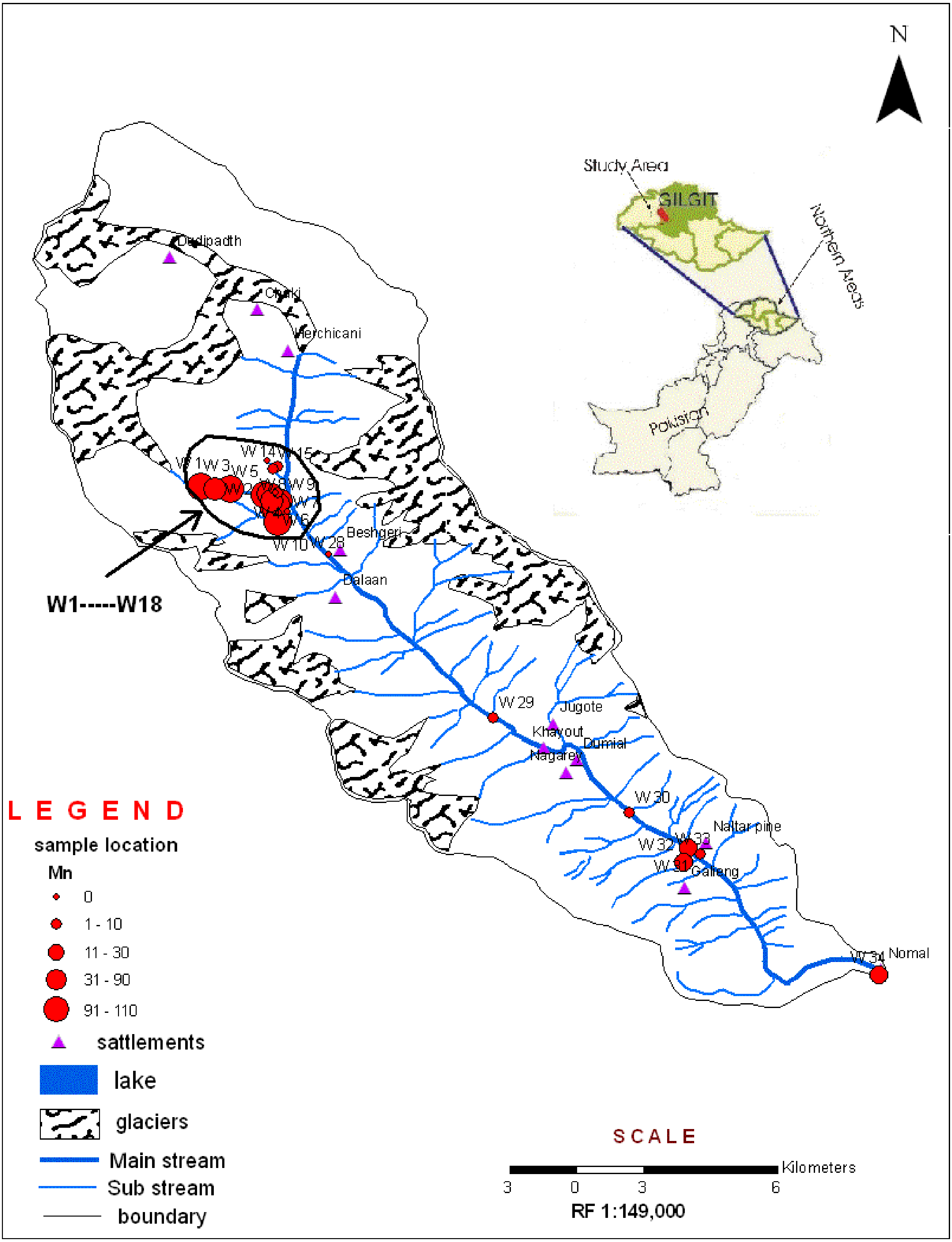

Fig.5.29. GIS based distribution pattern of Mn in the water of Naltar lakes and their streams at Naltar.

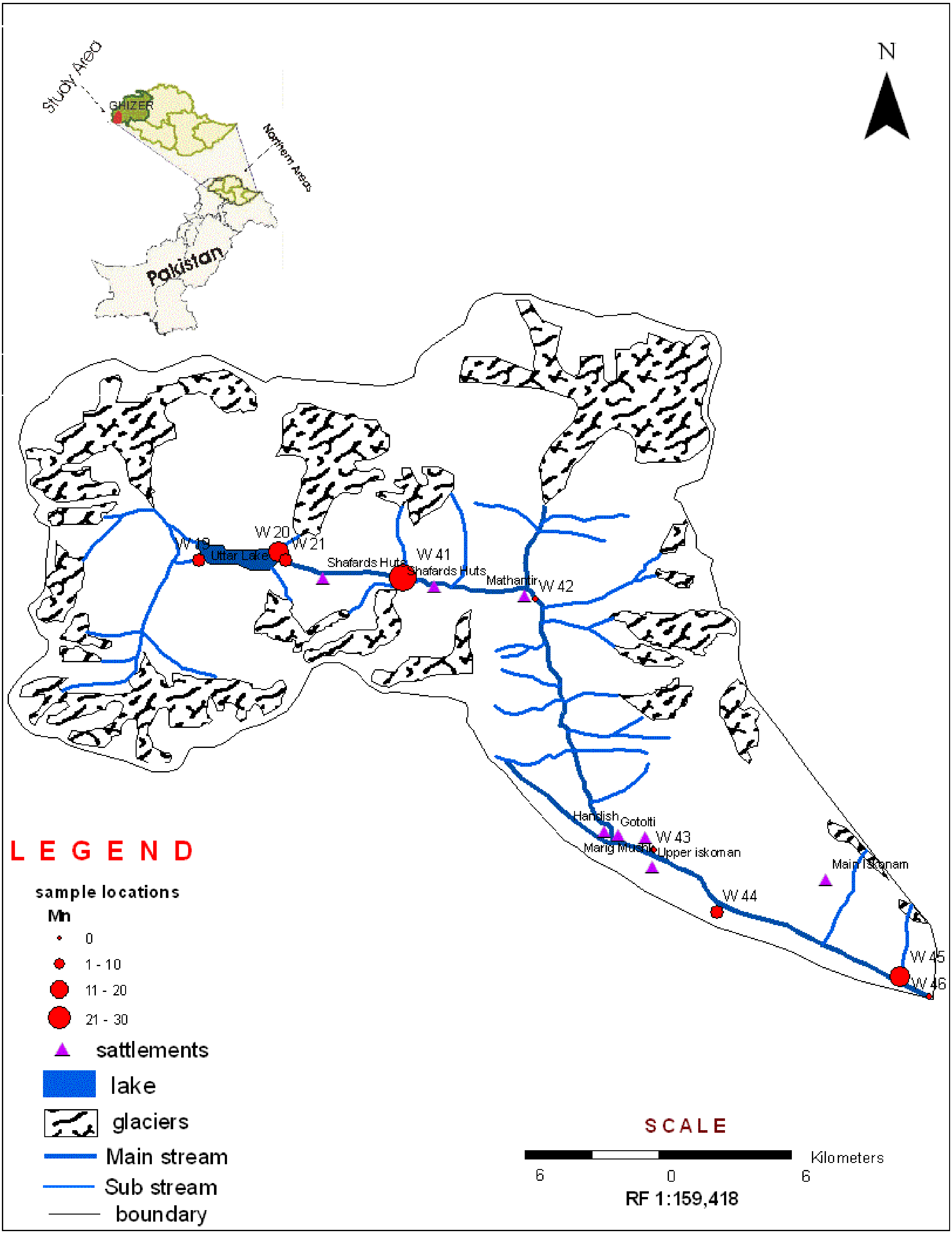

Fig.5.30. GIS based distribution pattern of Mn in the water of Uttar lake and its streams at Iskoman.

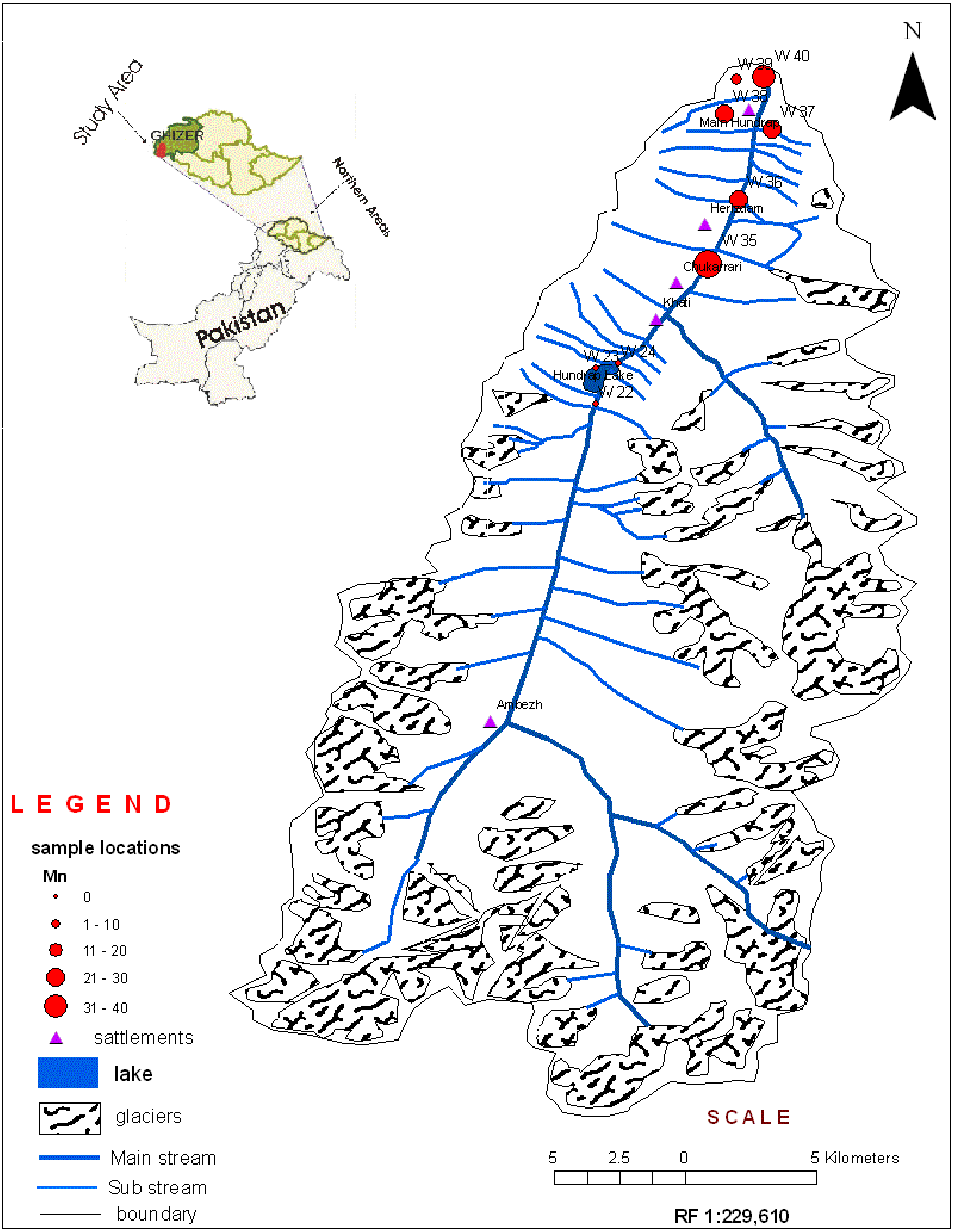

Fig.6.31. GIS based distribution pattern of Mn in the water of Hundrap lake and its streams at Hundrap.

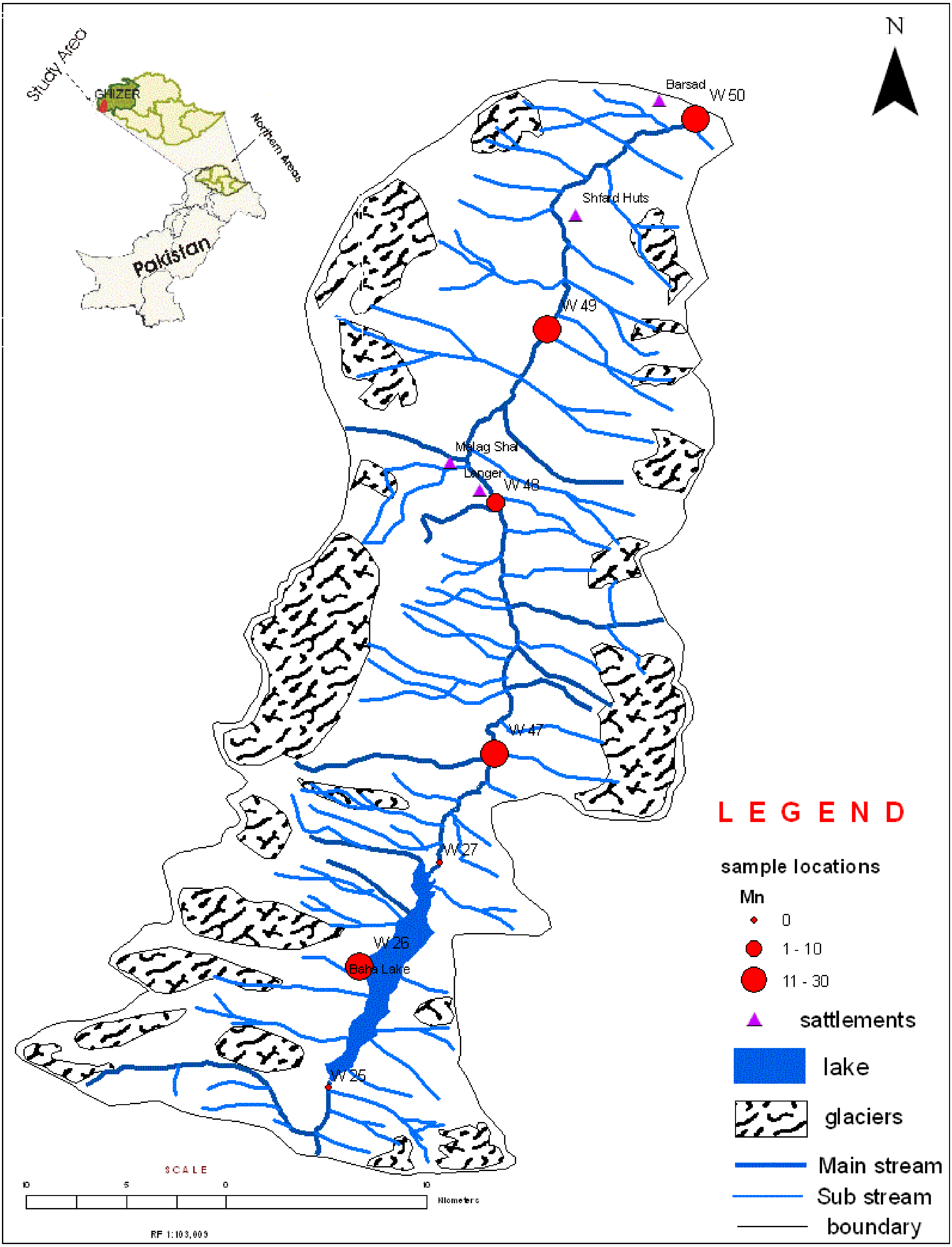

Fig.5.32. GIS based distribution pattern of Mn in the water of Baha lake and its streams at Khukosh.

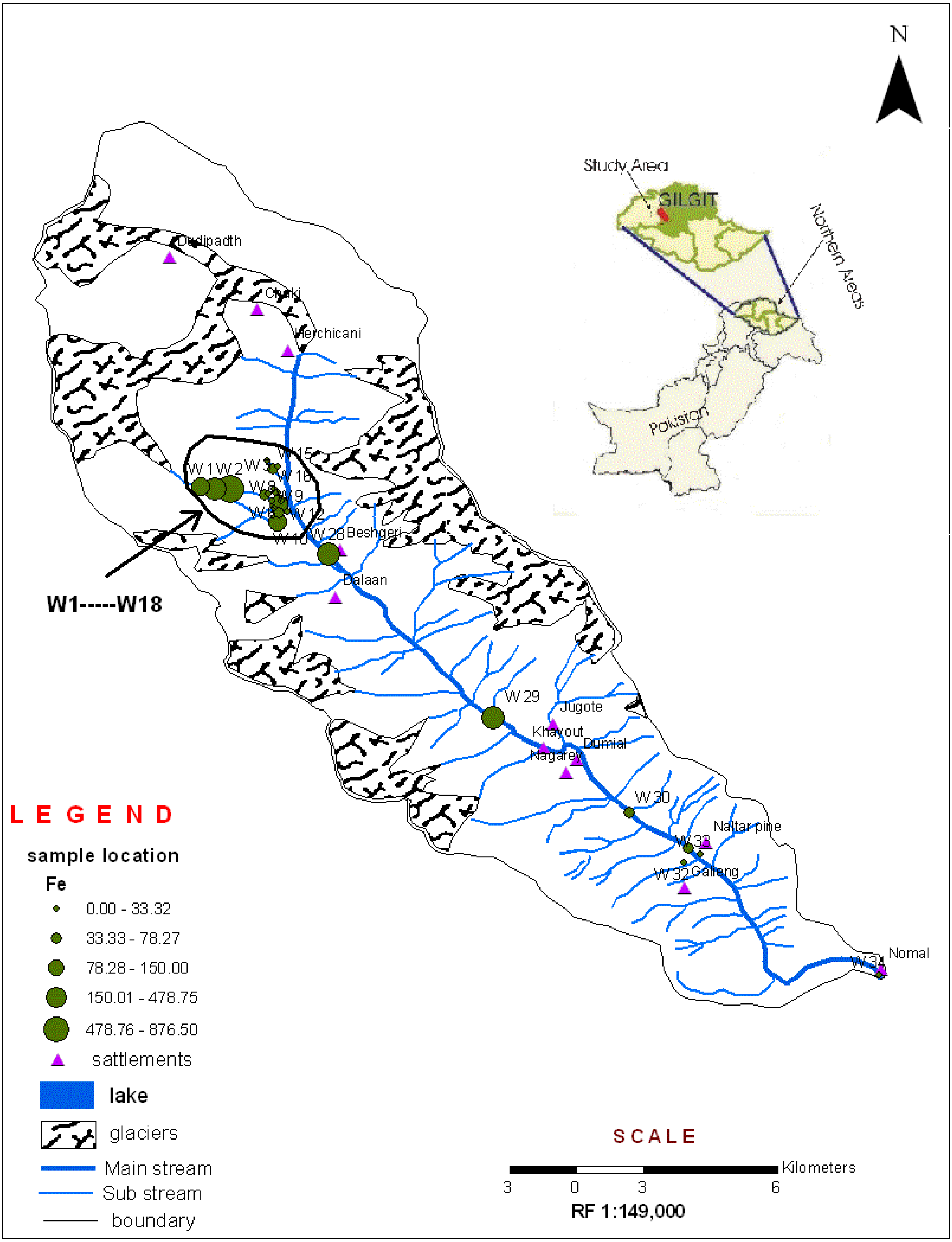

Fig.5.33. GIS based distribution pattern of Fe in the water of Naltar lakes and their streams at Naltar.

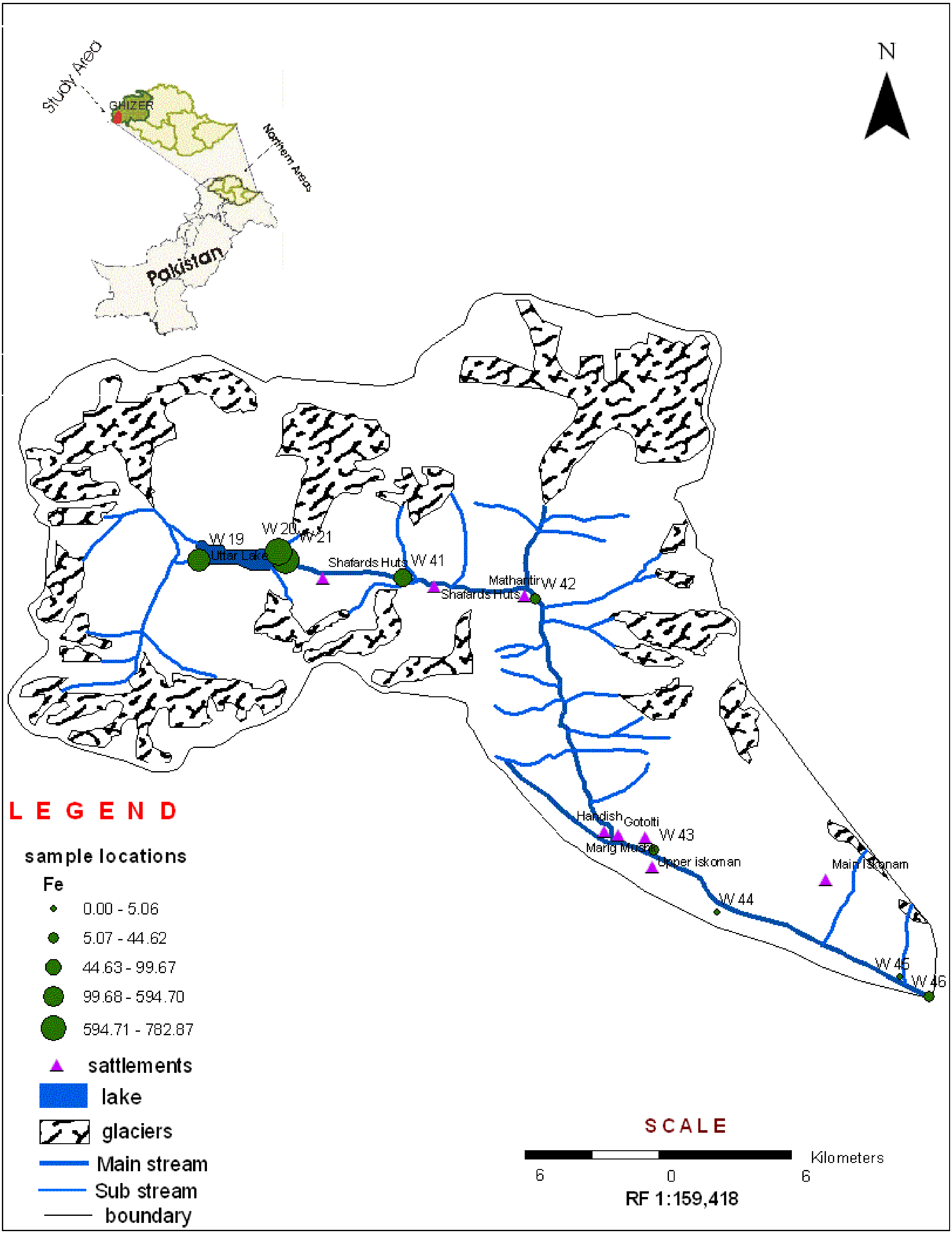

Fig.5.34. GIS based distribution pattern of Fe in the water of Uttar lake and its streams at Iskoman.

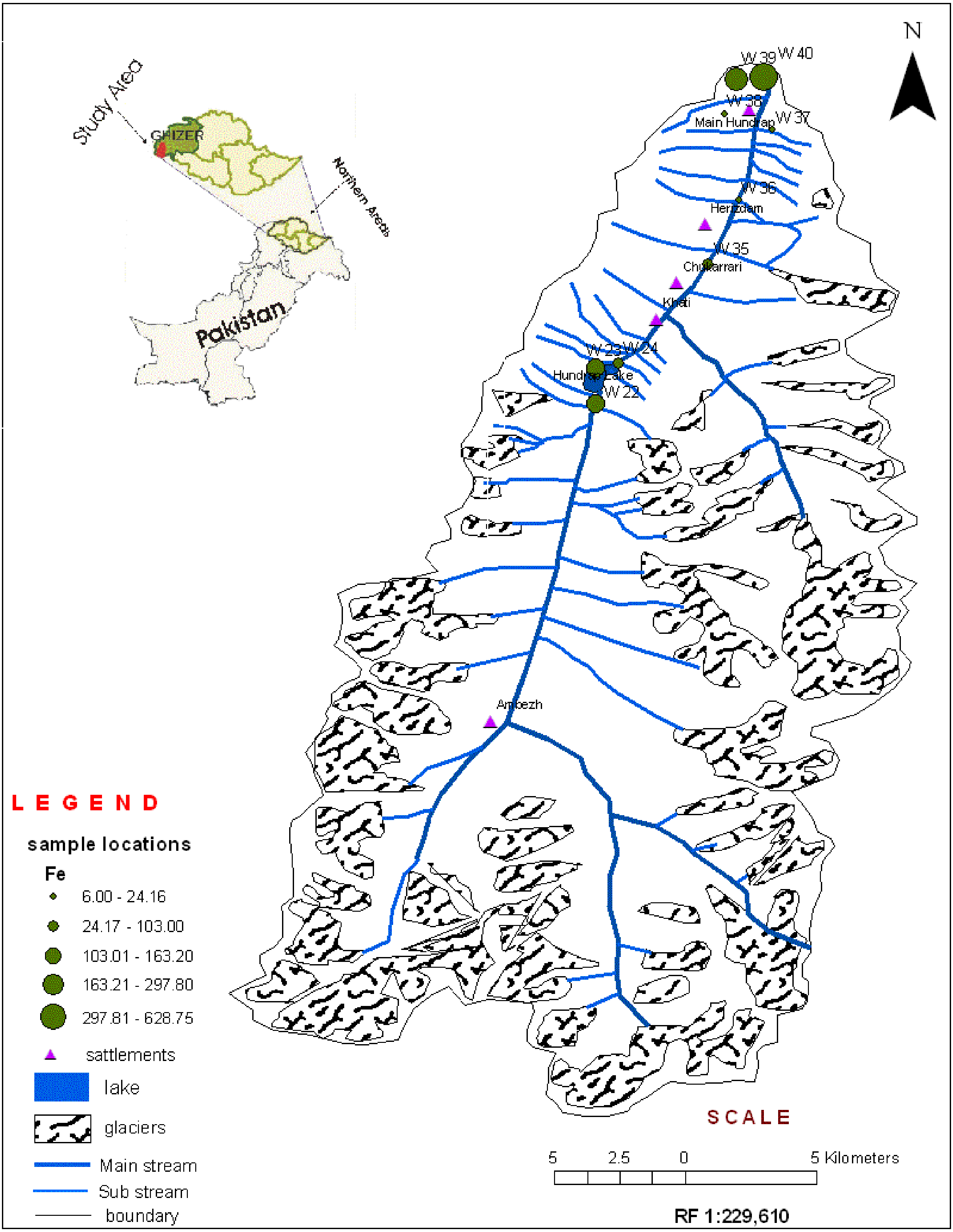

Fig.5.35. GIS distribution pattern of Fe in the water of Hundrap lake and its streams at Hundrap.

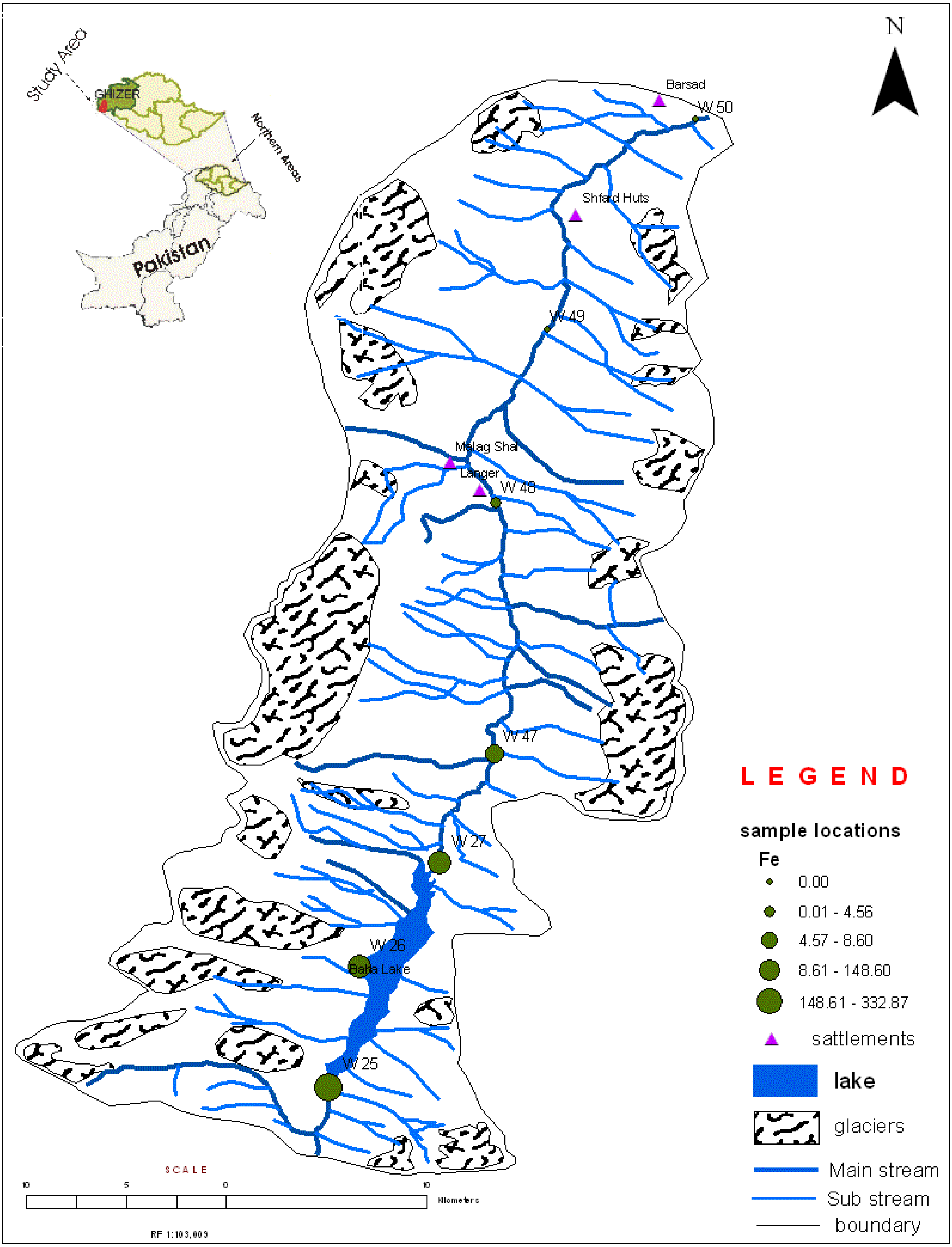

Fig.5.36. GIS based distribution pattern of Fe in the water of Baha lake and its streams at Khukosh.

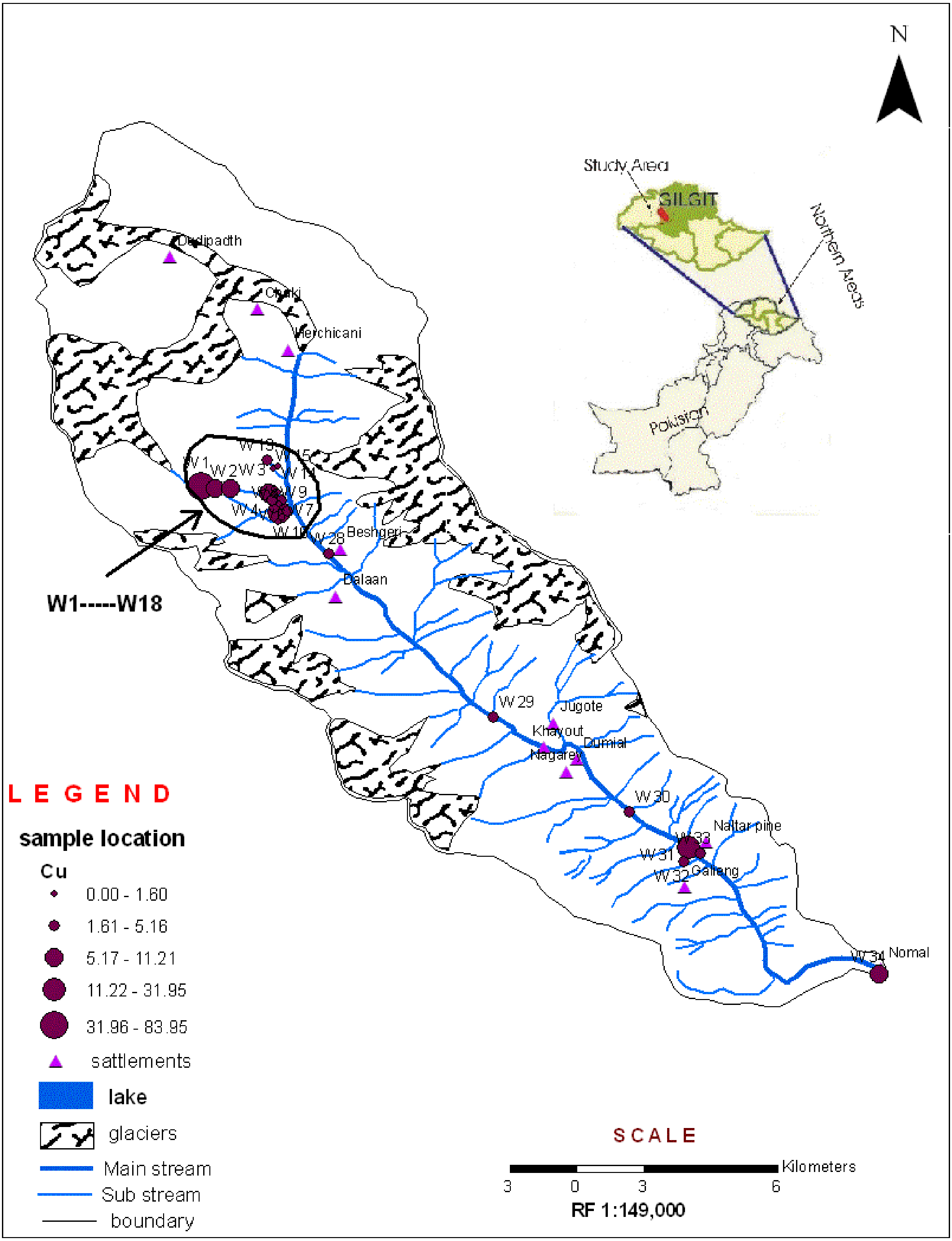

Fig.5.37. GIS based distribution pattern of Cu in the water of Naltar lakes and their streams at Naltar.

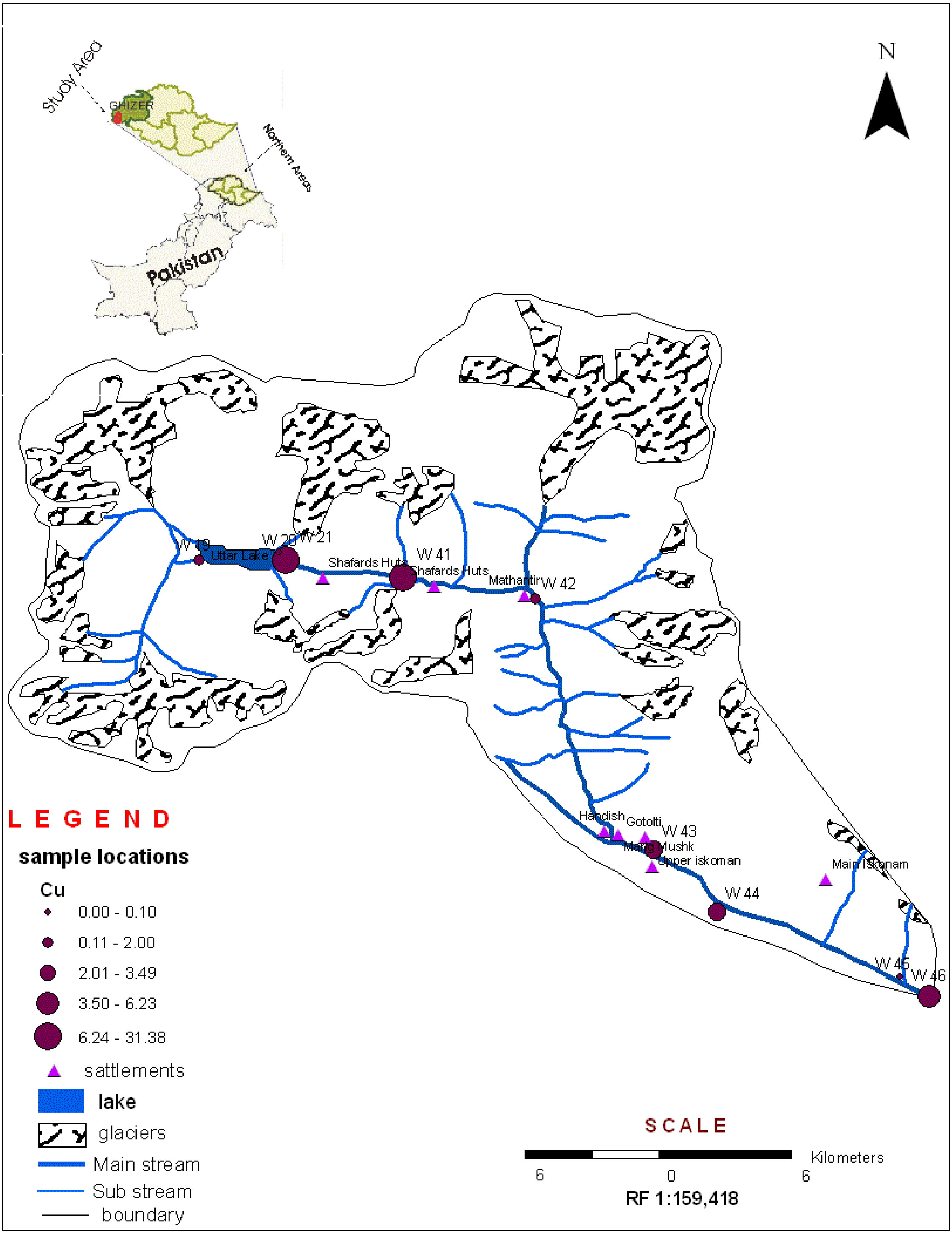

Fig.5.38. GIS based distribution pattern of Cu in the water of Uttar lake and its streams at Iskoman.

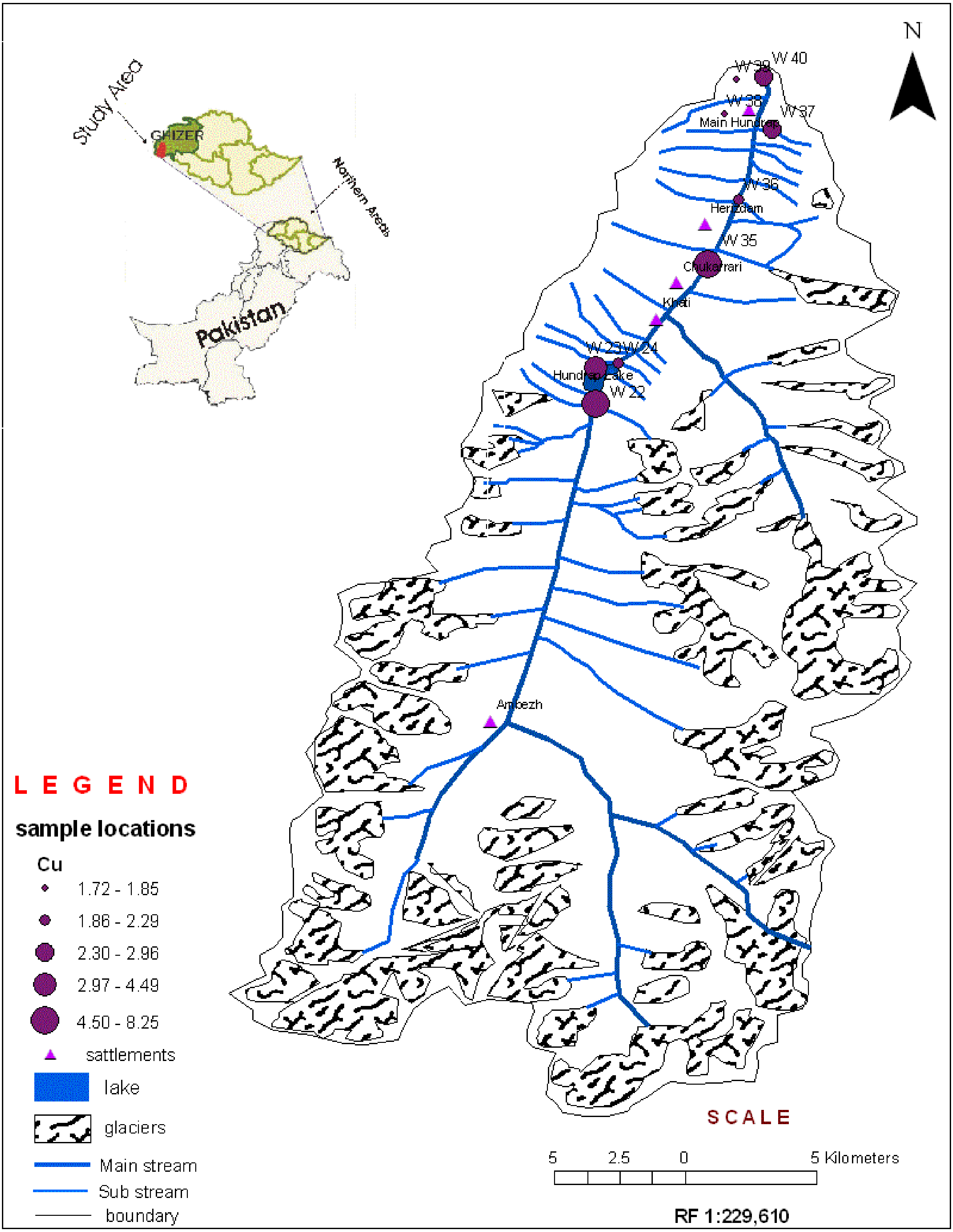

Fig.5.39. GIS based distribution pattern of Cu in the water of Hundrap lake and its streams at Hundrap.

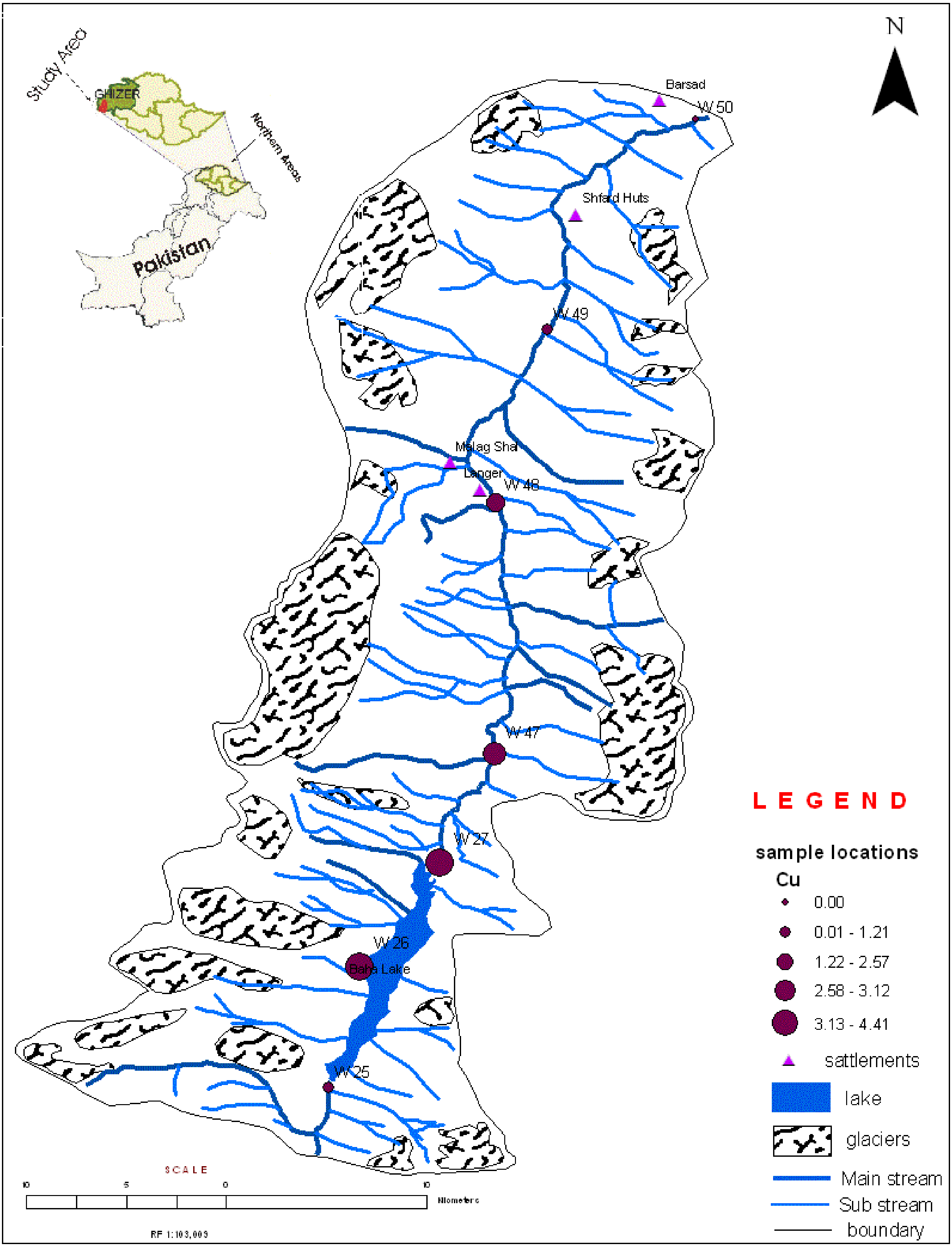

Fig.5.40. GIS based distribution pattern of Cu in the water of Baha lake and its streams at Khukosh.

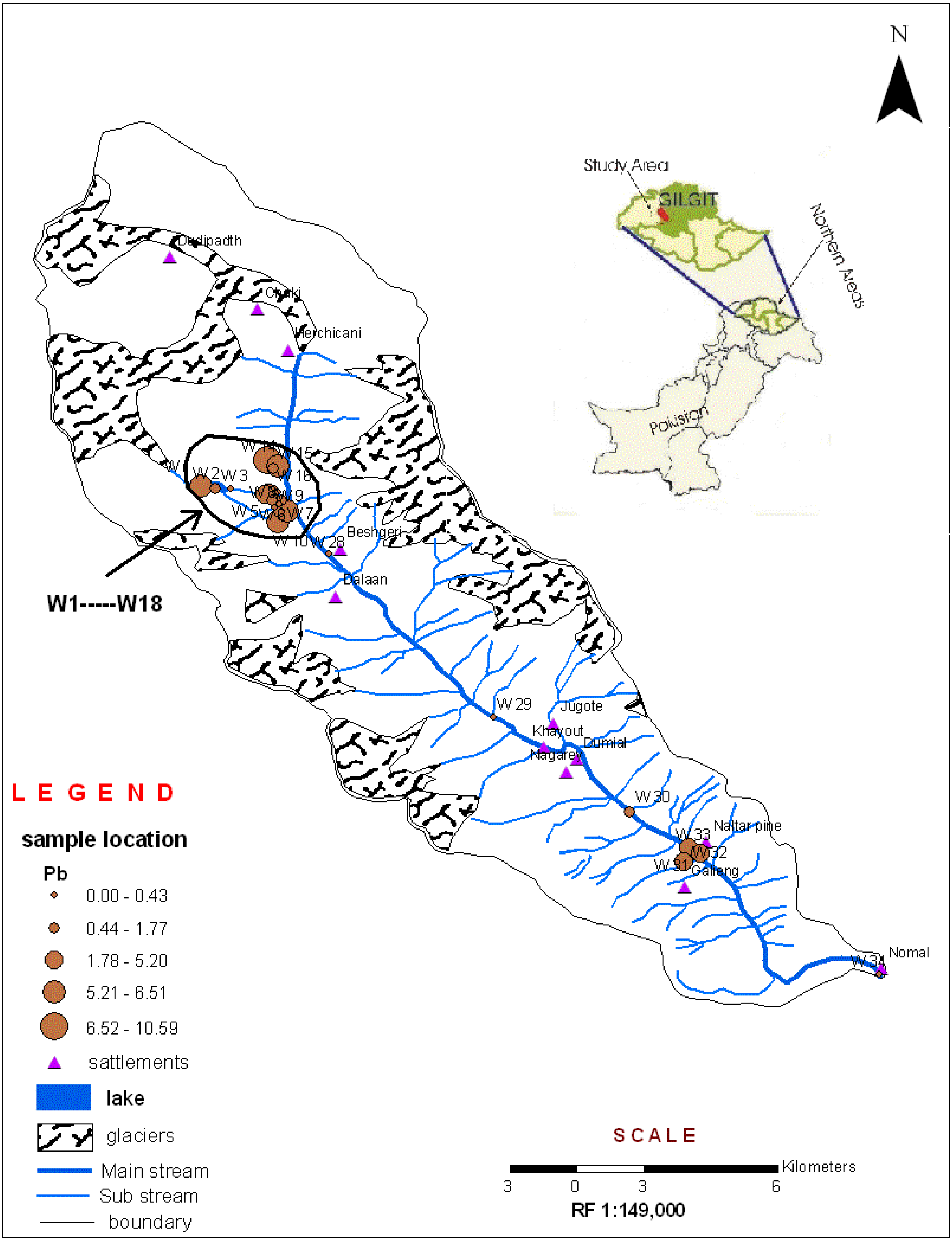

Fig.5.41. GIS based distribution pattern of Pb in the water of Naltar lakes and their streams at Naltar.

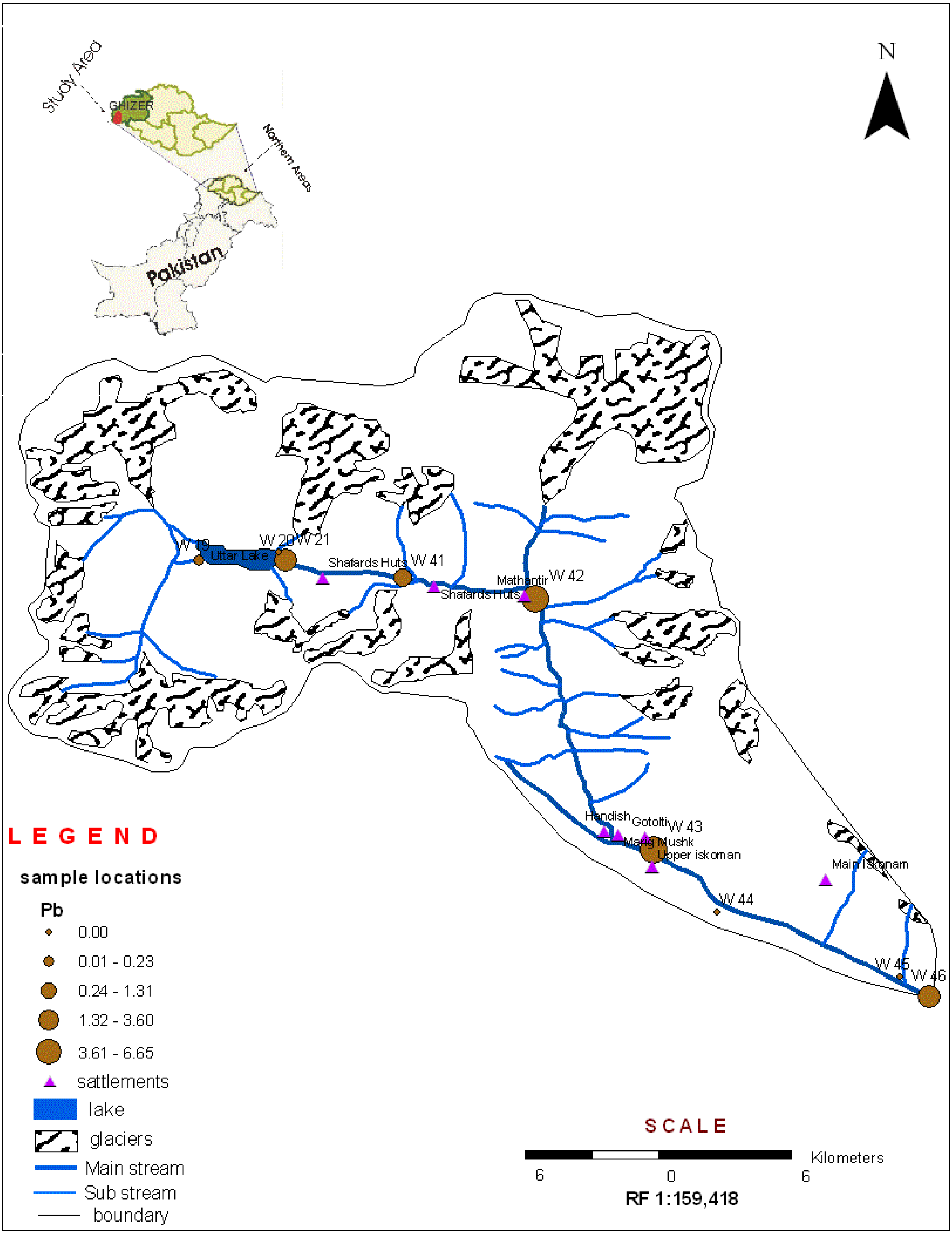

Fig.5.42. GIS based distribution pattern of Pb in the water of Uttar lake and its streams at Iskoman.

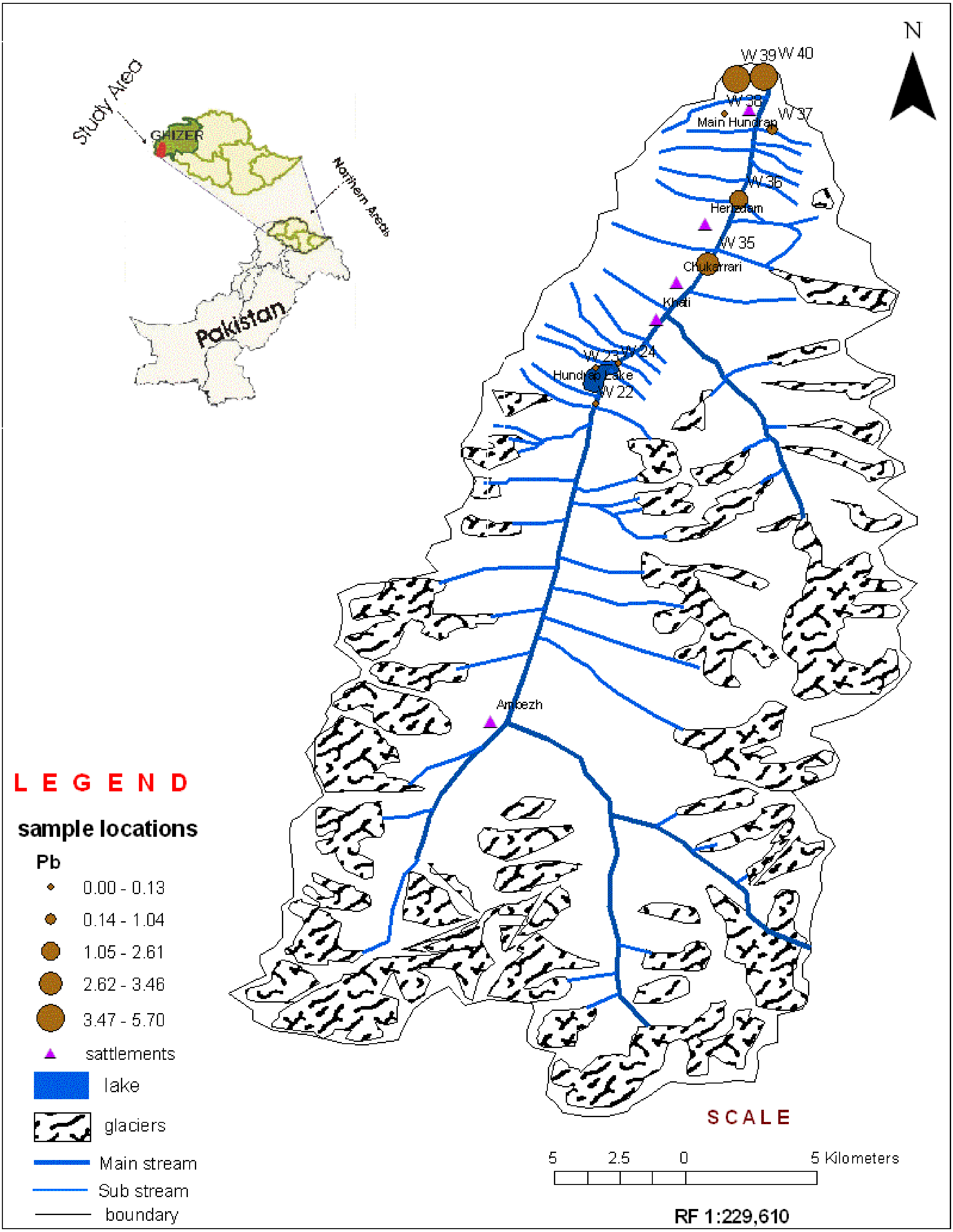

Fig.5.43. GIS based distribution of Pb in the water of Hundrap lake and its stream at Hundrap.

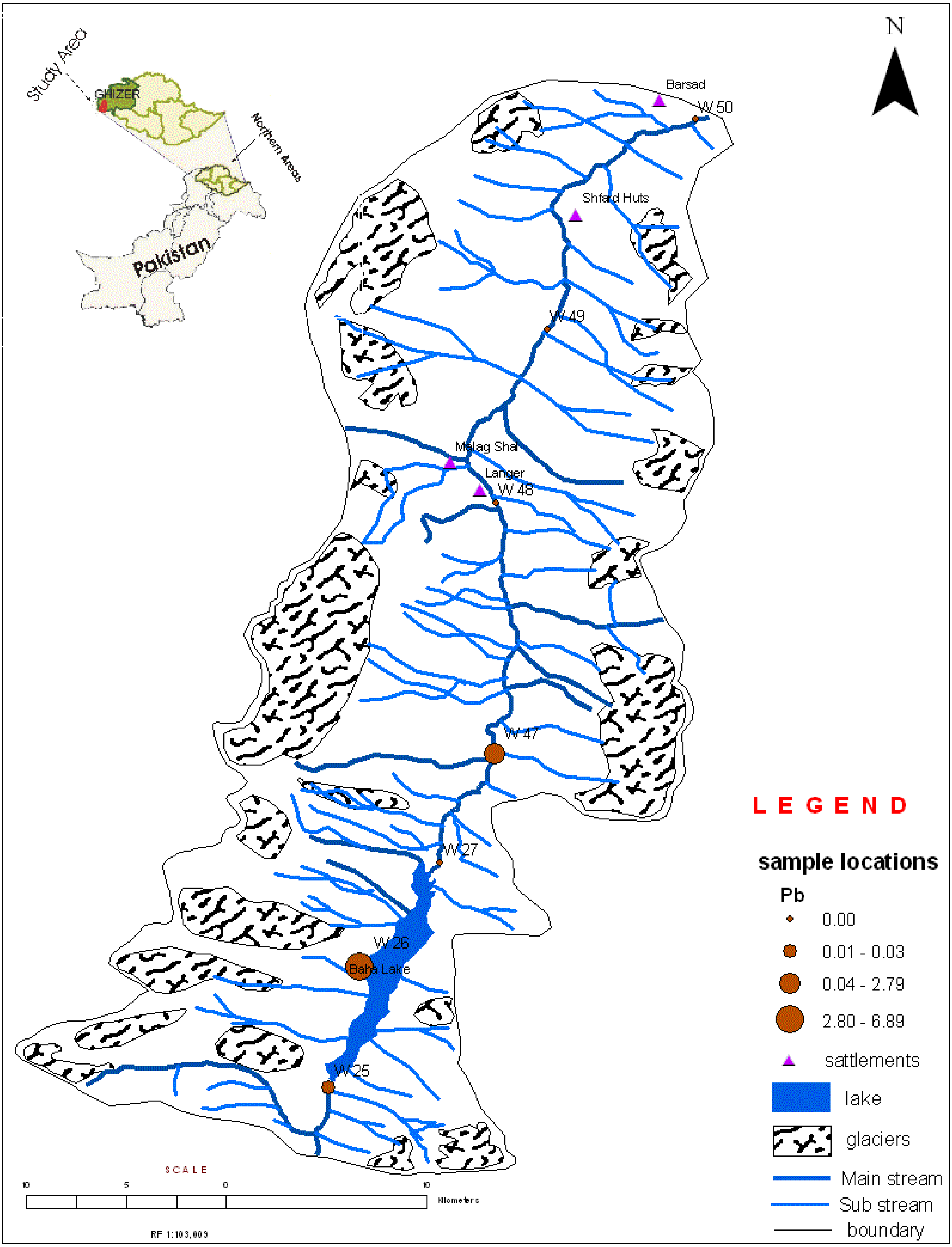

Fig.5.44. GIS based distribution pattern Pb in the water of Baha lake and its streams at Khukosh.

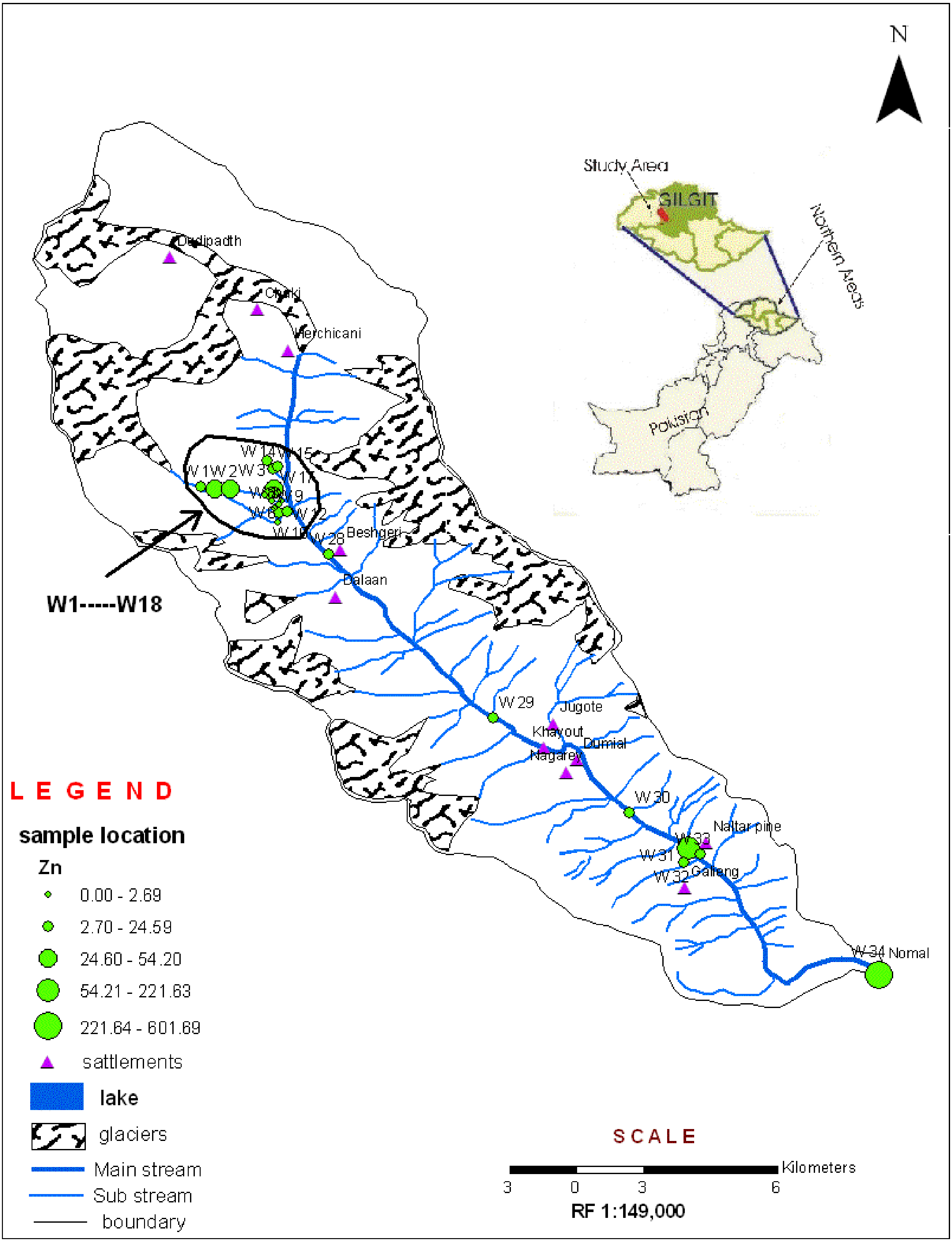

Fig.5.45. GIS based distribution pattern of Zn in the water of Naltar lakes and their streams at Naltar.

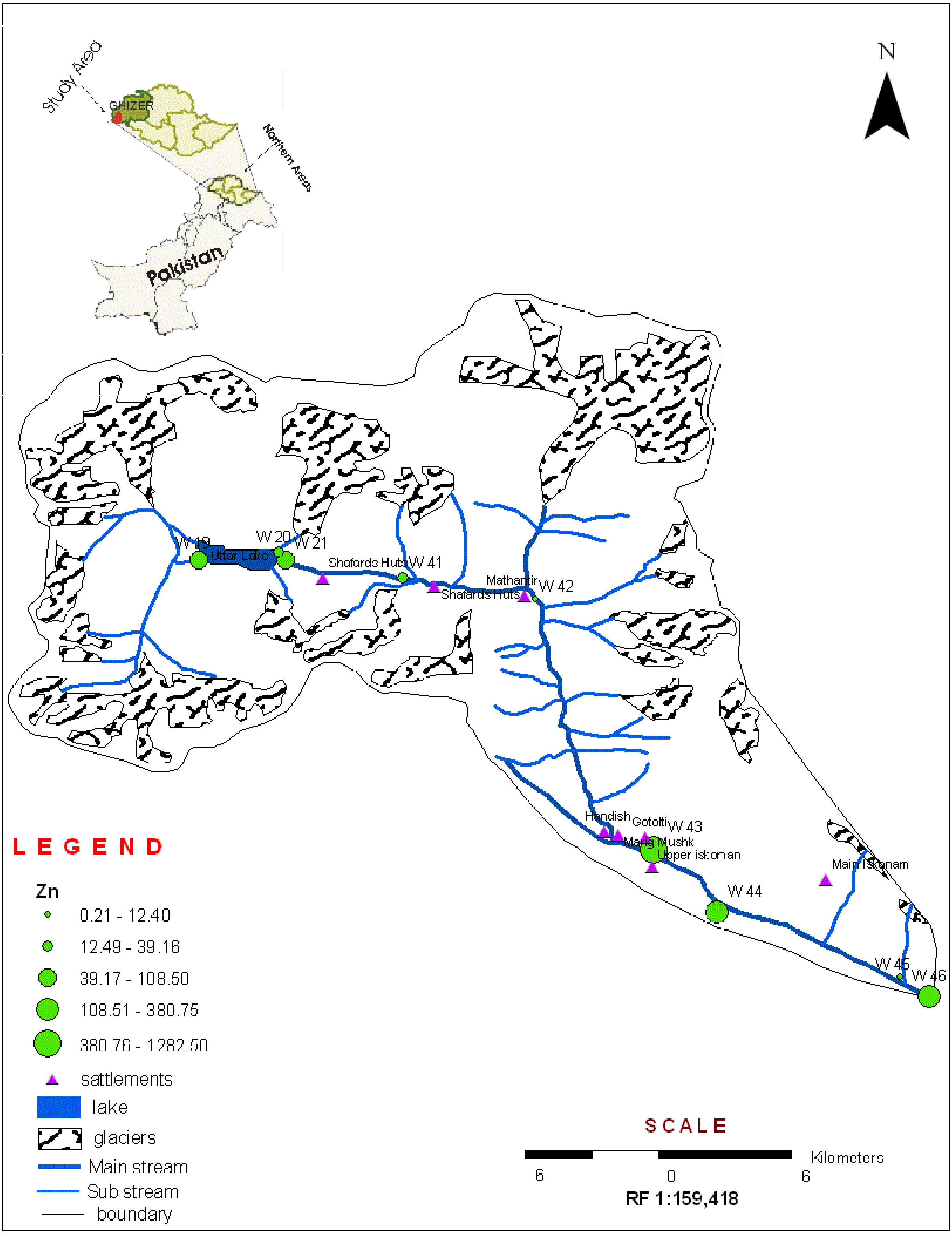

Fig.5.46. GIS based distribution pattern of Zn in the water of Uttar lake and its streams at Iskoman.

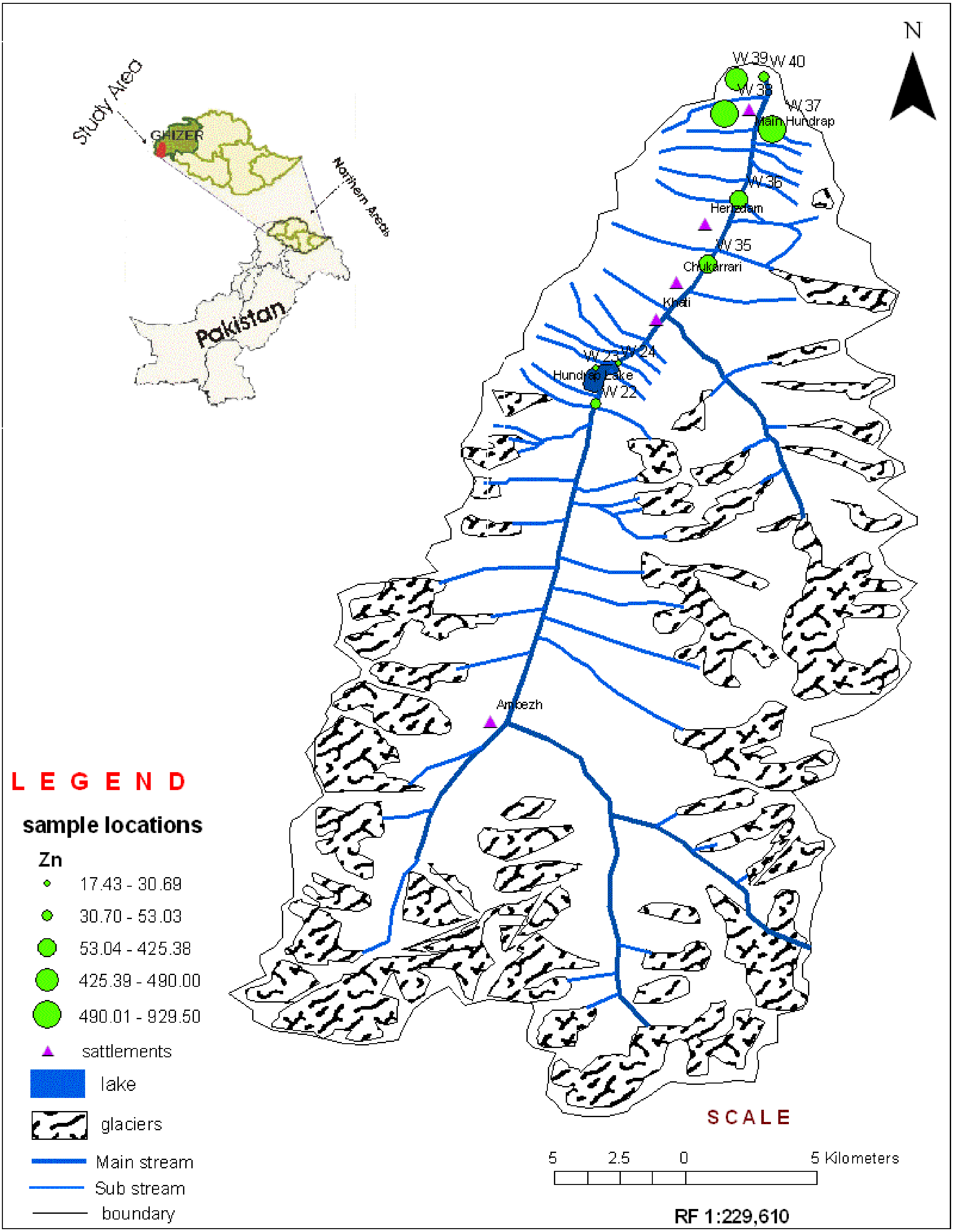

Fig.5.47. GIS based distribution pattern of Zn in the water of Hundrap lake and its streams at Hundrap.

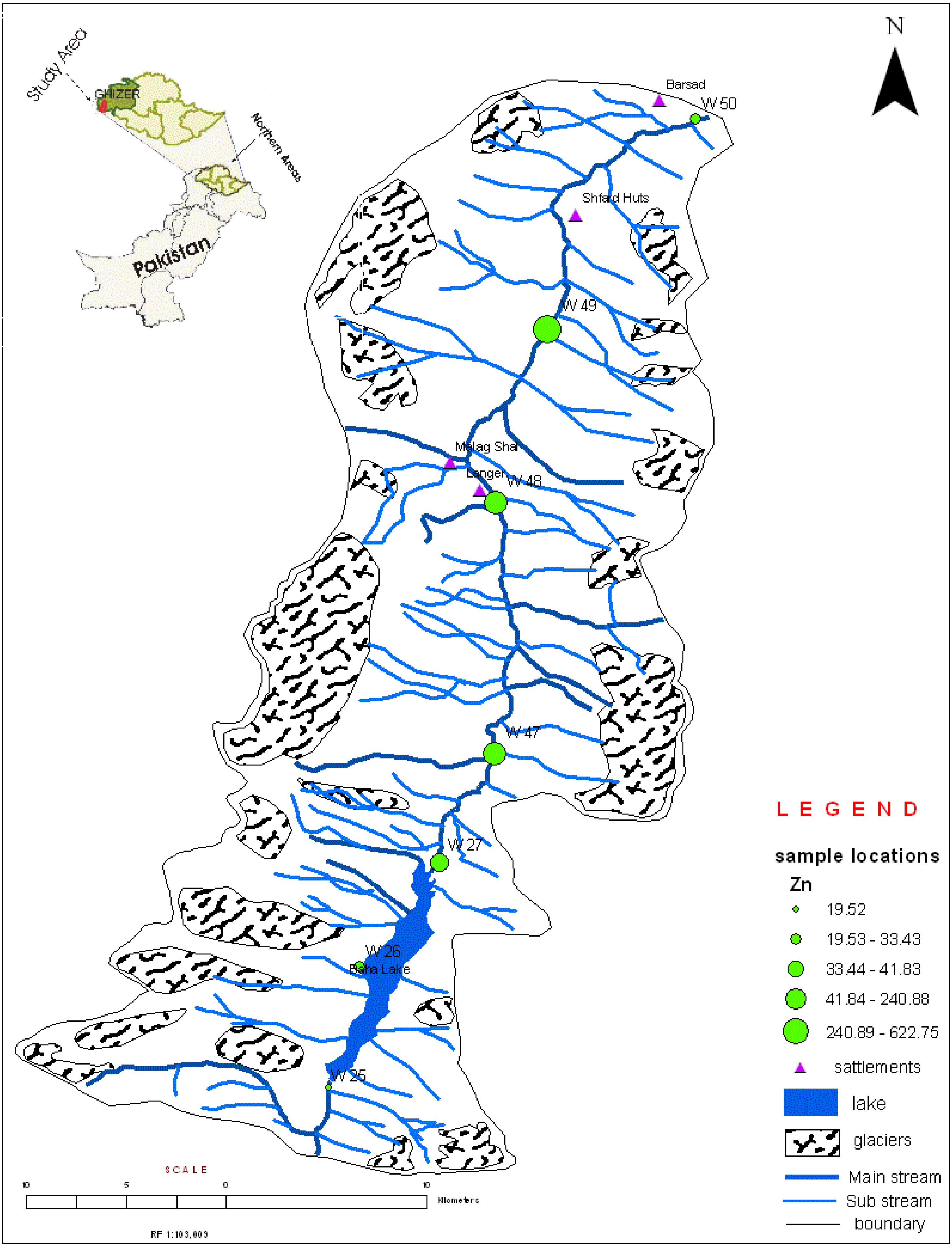

Fig.5.48. GIS based distribution pattern of Zn in the water of Baha lake and its streams at Khukosh.

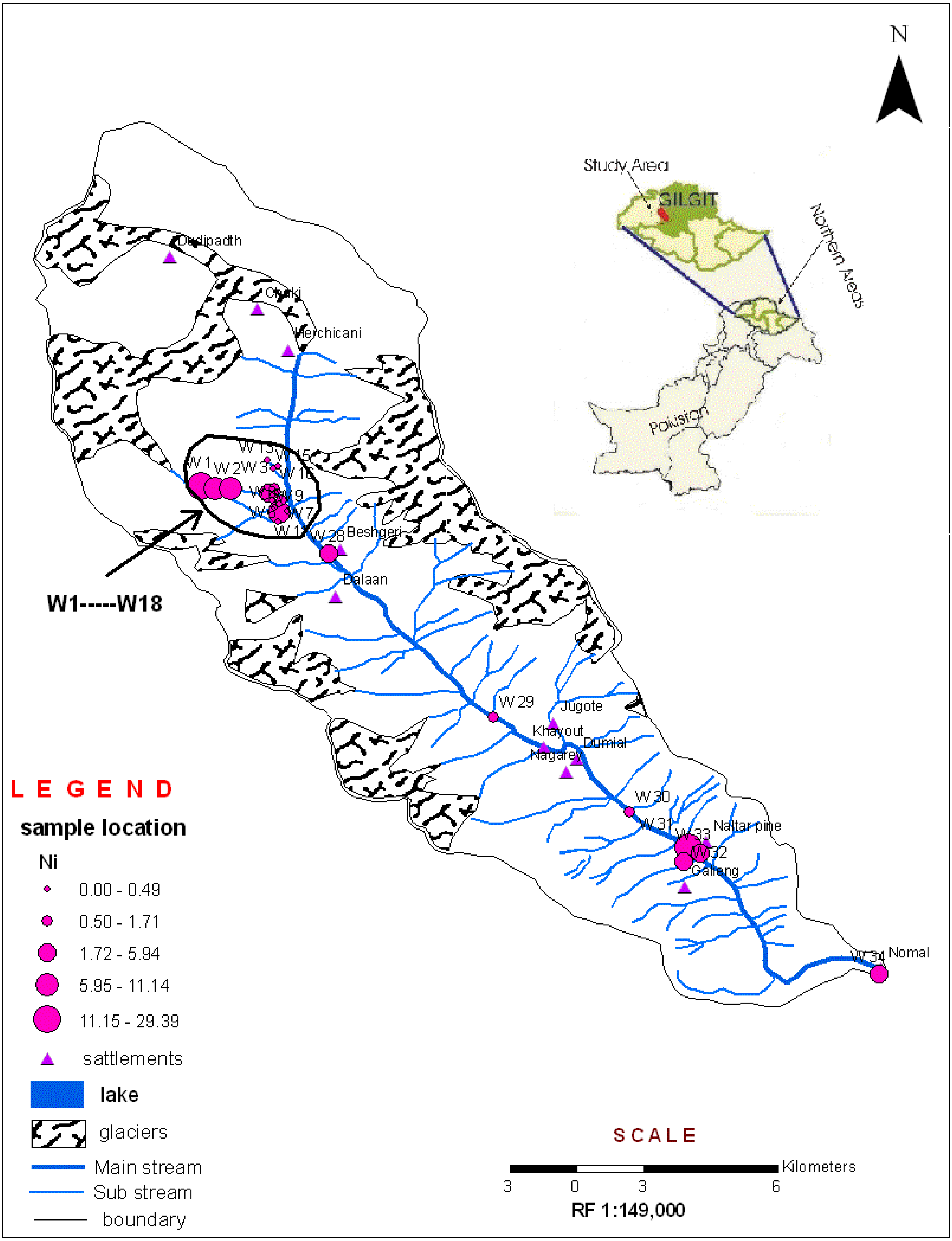

Fig.5.49. GIS based distribution pattern of Ni in the water of Naltar lakes and their streams at Naltar.

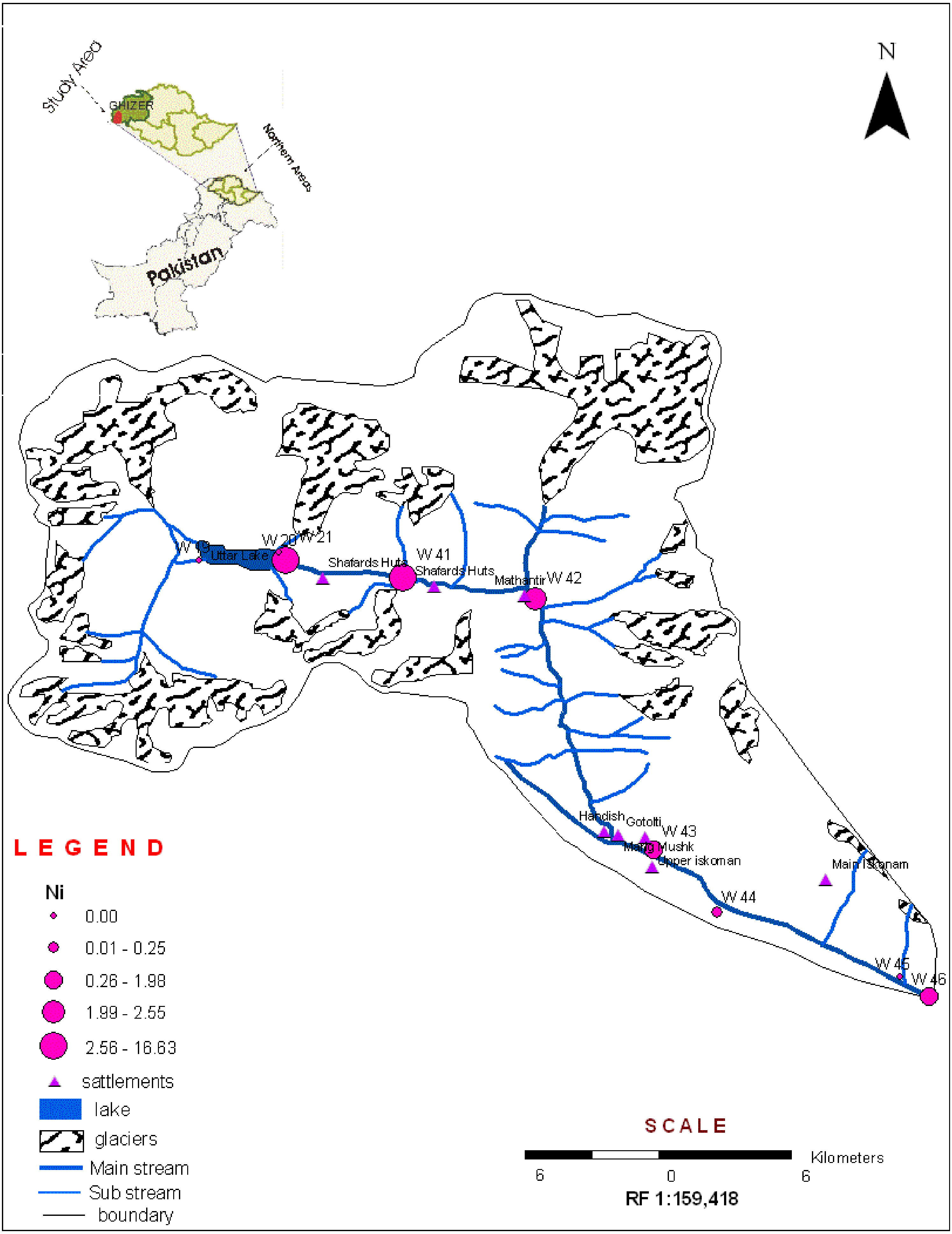

Fig.5.50. GIS based distribution pattern of Ni in the water of Uttar lake and its streams at Iskoman.

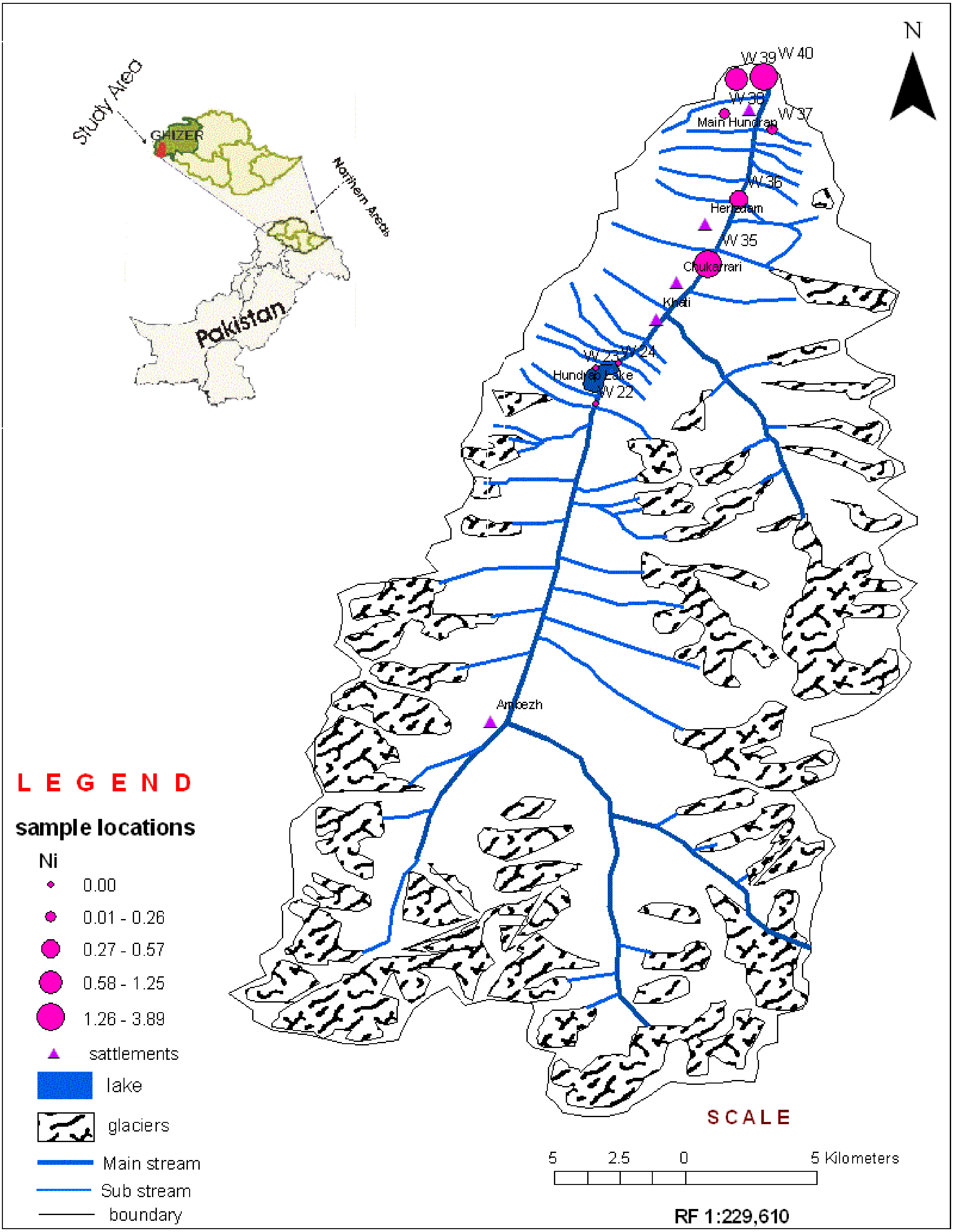

Fig.5.51. GIS based distribution pattern of Ni in the water of Hundrap lake and its streams at Hundrap.

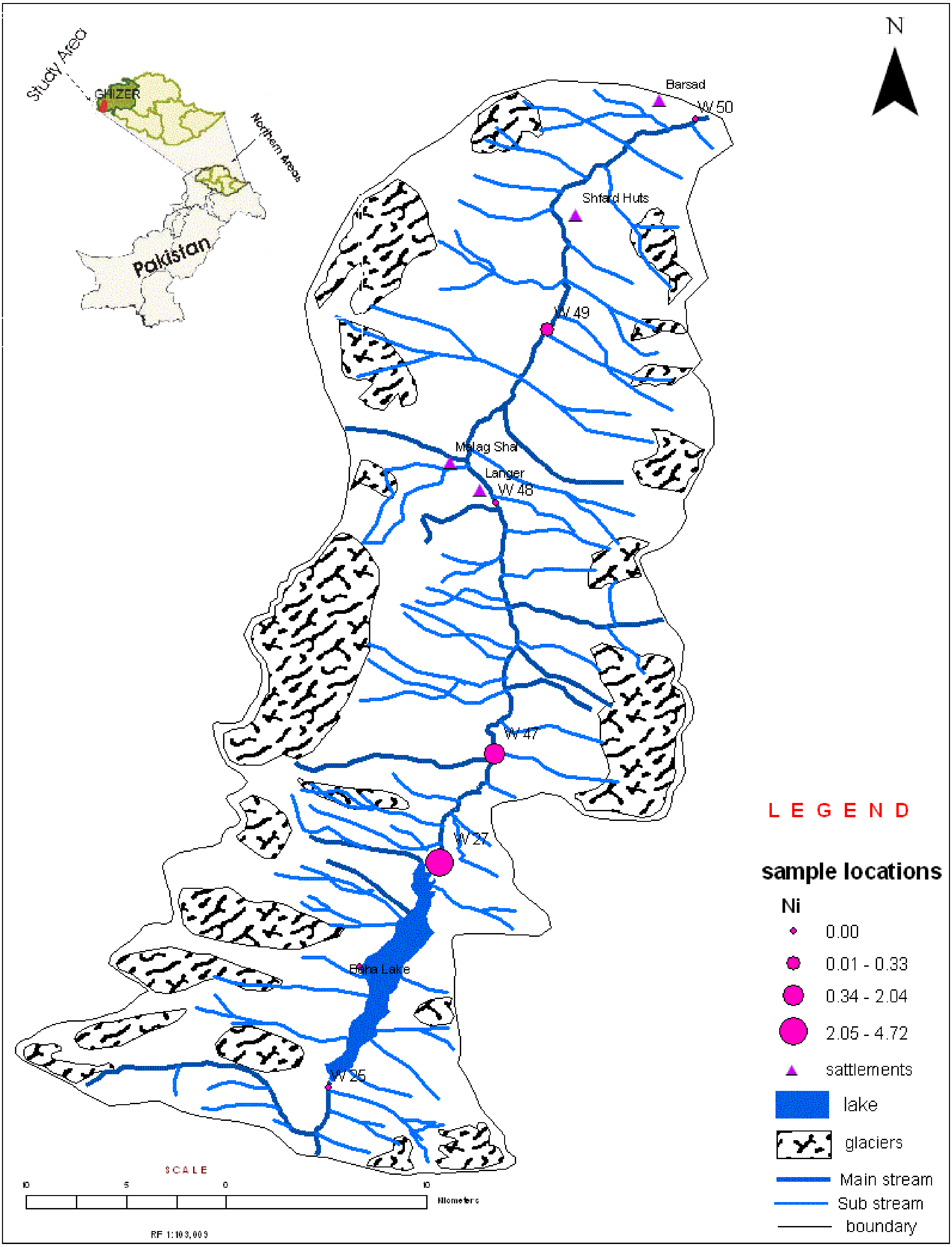

Fig.5.52. GIS based distribution pattern of Ni in the water of Baha lake and its streams at Khukosh.

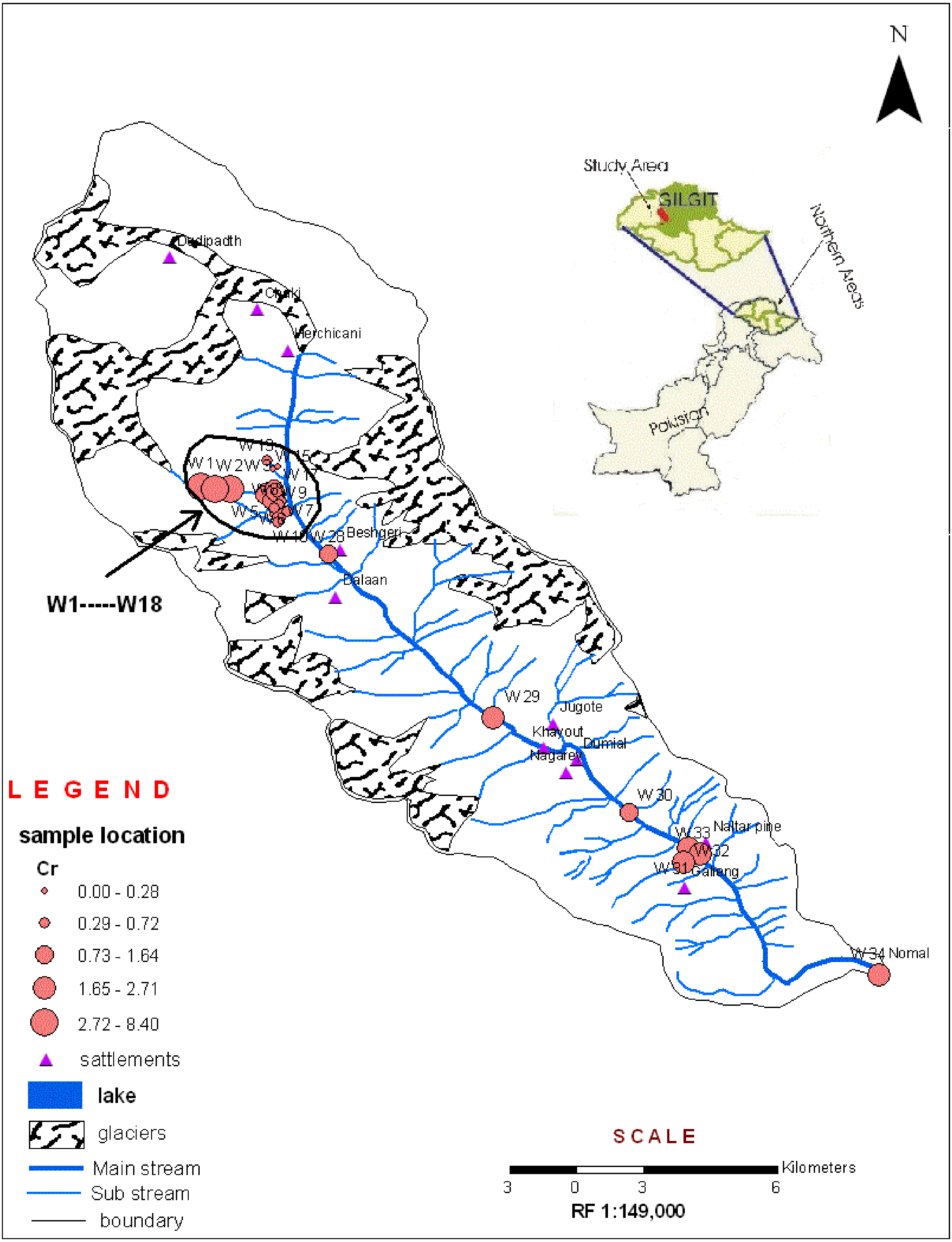

Fig.5.53. GIS based distribution pattern of Cr in the water of Naltar lakes and their streams at Naltar.

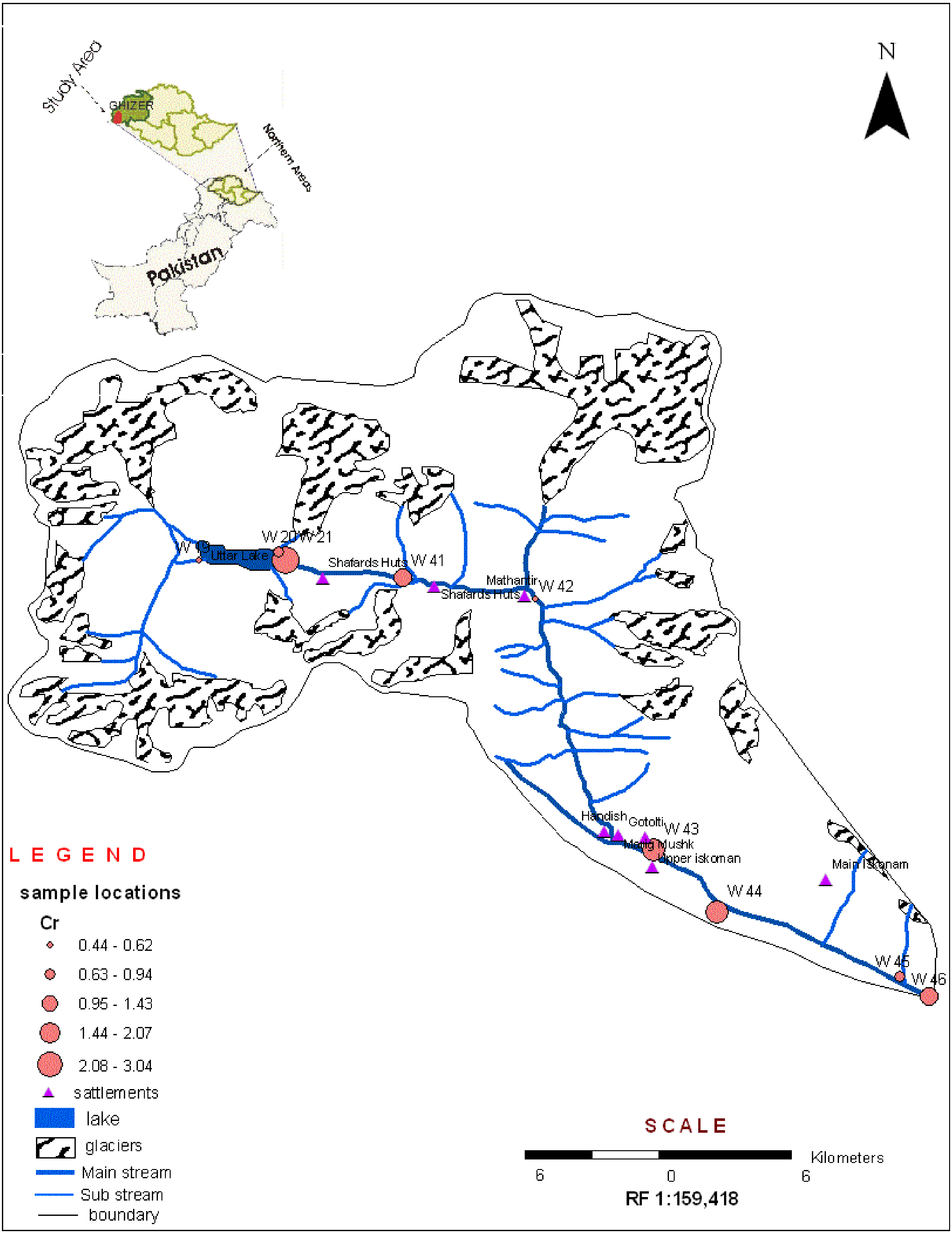

Fig.5.54. GIS based distribution pattern of Cr in the water of Uttar lake and its streams at Iskoman.

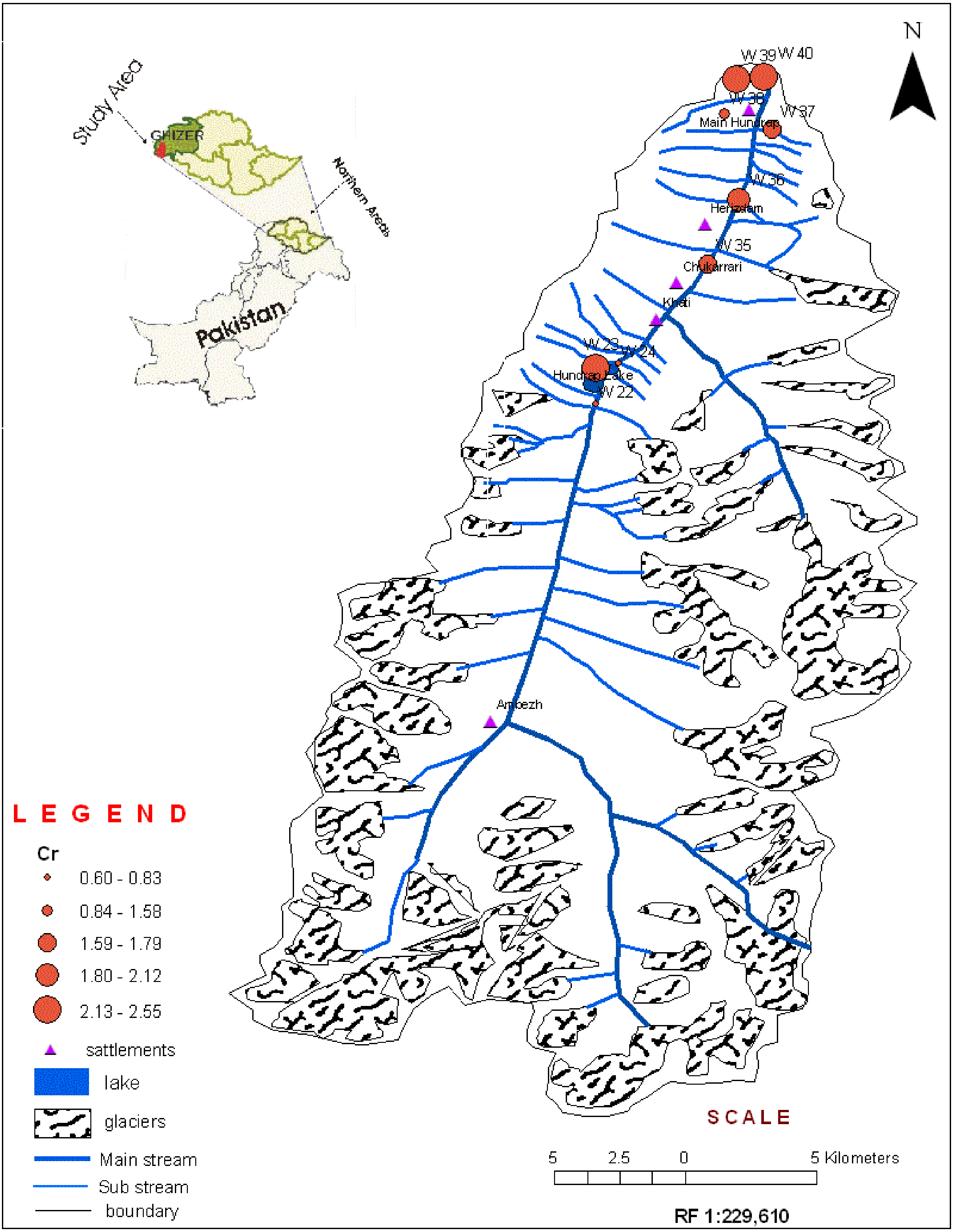

Fig.5.55. GIS based distribution pattern of Cr in the water of Hundrap lake and its streams at Hundrap.

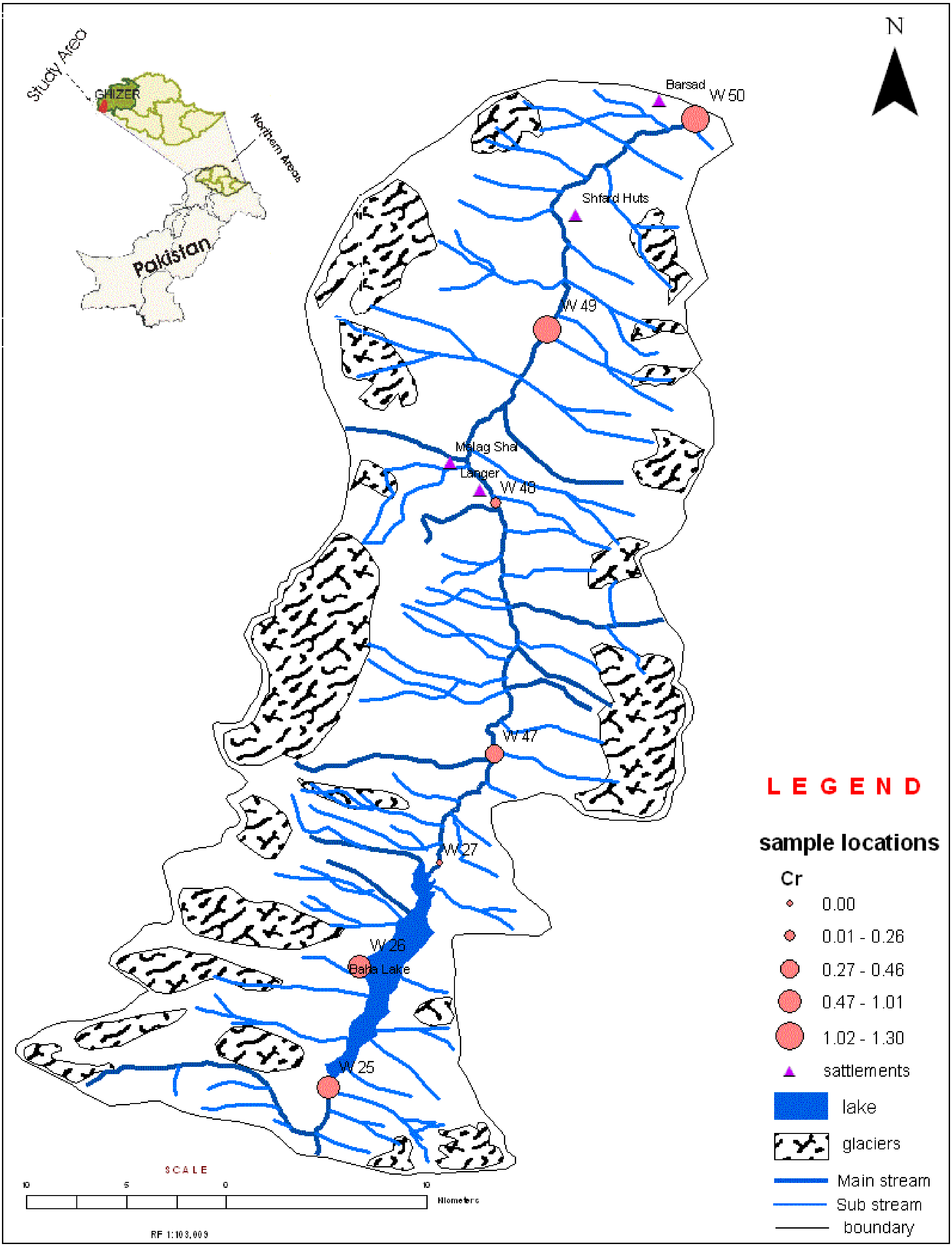

Fig.5.56. GIS based distribution pattern of Cr in the water Baha lake and its streams at Khukosh.

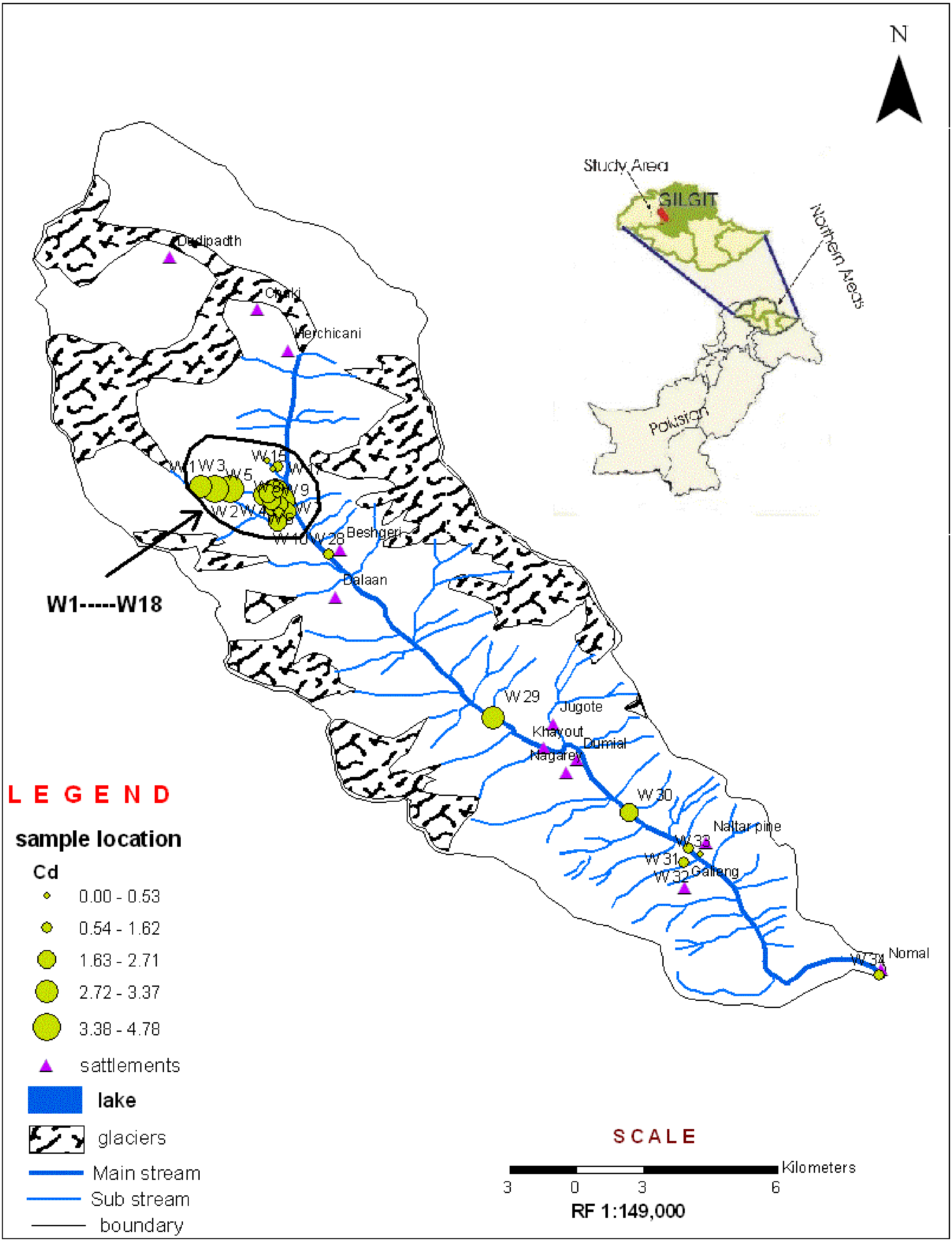

Fig.5.57. GIS based distribution pattern of Cd in the water of Naltar lakes and their streams at Naltar.

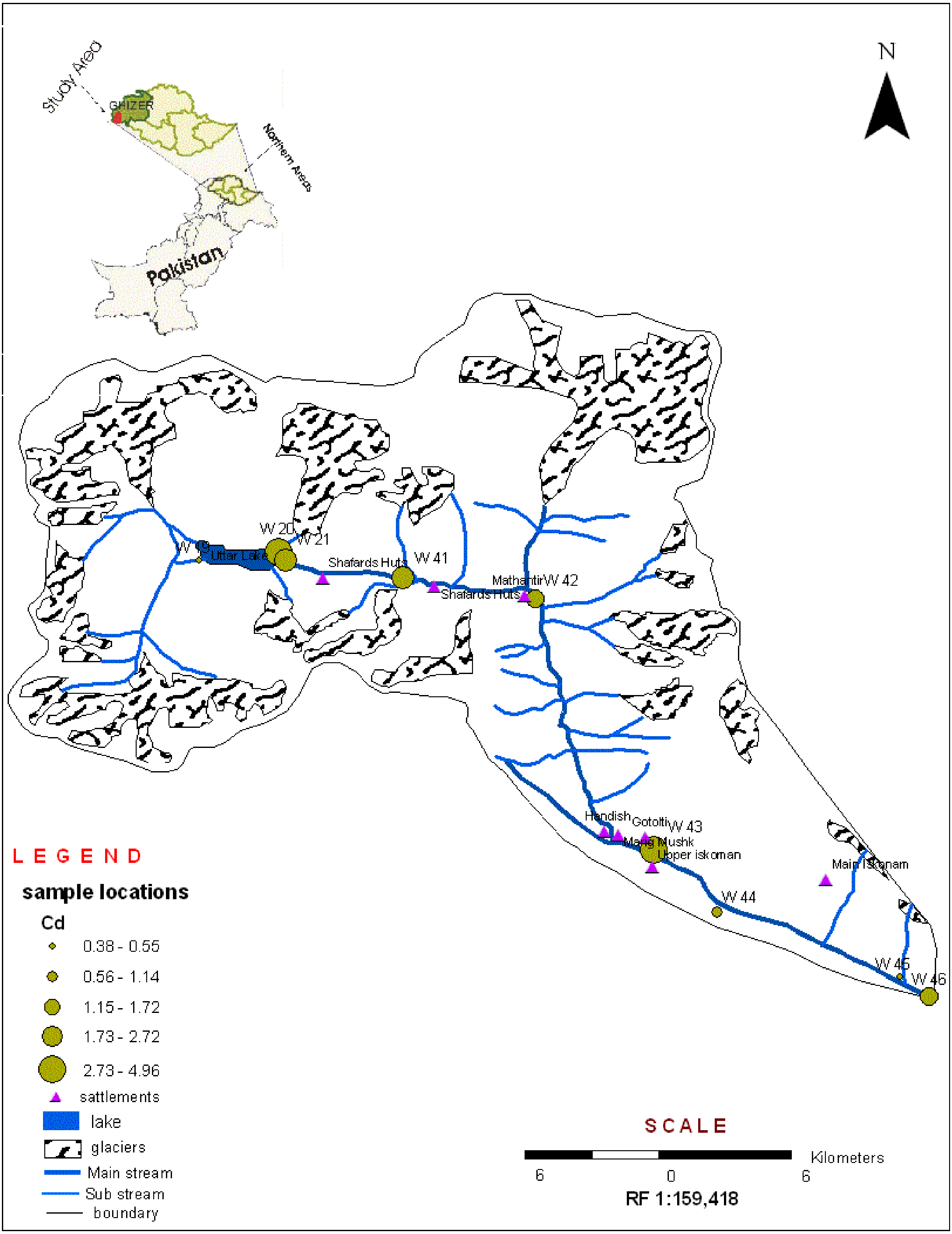

Fig.5.58. GIS based distribution pattern of Cd in the water of Uttar lake and its streams at Khukosh.

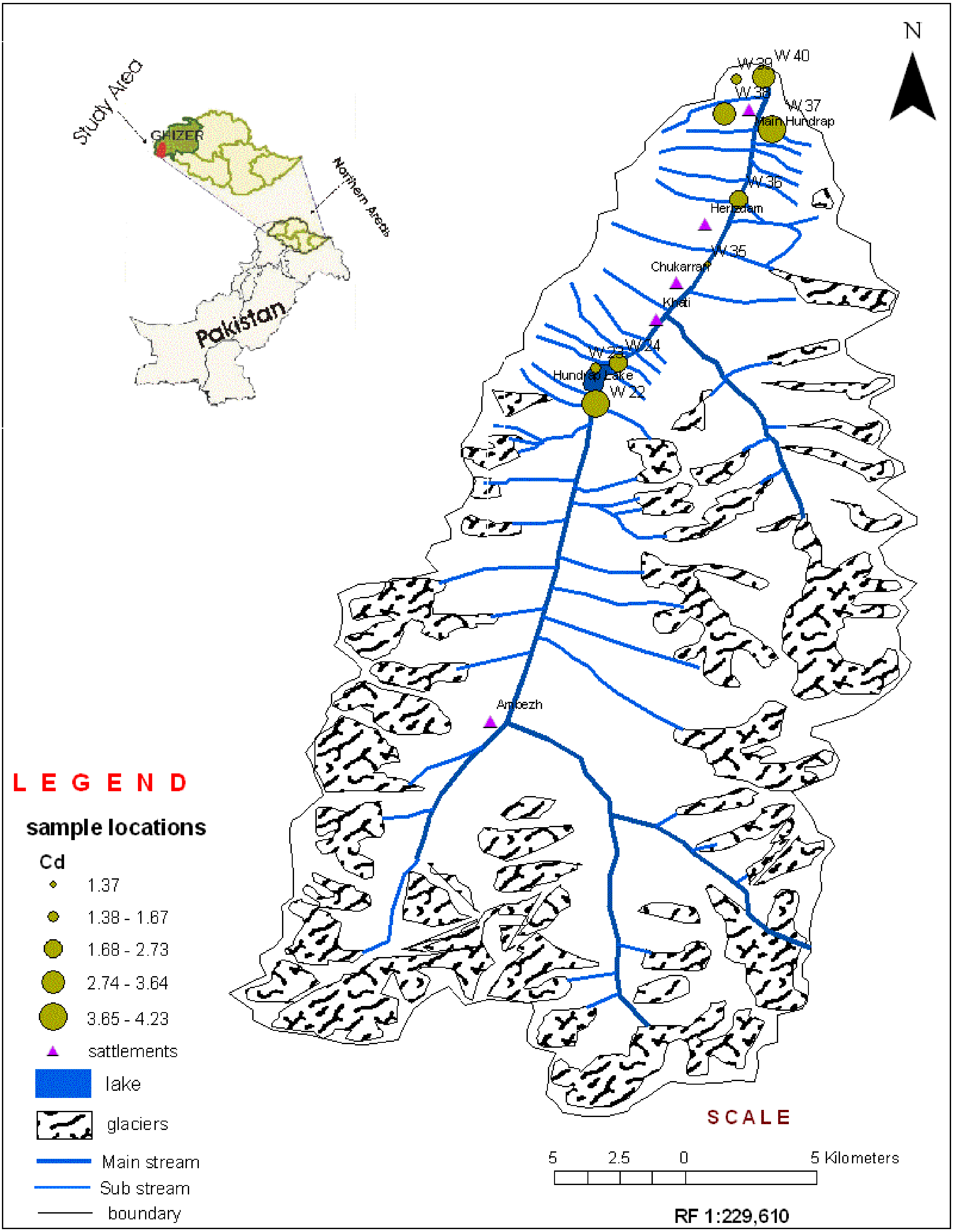

Fig.5.59. GIS based distribution pattern of Cd in the water of Hundrap lake and its streams at Hundrap.

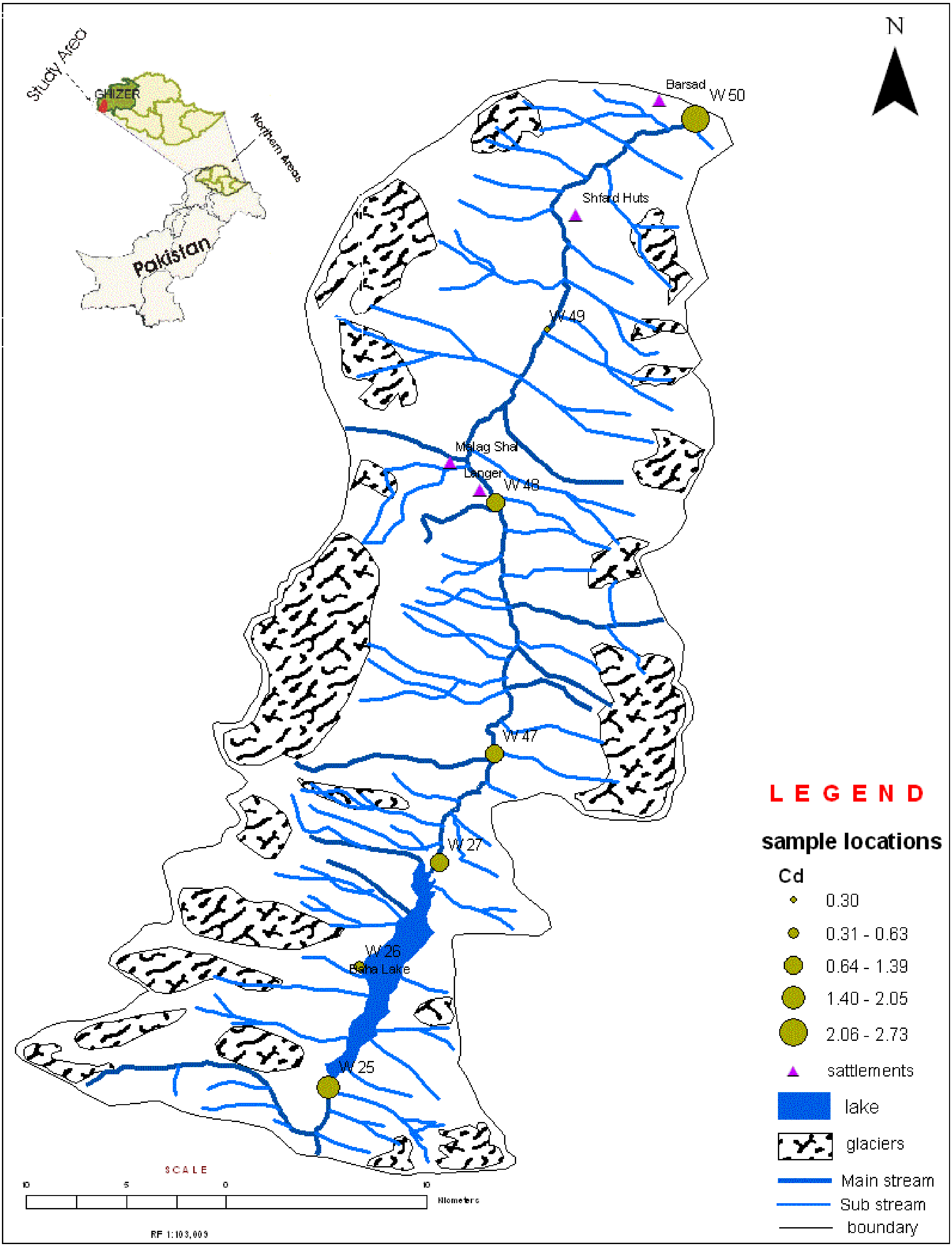

Fig.5.60. GIS based distribution pattern of Cd in the water of Baha lake and its streams at Khukosh.

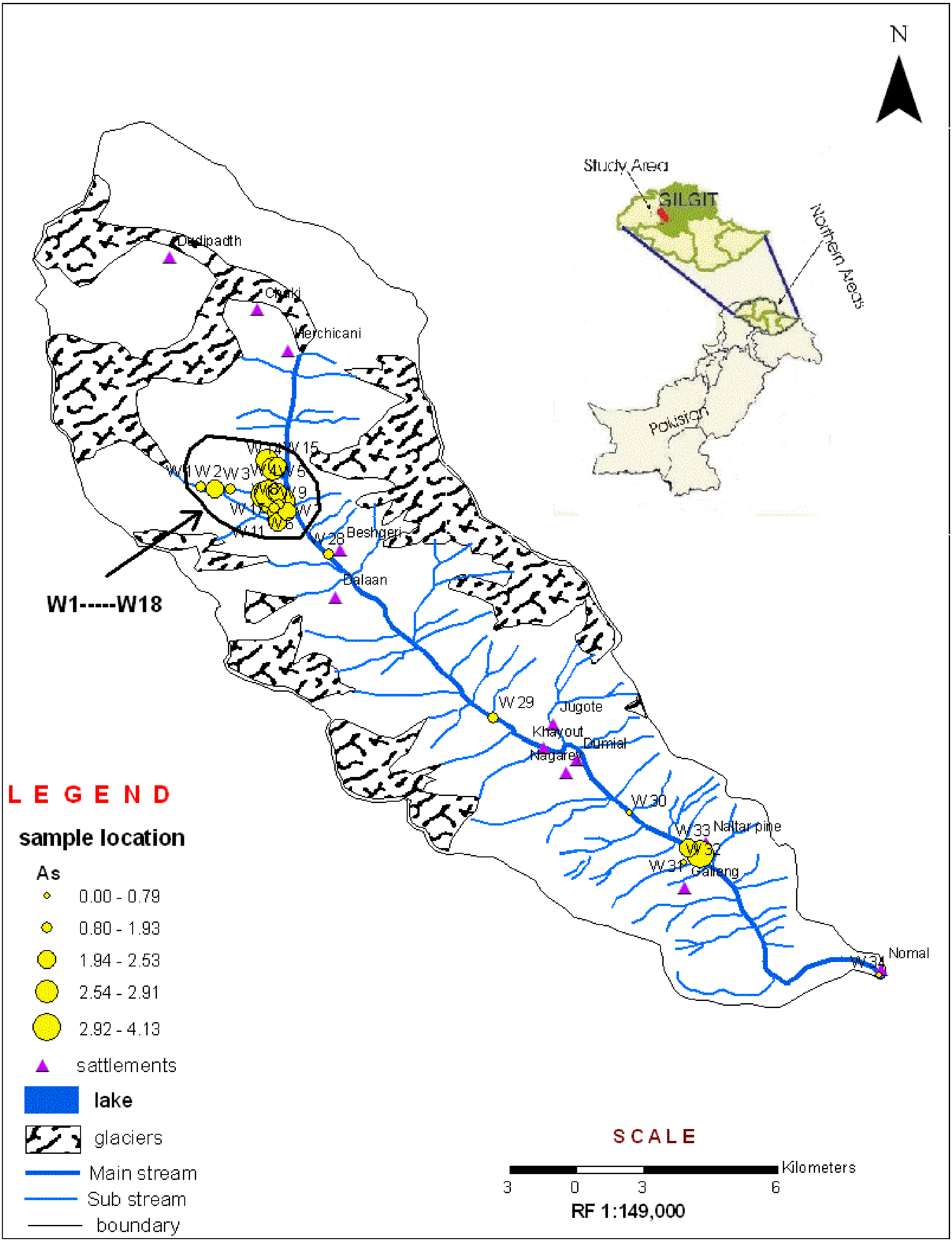

Fig.5.61. GIS based Distribution pattern of As in the water of Naltar lakes and their streams at Naltar.

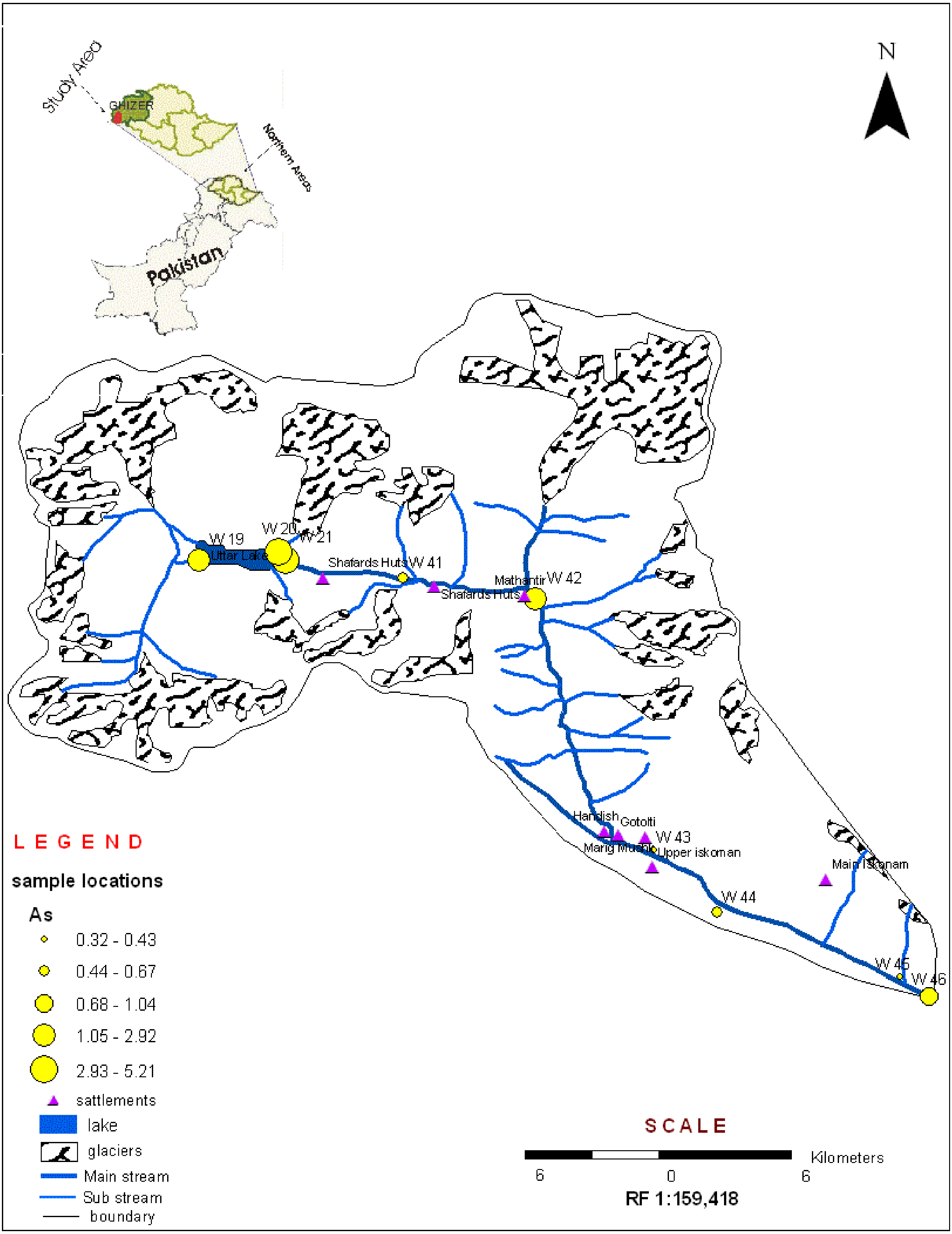

Fig.5.62. GIS based distribution pattern of As in the water of Uttar lake and its streams at Iskoman.

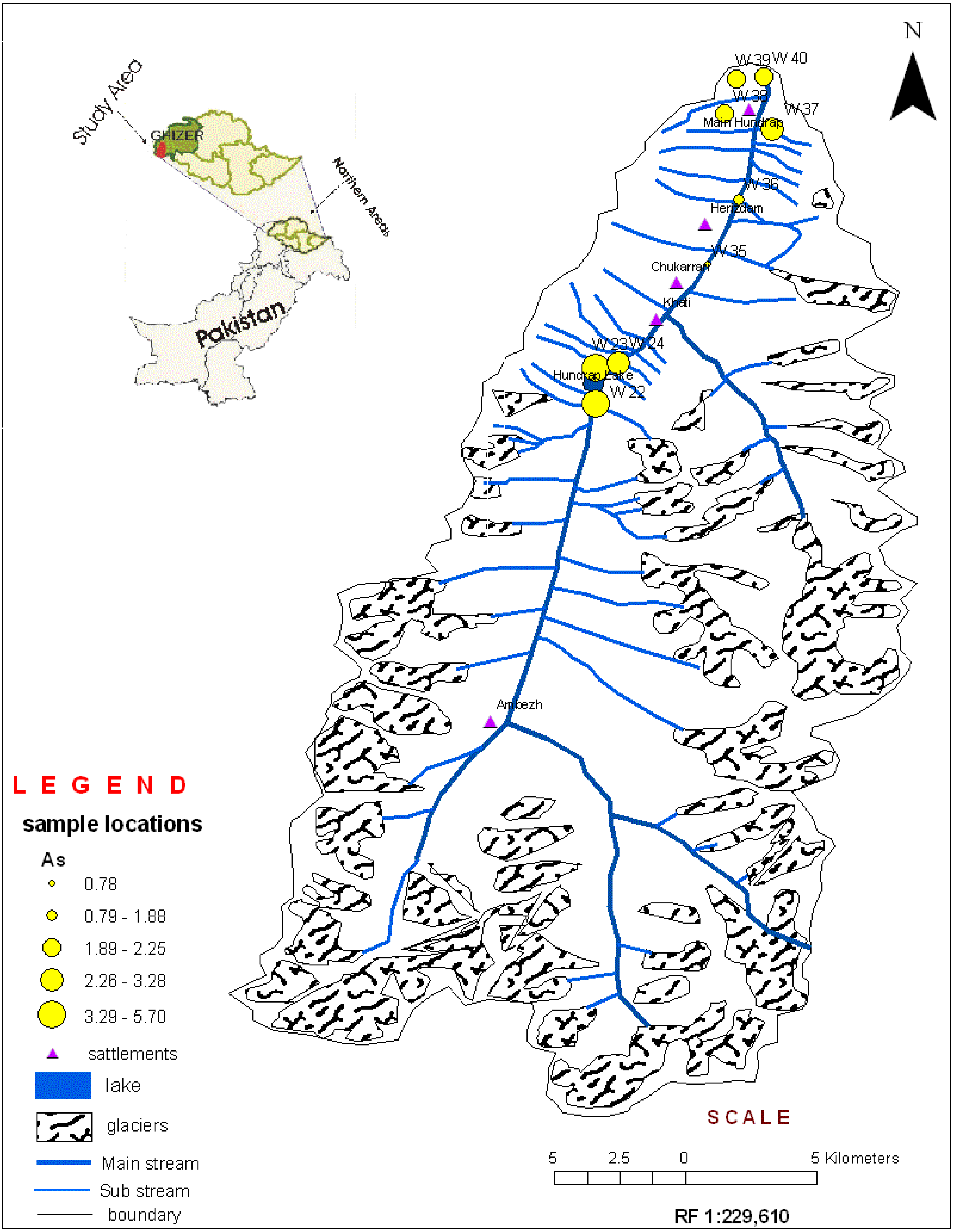

Fig.5.63. GIS based distribution pattern of As in the water of Hundrap lake and its streams at Hundrap.

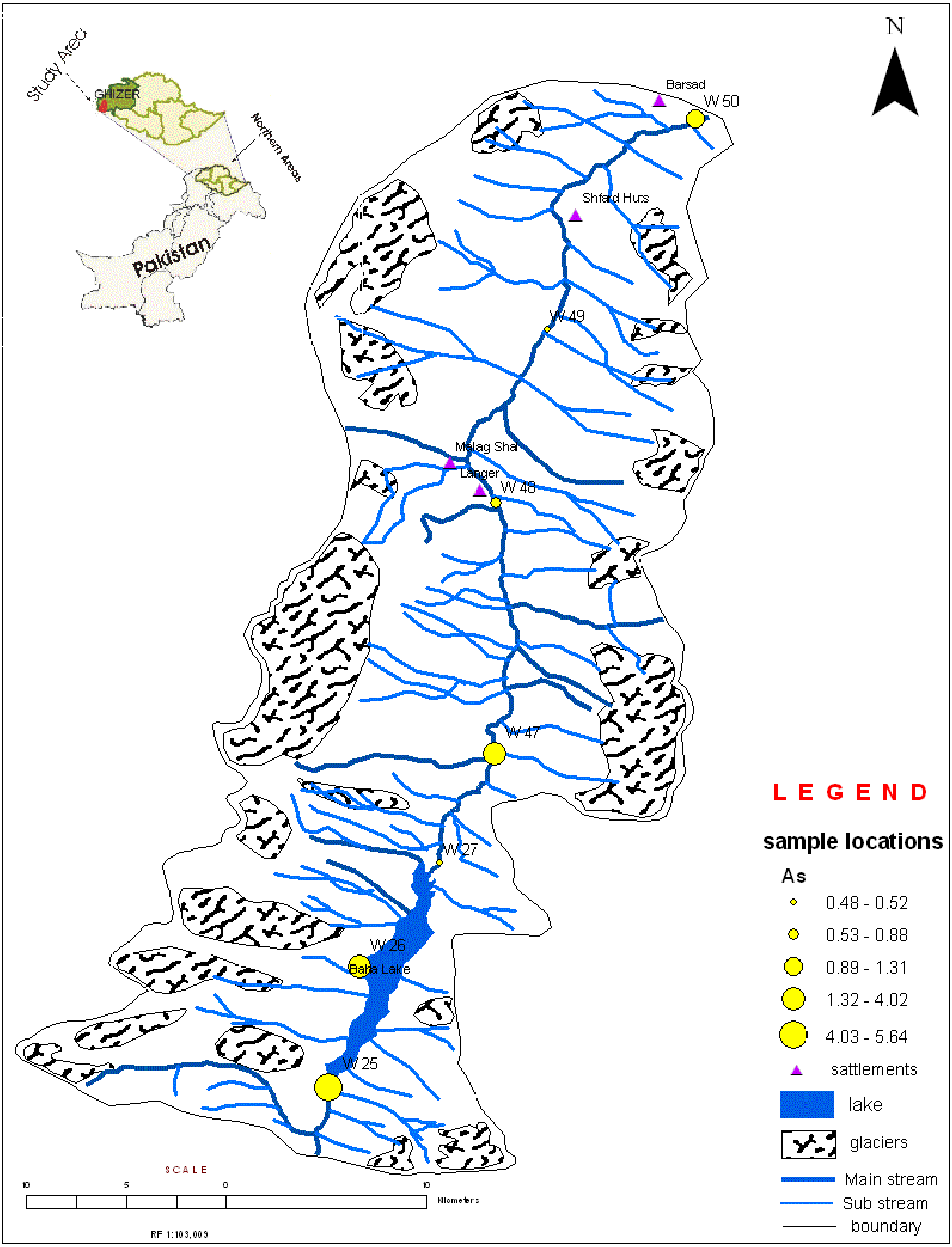

Fig.5.64. GIS based distribution pattern of As in the water of Baha lake and its streams at Khukosh.

CHAPTER 6

DISCUSSION

Water is a key to combat poverty, hunger, diseases and environmental degradation. Lack of data on water quality is hindering attempt to address water related issues in the region. Therefore, emerging issues to human health in the developing world due to access to unsafe drinking water and inappropriate sanitation facility. The provision of safe drinking water and hygienic sanitation to households and communities enhances health by reducing death and diseases through waterborne diseases such as, cholera, diarrhea and dysentery. Glaciers, springs ponds, and alpine lakes are the major water resources that fulfill the basic life requirements in the Gilgit, northern areas of Pakistan. People use the lakes' water for drinking and irrigation purposes. These lakes are also used by the grazing animals of the area. Besides fulfilling the basic needs of the inhabitants of the area, these lakes also have great significance in promotion of tourism in the region. The sustainable development especially in regard to the high altitude alpine lakes with their environmental conservation has always remained controversial due to remoteness. Therefore, the present study has been conducted in regard to the physico-chemical contamination in the high altitude alpine lakes and resulted environmental degradation in the Gilgit region. The geochemical data, obtained during this study for the water of high altitude alpine lakes and related streams were compared with the international water quality standards of WHO (2008) and USEPA (2009) and the quality of water was evaluated for domestic and irrigation purposes.

6.1. Physical parameters

The temperature in the water of the study area (i.e., Naltar wetland complex, Uttar, Hundrap and Baha lakes with their respective streams) was found lower than 8^oC. The low temperature can be attributed to the high altitude alpine zones and glaciers water.

The values of pH in all the representative water samples of lakes and streams, (Naltar wetland complex, Uttar, Hundrap and Baha lakes with their respective streams) varied from a minimum of 7.2 to maximum of 7.9 and was found within the permissible limit (6.5-8.5) set by WHO (2008) and USEPA (2009), therefore, the water is suitable for domestic as well as irrigation purposes.

The values of EC in all the representative water samples of high altitude alpine lakes and streams in the Naltar wetland complex, Uttar, Hundrap and Baha lakes and their respective streams varied from 106-281µs/cm, 128-217µs/cm, 90-181µs/cm and 103-241µs/cm respectively. These results show that the values of EC in all the water samples of lakes and streams were found within the permissible limit (1400) set by WHO (2008). Due to the low value of EC in the water the values of resistivity were found very high (i.e., >5 KΩ).

The values of TDS in all the water samples of lakes and streams in the study areas were found to be <181mg/L which were within the permissible limit of 1000mg/L of WHO and 500mg/L of USEPA.

The values of turbidity and salinity in all the water samples of lakes and streams in the study area were found to be <5 NTU and <3.8, respectively and was found within the permissible limit of WHO (2008) and USEPA (2009). However, it was noted that the turbidity was zero at lakes, while it slightly increased in down streams the lakes.

6.2. Anions

The concentrations of anions such as Cl^-, SO_4^{-2} and NO_3^- in Naltar (Naltar wetland complex and its stream) were found to be <42mg/L, <28mg/L and <5mg/L respectively, which were found within the permissible limit set by WHO (2008) and USEPA (2009). However, HCO_3^- was found higher (up to 320mg/L) than the limit of 250mg/L set by WHO (2008). Therefore, the concentrations of anions in Naltar were found in the order of $HCO_3^- > SO_4^{-2} > Cl^- > NO_3^-$ and water is considered as HCO_3^- type. In Iskoman (Uttar lake and its stream), the concentrations of $Cl,^-$ SO_4^{-2} and NO_3^- were found to be <29mg/L, <27mg/L and <3mg/L respectively, and were within the permissible limits set by WHO (2008) and USEPA (2009). HCO_3^- was found higher (up to 360mg/L) than the limits of 250mg/L set by WHO (2008). Therefore, the concentrations of anions in Iskoman were found in the order of $HCO_3^- > SO_4^{-2} > Cl^- > NO_3^-$ and water is considered as HCO_3 type. In Hundrap (Hundrap lake and its stream), the concentrations of Cl^-, SO_4^{-2} and NO_3^- were found to be <23mg/L, 27mg/L and <2mg/L respectively, which were within the permissible limits set by WHO (2008) and USEPA (2009). However, HCO_3^- was found higher (up to 360mg/L) than the permissible limit of 250mg/L set by WHO (2008). The concentrations of anions in Hundrap were found in the order of $HCO_3^- > SO_4^{-2} > Cl^- > NO_3^-$, therefore, water is considered as HCO_3^- type. In Khukosh (Baha lake and its stream), the concentration of anions such as Cl^-, SO_4^{-2} and NO_3^- and HCO_3^- were found to be <23mg/L, <50mg/L, <3mg/L and <210mg/L, respectively, and were within the permissible limits set by WHO (2008) and USEPA (2009). The concentrations of anions in Khukosh were found in the order of $HCO_3^- > SO_4^{-2} > Cl^- > NO_3^-$, therefore water is considered as $HCO3^-$ type.

On the basis of these results, it was concluded that the water of high altitude alpine lakes with their relevant streams of the Gilgit and Ghizar Districts Northern Areas of Pakistan have the concentration of anions below the permissible limit except $HCO3^-$ which was found relatively higher than the permissible limit set by WHO (2008) and USEPA (2009). This high concentration of HCO_3^- in the water can be attributed to the peculation of water through the HCO_3^- rocks i.e. limestone, dolomite, as the solubility of Na_2CO_3 and $CaCO_3$ in water is also one of the main reasons to influence the $HCO3^-$ concentration in water bodies.

6.3. Light elements

The concentrations of light elements such as Na, K, Ca, and Mg in Naltar wetland complex and its related streams were found to be <35mg/L, <5mg/L, <57mg/L and <39mg/L, respectively, which were found within the permissible limit set by WHO (2008). The concentrations of light elements in Naltar were found in the order of Ca>Mg> Na > K. The high concentration of Ca relative to other light elements could be due to the weathering and decomposition of calastic sedimentary rocks, which are dominantly present in Naltar. The concentrations of Na, K, Ca, and Mg in Iskoman (Uttar lake and its stream) were found to be <124mg/L, <5mg/L, <74mg/L and <30mg/L respectively and were found within the permissible limits set by WHO (2008). The concentrations of light element in Iskoman were found in the order of Ca>Mg> Na > K. This high concentration of Ca could be due to the joining of sub streams to main stream having exposure of marble in the catchments areas. Calcium leached from these marble during weathering and dissolved therefore, increases Ca concentration in lake water. In Hundrap (Hundrap lake and its stream) the concentrations of Na, K, Ca, and Mg were found to be <34mg/L, <4mg/L, <59mg/L and <26mg/L respectively, which were found within the permissible limits set by WHO (2009). The concentration of light elements in Hundrap found in the order of Ca> Mg > Na >K. This high concentration of Ca in the water samples with respect to other light elements in the region was purely due to the wreathing of calc alkaline gabbroic rocks and hornblende cumulates that contains Ca as a major constituent, which probably leached into the sub streams and then into main stream. In Khukosh (Baha lake and its stream) the concentrations of Na, K, Ca, and Mg were found to be <141mg/L, <5mg/L, 51mg/L and <28mg/l respectively and is within the permissible limit set by WHO (2008). The concentration of anions in Khukosh region were found in the order of Na > Ca > Mg > K.

It is concluded that, the lakes and streams water in the Gilgit and Ghizar Districts Northern Areas of Pakistan are having the concentration of light elements below the permissible limit set by WHO (2009), and water is suitable for domestic purposes.

6.4. Heavy metals

The concentrations of trace and heavy metals in water of high altitude alpine lakes with their related streams (i.e., Naltar wetland complex, Uttar, Hundrap and Baha lakes with their respective streams) are compared with the international water quality standards i.e., WHO-2008 and USEPA- 2009, to evaluate the quality of water in these regions.

The concentrations of Mn in the water of lakes and streams found below the detection level (<0.5μg/L) in most of the water samples. The observed concentrations of Mn in rest of the water samples in the Naltar wetland complex, Uttar, Hundrap, and Baha lakes with their respective streams were found to be <110μg/L, <30μg/L, <40μg/L, and <30μg/L respectively, which were found within the permissible limits set by WHO-500μg/L. However, in some of the Naltar lakes water samples, the concentration of Mn was found slightly higher than the USEPA (2009). This higher concentration of Mn in Naltar lakes will lead to taste problem in the water and also health related problems such as physiological and particularly neurological disorder (Criddle, 1992).

The concentrations of Fe in the water of Naltar wetland complex, Uttar, Hundrap, and Baha lakes with their respective streams were found to be <876μg/l, <782μg/L, <629μg/L, and <332μg/L respectively. These results showed that the concentrations of Fe in Naltar wetland complex and its related streams were found within the permissible limit set by WHO (2008). The samples W2 and W3, collected from the centre and outlet parts of Naltar lake1 (Bodorok bari), having concentration of 479μg/L and 877μg/L respectively showed slightly higher than the permissible limit (300μg/L) of WHO (2008). In Iskoman (Uttar lake and its stream), the concentrations of Fe were found within the permissible limit set by WHO (2008) and USEPA (2009) in all the stream water samples while in lake’s water samples the concentration of Fe was found slightly higher than the permissible limit of (300μg/L) of WHO (2008). In Hundrap (Hundrap lake and its stream), the concentrations of Fe were found within the permissible in all the water samples except sample W40, collected from the end of the Hundrap population has the concentration of 628μg/L which was found higher than the permissible limit of (300μg/L) set by WHO (2008) and USEPA (2009). In Khukosh (Baha lake and its stream), all the water samples showed the concentration of Fe within the permissible limit set by WHO (2008) and USEPA (2009). The concentrations of Fe were found slightly increases from the permissible limit set by WHO (2008), in Naltar lake1 (Bodorok bari) and Uttar lake, therefore, it can cause the small intestine infection (Bhattacharjee, 2001), and secondary hemochromtosis in which iron gets accumulated in liver and heart, even death in young children (Bothwell et al,.1979).

The measured concentrations of Cu in Naltar wetland complex, Uttar, Hundrap, and Baha lakes and their related streams were found to be <84µg/L, <31.38µg/L, <8.25µg/L and <4µg/L, respectively, which are within the permissible limits set by WHO (2008) and USEPA (2009).

The concentrations of Pb in the water of lakes and streams were found below the detection level (<0.5µg/L) in most of the water samples. However, the obtained values of Pb in the Naltar wetland complex, Uttar, Hundrap, and Baha lakes and their related streams were found to be <10µg/L, <7µg/L, <2µg/L and <7µg/L, respectively. These results showed that, in all the lakes and associated streams the Pb concentration was found within the permissible limit of WHO (2008).

The calculated concentrations of Zn in Naltar wetland complex, Uttar, Hundrap, and Baha lakes with their respective streams were found to be <601µg/L, <1283µg/L, <929µg/L and <623µg/L respectively, which were found within the permissible limit of WHO (2008).

The concentrations of Ni in most of the water samples of areas under investigation were found below the detection level (<0.5µg/L). The measured concentrations of Ni in water of Naltar wetland complex, Uttar, Hundrap, and Baha lakes with their respective streams were found to be <29µg/L, <17µg/L, <4µg/L and <5µg/L respectively, and are within the permissible limit. The sample W1, collected from Naltar region has higher Ni concentration of 29µg/L as compared to the permissible limit set by WHO (2008). This increase of Ni concentration can be attributed to the volcanic rocks present at the region.

The concentration of Cr in all the representative water samples of lakes and streams of Naltar wetland complex, Uttar, Hundrap, and Baha lakes with their respective streams were found <8µg/L, which were found within the permissible limit set by WHO (2008).

The concentration of Cd in the water of lakes and streams of the areas studied (i.e., Naltar wetland complex, Uttar, Hundrap, and Baha lakes with their respective streams), were found to be <5µg/L, <4µg/L, 4µg/L and <3µg/L respectively. These results showed that the concentrations of Cd in most of the representative water samples were found within the permissible limits set by WHO (2008). However, some of the water samples collected from Naltar, Iskoman and at Hundrap regions have slightly increase of Cd concentration from the permissible limit of 3µg/L set by WHO (2008). This increase of Cd concentrations in such areas can causes intestinal, lung and kidney damage problems (Barrento et al., 2009).

Mercury has been found below the detection level (0.05µg/L) in all the representative water samples of lakes and related streams of areas under investigation. While the concentrations of As in the water of Naltar wetland complex, Uttar, Hundrap, and Baha lakes with their respective streams were found to be <4µg/L, <5µg/L, <6µg/L and <6µg/L, respectively and are within the permissible limit of 10µg/L set by WHO (2008).

6.5. Statistical analysis of water quality.

In order to identify the interaction between physio-chemical parameters in the water of Naltar wetland complex, Uttar, Hundrap, and Baha lakes with their respective streams (Tables 7.1, 7.2, 7.3 and 7.4), a statistical method of SPSS like Pearson’s correlation was applied on representative water samples of these areas (Muhammad et al., 2010). The correlation was done for the selected physio-chemical parameters such as, pH, EC, TDS, Cl, SO_4, NO_3, HCO_3, Na, K, Ca, Mg, Mn, Fe, Cu, Pb, Zn, Ni, Cr, Cd and As.

Table.7.1 showed the interrelationship of selected physio-chemical parameters in Naltar (Naltar wetland complex and its stream). The correlation matrix showed that some of the parameter pairs had no any interrelationship, however, strong positive correlation was found between pairs such as EC-TDS (r =.587), EC-K (r =.580), Cl-HCO_3 (r =. 585), Cl-Ca (r =.712), Cl-Mg (r =.747), Cl-Zn (r =.544), Na-Mg (r =.630), K-Ca (r =.652), K-Mg (r =.583), Ca-Mg (r =.762), Ca-Zn (r =.688), Mg-Zn (r =.695), Cu-Ni (r =.930), Cu-Cr (r =.682), and Ni-Cr (r =.711), and strong negative correlation between pairs such as EC-As (r=-.525), K-As (r=-.723) and Ca-As (r=-.605) were found between most of the parameters pairs in Naltar.

The correlation matrix (Table.7.2) for Iskoman (Uttar lake and respective stream) indicated that the physio-chemical parameter pairs which have strong positive correlations were found as EC-TDS (r =.825), EC-NO_3 (r =.577), TDS-NO_3 (r =.711), Cl-HCO_3 (r =.818), Cl-Ca (r =.679), Cl-Mg (r =.609), Cl-Pb (r =.571), Cl-Zn (r =.739), SO_4-HCO_3 (r =.620), SO_4-K (r =.919), SO_4-Ca (r =.728), SO_4-Zn (r =.555), HCO_3-Ca (r =.904), HCO_3-Mg (r =.790), HCO_3-Pb (r =.657), HCO_3-Zn (r =.890), Na-Mg (r =.759), K-Ca (r =.707), Ca-Mg (r =.634), Ca-Zn (r =.793), Mg-Zn (r =.691), Fe-As (r =.919), Cu-Ni (r= 973), Pb-Zn (r =.625), Pb-Cd (r =.573) and Zn-Cd (r =.623) and strong negative correlations as, pH-Cl (r =-.813), pH- HCO_3 (r =-.558), pH-Zn (r =-.702), pH-Cd (r =-.519), EC-Pb (r =-.741), EC-Cd (r =-.735), TDS-Pb (r =-.589), TDS-Cd (r =-.764), Cl-Mn (r =-.565), Cl-Fe (r =-.647), Cl-As (r =-.566), SO_4-Fe (r =-.560), SO_4-As (r =-.581), NO_3-Fe (r =-.717), NO_3-Cd (r =-.690), NO_3-As (r =-.543), HCO_3-Mn (r =-.598), HCO_3-Fe (r =-.651), HCO_3-As (r =-.632), K-Fe (r =-

.600) K-As (r =-.683), Ca-Fe (r = 773), Ca-As (r = 829), Mg-Mn (r =-.738) and Mn-Zn (r =-.523).

The correlation matrix (Table.7.3) for Hundrap (Hundrap lake and respective stream) indicated that, the physio-chemical parameter pairs which have strong positive correlations were found as EC-SO_4 (r =.862), EC-HCO_3 (r =.779), EC-Na (r =.532), EC-K (r =.542), TDS-Cl (r =.549), TDS-NO_3 (r =.823), TDS-Na (r =.584), TDS-K (r =.884), TDS-Ca (r =.712), TDS-Mg (r =.761), TDS-Mn (r =.511), TDS-Fe (r =.621), TDS-Pb (r =.777), TDS-Cr (r =.574), Cl-SO_4 (r =.700), Cl-Na (r =.537), Cl-K (r =.705), Cl- Ca (r =.957), Cl-Mg (r =.889), Cl-Mn (r =.787), Cl-Pb (r =.610), Cl-Zn (r =.605), Cl- Ni (r =.543), SO_4-Na (r =.734), SO_4-K (r =.698), SO_4-Ca (r =.664), SO_4-Mg (r =.764), SO_4-Zn (r =.730), NO_3-K (r =.594), NO_3-Ca (r =.569), NO_3-Mg (r =.534), NO_3-Pb (r =.607), NO_3-Cr (r =.595), Na-K (r =.869), Na-Ca (r =.652), Na-Mg (r =.825), Na-Zn (r =.717), K-Ca (r =.839), K-Mg (r =.926), K-Mn (r =.605), K-Pb (r =.789), K-Cr (r =.596), Ca-Mg (r =.936), Ca-Mn (r =.861), Ca-Pb (r =.709), Ca-Zn (r =.558), Ca-Ni (r =.608), Ca-Cr (r =.513), Mg-Mn (r =.668), Mg-Pb (r =.660), Mg-Zn (r =.674), Mg-Cr (r =.552), Fe-Pb (r =.679), Pb-Ni (r =.742), and Pb-Cr (r =.622) and the parameter pairs which have strong negative correlations were found as pH-Cd (r =-.545), TDS-As (r =-.506), Cl-As (r =-.829), SO4-As (r =-.676), Na-Cu (r =-.536), K-As (r =-.609), Ca-As (r =-.815), Mg-As (r =-.709), Pb-As (r =-.602) and Ni-As (r =-.658)

The correlation matrix (Table.7.4) for Khukosh (Baha lake and respective stream) indicated that, the physio-chemical parameter pairs which have strong positive correlations were found as, pH-HCO_3 (r =.561), EC-TDS (r =.867), EC-NO_3 (r =.582) , EC-HCO_3 (r =.600), EC-K (r =.578), EC-Ca (r =.639), EC-NI (r =.669), TDS-HCO_3 (r =.641), TDS-K (r =.684), TDS-Ca (r =.725), TDS-Zn (r =.569), Cl-

HCO_3 (r =.528), Cl-Na (r =.977), Cl-K (r =.629), Cl-Mg (r =.984), SO_4-NO_3 (r =.928), SO_4-Ni (r =.952), NO_3-Cu (r =604), NO_3-Ni (r =952), HCO_3-Na (r =675), HCO_3-K (r =.511), HCO_3-Mg (r =.592), Na-K (r =.617), Na-Ca (r =.506), Na-Mg (r =.975), K-Ca (r =.963), K-Mg (r =.661), K-Zn (r =.569), Ca-Mg (r =.514), Ca-Zn (r =.631), Mn-Cr (r =.525), Fe-As (r =.724) and Cu-Pb (r =.657) and the parameter pairs which have strong negative correlations were found as EC-As (r =-.652), TDS-Cd (r =-.570), TDS-As (r =-.646), Cl-Fe (r =-.615), Cl-Cu (r =-.599), Cl-As (r =-.592), SO_4-Cr (r =-.636), NO_3-Cr (r =-.760), HCO_3-Cu (r =-.526), HCO_3-As (r =-.734), Na-Fe (r =-.619), Na-Cu (r =-.683), Na-As (r =-.635), K-Fe (r =-.574), K-Pb (r =-.624), K-As (r =-.840), Ca-Fe (r =-.650) Ca-Pb (r =-.576), Ca-As (r =-.833), Mg-Fe (r =-.545), Mg-Cu (r =-.600), Mg-Ni (r =-.527), Mg-As (r =-.609), Mn-Fe (r =-.565), Fe-Zn (r =-.504), Cu-Cr (r =-.730), Zn-Cd (r =-.617) and Ni-Cr (r =-.703).

Table.6.1. Pearson’s correlationship matrix of physio-chemical pairs in Naltar (Naltar wetland complex and related stream)

Correlations

	pH	EC	TDS	Cl^-	SO_4^-	NO_3^-	HCO_3^-	Na	K	Ca	Mg	Mn	Fe	Cu	Pb	Zn	Ni	Cr	Cd	As
pH	1	-.067	-.009	-.217	.016	.072	.041	.031	-.118	-.179	-.093	.209	-.084	.010	-.044	-.236	.034	.043	-.244	.015
EC		1	.587**	.117	.468**	.401**	.226	.099	.580**	.186	.177	-.235	.072	.099	-.284*	.029	.161	.047	-.134	-.525**
TDS			1	.283*	.355*	.323*	.221	.211	.481**	.342*	.287*	-.196	.095	.030	-.129	.051	.092	.111	-.166	-.442**
Cl^-				1	.281*	.266	.558**	.427**	.478**	.712**	.747**	-.234	-.201	-.034	.106	.544**	.071	.126	-.088	-.401**
SO_4^-					1	.404**	.288*	.065	.399**	.483**	.255	-.301*	-.073	.056	-.053	.333*	.153	-.008	-.071	-.335*
NO_3^-						1	.103	-.102	.483**	.174	.244	-.145	-.244	-.102	-.023	-.027	.002	-.062	-.288*	-.373**
HCO_3^-							1	.280*	.378**	.457**	.417**	-.287*	-.076	-.085	.181	.306*	.031	.052	-.074	-.342*
Na								1	.362**	.421**	.630**	-.141	-.196	-.097	-.149	.307*	-.114	-.057	-.126	-.353*
K									1	.652**	.583**	-.067	-.094	.026	-.097	.356*	.133	.068	-.028	-.723**
Ca										1	.762**	-.203	-.152	.022	.106	.688**	.123	.108	.009	-.605**
Mg											1	-.242	-.114	-.055	-.018	.695**	-.025	.127	-.033	-.468**
Mn												1	.077	.233	.083	-.188	.241	.364**	.306*	-.002
Fe													1	.104	-.080	-.193	.198	.371**	.309*	.295*
Cu														1	.205	-.085	.930**	.682**	.122	-.023
Pb															1	.032	.196	.131	-.128	.069
Zn																1	-.106	.083	.194	-.281
Ni																	1	.711**	.131	-.111
Cr																		1	.363**	-.044
Cd																			1	.111
As																				1

** Correlation is significant at the 0.01 level (2-tailed).
 * Correlation is significant at the 0.05 level (2-tailed).

Table.6.2. Pearson's correlationship matrix of physio-chemical pairs in Iskoman (Uttar lake and respective stream)

	pH	EC	TDS	Cl^-	SO_4^-	NO_3^-	HCO_3^-	Na	K	Ca	Mg	Mn	Fe	Cu	Pb	Zn	Ni	Cr	Cd	As
pH	1	.174	.324	-.813**	-.320	.036	-.558	.370	-.107	-.410	-.290	.285	.184	.388	-.387	-.702*	.366	-.190	-.519	.243
EC		1	.825**	-.152	.114	.577	-.361	.056	.245	-.125	-.159	.410	-.209	-.181	-.741*	-.413	-.238	-.126	-.735*	-.288
TDS			1	-.046	-.091	.711*	-.217	.370	.041	-.079	.119	.151	-.412	-.247	-.589	-.462	-.282	-.231	-.764*	-.336
Cl^-				1	.478	.356	.818**	.044	.263	.679*	.609	-.565	-.647	-.437	.571	.739*	-.393	.094	.291	-.566
SO_4^-					1	.352	.620	.179	.919**	.728*	.281	-.221	-.560	-.130	.408	.555	-.113	.140	.117	-.581
NO_3^-						1	.106	.136	.362	.179	.087	-.138	-.717*	-.369	-.080	-.211	-.315	-.423	-.690*	-.543
HCO_3^-							1	.427	.476	.904**	.790*	-.598	-.651	-.333	.657	.890**	-.296	.159	.471	-.632
Na								1	.198	.425	.759*	-.427	-.387	-.131	.056	.221	-.210	.130	-.136	-.336
K									1	.707*	.109	.103	-.600	-.078	.147	.352	-.018	-.030	.017	-.683*
Ca										1	.634	-.267	-.773*	-.134	.453	.793*	-.079	.194	.335	-.829**
Mg											1	-.738*	-.468	-.354	.397	.691*	-.430	.293	.204	-.413
Mn												1	.207	.358	-.682*	-.523	.427	-.135	-.147	.005
Fe													1	.265	-.231	-.344	.166	.187	.202	.919**
Cu														1	.129	-.182	.973**	.603	.141	.303
Pb															1	.625	.160	.315	.573	-.031
Zn																1	-.197	.416	.623	-.429
Ni																	1	.456	.164	.207
Cr																		1	.421	.189
Cd																			1	.152
As																				1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table.6.3. Pearson's correlationship matrix of physio-chemical pairs in Hundrap (Hundrap lake and respective stream).

Correlations

	pH	EC	TDS	Cl^-	SO_4^-	NO_3^-	HCO_3^-	Na	K	Ca	Mg	Mn	Fe	Cu	Pb	Zn	Ni	Cr	Cd	As
pH	1	.431	-.002	.204	.249	-.078	.478	-.249	-.090	.018	.071	-.081	-.276	-.024	-.032	.074	-.066	.234	-.545	-.111
EC		1	.374	.346	.862**	-.158	.779*	.532	.542	.330	.488	.210	.211	-.286	.404	.425	.210	.180	-.087	-.446
TDS			1	.549	.403	.823**	.344	.584	.884**	.712*	.761*	.511	.621	-.443	.777*	.127	.388	.574	.020	-.506
Cl^-				1	.700*	.430	.053	.537	.705*	.957**	.889**	.787*	-.111	-.131	.610	.605	.543	.441	-.253	-.829**
SO_4^-					1	-.054	.487	.734*	.698*	.664	.764*	.494	-.012	-.261	.479	.730*	.333	.217	-.033	-.676*
NO_3^-						1	-.038	.254	.596	.569	.534	.382	.488	-.204	.607	-.120	.278	.595	-.030	-.213
HCO_3^-							1	.204	.331	.017	.201	-.210	.397	-.384	.438	-.091	.031	.188	-.331	-.200
Na								1	.869**	.652	.825**	.406	.221	-.536	.470	.717*	.127	.409	.300	-.409
K									1	.839**	.926**	.605	.467	-.463	.789*	.470	.422	.596	.050	-.609
Ca										1	.936**	.861**	.111	-.183	.709*	.558	.608	.513	-.123	-.815**
Mg											1	.668*	.121	-.438	.660	.674*	.366	.552	-.017	-.709*
Mn												1	.139	.161	.583	.396	.823**	.354	-.124	-.791*
Fe													1	-.060	.679*	-.479	.430	.423	-.055	-.018
Cu														1	-.093	-.335	.410	-.200	-.128	.202
Pb															1	-.032	.742*	.622	-.379	-.602
Zn																1	-.069	.093	.288	-.421
Ni																	1	.358	-.431	-.658
Cr																		1	-.491	-.169
Cd																			1	.278
As																				1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table.6.4. Pearson's correlationship matrix of physio-chemical pairs in Khukosh (Baha lake and respective stream).

Correlations

	pH	EC	TDS	Cl^-	SO_4^-	NO_3^-	HCO_3^-	Na	K	Ca	Mg	Mn	Fe	Cu	Pb	Zn	Ni	Cr	Cd	As
pH	1	.380	.172	-.002	.416	.367	.561	.147	-.025	.120	-.049	.456	-.457	-.104	.057	-.087	.363	.174	.205	-.434
EC		1	.867*	-.084	.401	.582	.600	.018	.578	.639	-.008	-.367	-.102	.106	-.361	.147	.669	-.271	-.275	-.652
TDS			1	.108	.153	.326	.641	.216	.684	.725	.231	-.141	-.177	-.057	-.336	.569	.356	.003	-.570	-.646
Cl^-				1	-.357	-.407	.528	.977**	.629	.494	.984**	.252	-.615	-.599	-.476	.414	-.493	.293	.118	-.592
SO_4^-					1	.928**	-.172	-.348	.185	.403	-.442	-.092	-.369	.379	-.116	.025	.904**	-.636	-.029	-.214
NO_3^-						1	-.104	-.404	.274	.460	-.450	-.186	-.312	.604	.017	-.013	.952**	-.760*	-.253	-.351
HCO_3^-							1	.675	.511	.475	.592	.168	-.348	-.526	-.405	.275	-.051	.445	.016	-.734
Na								1	.617	.506	.975**	.321	-.619	-.683	-.493	.458	-.467	.420	.115	-.635
K									1	.963**	.661	-.187	-.574	-.176	-.624	.569	.219	-.259	-.302	-.840*
Ca										1	.514	-.098	-.650	-.108	-.576	.631	.394	-.302	-.355	-.833*
Mg											1	.228	-.545	-.600	-.464	.478	-.527	.350	.006	-.609
Mn												1	-.565	-.139	.475	.401	-.384	.525	-.219	-.104
Fe													1	.096	.124	-.504	-.104	.087	.167	.724
Cu														1	.657	-.293	.476	-.730	-.480	.072
Pb															1	-.221	-.146	-.007	-.400	.339
Zn																1	-.133	.273	-.617	-.370
Ni																	1	-.703	-.080	-.257
Cr																		1	.134	.162
Cd																			1	.251
As																				1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

6.6. Health risk assessment

The local people were interviewed in the selected areas for the information such as living standard, health, economic conditions, dietary habit, and drinking water resources. It was generally noted that local people were directly using lakes, streams and springs water for their drinking and domestic purposes without any proper sanitations system. The main reasons for using such water resources for drinking and domestic purpose was remoteness, poverty and lack of awareness of local community in these regions.

Trace and heavy metals like Cr, Cd, Pb, Hg and As have a relatively high density and are toxic even at low concentrations. These trace and heavy metals are natural components of the earth crust but to a small extent they entered our bodies through food, air and drinking water. The trace and heavy metals are considered as toxic for human health, because in the body they bioaccumulate over the long period of time and effect body haematopoiesis and can lead to blood disorders. The human organs such as liver, kidney, circulatory and nervous systems may also be affected (Marques et al., 2001). For health risk assessment the average daily dose (ADD), hazard quotient (HQ) and cancer risk (CR) related to the trace and heavy metals (i.e., Mn, Fe, Cu, Pb, Zn, Ni, Cr, Cd and As) in the water of lakes and streams of the study areas (Naltar wetland complex, Uttar, Hundrap and Baha lakes with their respective streams) were calculated by using an approach set by USEPA (1999). Health risk assessment is generally based on a quantification of health risk level in relation to two types of adverse effects such as chronic (noncarcinogenic) and carcinogenic. Chronically health risk (i.e., ADD and HQ) in water was calculated by using the approach of USEPA (1999), as follow:

$$HQ = ADD / RfD$$

Where HQ mean hazard quotient, ADD, is average daily dose and RfD is reference dose (mg/kg-day), which differs for different elements.

$$ADD = \frac{C \times IR \times ED \times EF}{BW \times AT\ (ED \times EF)}$$

Where,

C = Concentration of metal.

IR = Ingestion rate unit /time = 2L

ED = Exposure duration = 67 (Year)

EF = Exposure frequency = 365 (Days)

BW = Body weight = 72 (Average)

AT = Average time (AT= ED x EF)

After the calculation

$$ADD = C \times 0.027$$

After calculation of ADD, the hazard quotient (HQ) was calculated as:

$$HQ = ADD/RfD$$

Carcinogenically health risk will be calculated as:

$$CR = ADD \times \text{Slope Factor}$$

For arsenic (As) Slope Factor was considered as 1.5

The calculated values of ADD, HQ and CR in the water of lakes and streams of the study area were given in Tables.6.5, 6.6, 6.7 and 6.8.

6.6.1. Average daily dose (ADD)

The calculated values of ADD in the water of Naltar (Naltar wetland complex and its related streams) (Table.7.5) suggested that, people who have consumed water contaminated with trace and heavy metals have ADD values for Mn ranged from 0-

2.97E-03 mg/kg-day, with an average value of 1.17E-03 mg/kg- day, Fe contaminated ranged from 0-2.36E-02 mg/kg-day with an average value of 3.07E-03 mg/kg-day, Cu contaminated ranged from 0-2.26E-03mg/kg-day with an average value of 2.37E-04 mg/kg-day, Pb contaminated ranged from 0-2.85E-04 mg/kg-day with an average value of 7.17E-05 mg/kg-day, Zn contaminated ranged from 0-1.62E-02 mg/kg-day with an average value of 1.26E-03 mg/kg-day, Ni contaminated ranged from 0-7.93E-04 mg/kg-day with an average value of 1.13E-04 mg/kg-day, Cr contaminated ranged from 1.08E-06-2.26E-04 mg/kg-day with an average value of 4.99E-05 mg/kg-day, Cd contaminated ranged from 0-1.29E-04 mg/kg-day with an average value of 6.01E-05 mg/kg-day and As contaminated ranged from 2.05E-05-1.11E-04 mg/kg-day with an average value of 6.21E-05 mg/kg-day.

The calculated values of ADD in Iskoman (Uttar lake and respective stream) (Table.7.6) suggested that, people who have consumed water contaminated with trace metals have ADD values for Mn ranged from 0-8.10E-04 mg/kg-day with an average value of 3.37E-04 mg/kg-day, Fe contaminated ranged from 0-2.11E-02 mg/kg-day with an average value of 6.99E-03 mg/kg-day, Cu contaminated ranged from 0-8.47E-04 mg/kg-day with an average value of 2.28E-04 mg/kg-day, Pb contaminated ranged from 0-1.79E-04 mg/kg-day with an average value of 5.96E-05 mg/kg-day, Zn contaminated ranged from 2.21E-04-3.46E-02 mg/kg-day with an average value of 6.93E-03 mg/kg-day, Ni contaminated ranged from 0-4.49E-04 mg/kg-day with an average value of 1.10E-04 mg/kg-day, Cr contaminated ranged from 1.18E-05-8.20E-05 mg/kg-day with an average value of 3.80E-05 mg/kg-day. Cd contaminated ranged from 1.02E-05-1.33E-04 mg/kg-day with an average value of 5.72E-05 mg/kg-day and As contaminated ranged from 8.64E-06-1.40E-04 mg/kg-day with an average value of 5.25E-05mg/kg-day.

The calculated values of ADD in Hundrap (Hundrap lake and respective stream) (Table.7.7) indicated that, people who have consumed water contaminated with Mn the value of ADD ranged from 0-1.08E-03 mg/kg-day with an average value of 4.20E-04 mg/kg-day, Fe contaminated with ranged from 1.62E-04-1.69E-02 mg/kg-day with an average value of 4.44E-03 mg/kg-day, Cu contaminated ranged from 4.64E-05-2.22E-04 mg/kg-day with an average value of 1.01E-04 mg/kg-day, Pb contaminated ranged from 0-1.53E-04 mg/kg-day with an average value of 5.46E-05 mg/kg-day, Zn contaminated ranged from 4.70E-04-2.50E-02 mg/kg-day with an average value of 9.76E-03 mg/kg-day, Water consumed Ni contaminated ranged from 0-1.05E-04 mg/kg-day with an average value of 2.64E-05 mg/kg-day, Cr contaminated ranged from 1.62E-05-6.88E-05 mg/kg-day with an average value of 4.84E-05 mg/kg-day, Cd contaminated ranged from 3.69E-05-1.14E-04 mg/kg-day with an average value of 7.36E-05 mg/kg-day and As contaminated ranged from 2.10E-05-1.53E-04 mg/kg-day with an average value of 8.04E-05mg/kg-day.

The calculated values of ADD in Khukosh (Baha lake and respective stream) (Table.7.8) showed that, people who have consumed water contaminated with Mn the value of ADD ranged from 0-8.10E-04 mg/kg-day with an average value of 5.01E-04 mg/kg-day, Fe contaminated ranged from 0-8.98E-03 mg/kg-day with an average value of 2.26E-03 mg/kg-day, Cu contaminated ranged from 0-1.19E-04 mg/kg-day with an average value of 6.11E-05 mg/kg-day, Pb contaminated ranged from 0-1.86E-04 mg/kg-day with an average value of 3.74E-05 mg/kg-day, Zn contaminated ranged from 5.27E-04-1.68E-02 mg/kg-day with an average value of 4.60E-03 mg/kg-day, Ni contaminated ranged from 0-1.27E-04 mg/kg-day with an average value of 2.73E-05 g/kg-day, Cr contaminated ranged from 0-3.51E-05 mg/kg-day with an average value of 1.99E-05 mg/kg-day, Cd contaminated ranged from 8.10E-06-7.37E-05 mg/kg-day with an average value of 3.74E-05 mg/kg-day and As contaminated ranged from 1.26E-05-1.52E-04 mg/kg-day with an average value of 6.15E-06mg/kg-day.

6.6.2. Hazard quotient (HQ)

The calculated values of HQ in the water of lakes and streams of the study area (Naltar wetland complex, Uttar, Hundrap and Baha lakes with their respective streams) were given in the Table.7.5, 7.6, 7.7 and 7.8. The calculated values of HQ in Naltar wetland complex and their related stream (Table.7.5) indicated that people who have consumed drinking contaminated with trace and heavy metals had the HQ values ranged from 0.00-0.02, 0.00-0.03, 0.00-0.06, 0.00-0.07, 0.00-0.05, 0.00-0.03, 0.00-0.00, 0.00-0.25 and 0.06-0.37 with an average values of 0.00, 0.00, 0.00, 0.01, 0.00, 0.00, 0.00, 0.12 and 0.20 for Mn, Fe, Cu, Pb, Zn, Ni, Cr, Cd and As respectively.

The HQ values in Iskoman (Uttar lake and related streams) (Table.7.6) indicated that people who have consumed drinking water contaminated with trace and heavy metals had the HQ values ranged from 0.00-0.00, 0.00-0.03, 0.00-0.02, 0.00-0.04, 0.00-0.11, 0.00-0.02, 0.00-0.00, 0.02-0.26 and 0.02-0.46 with an average values of 0.00, 0.00, 0.00, 0.01, 0.02, 0.00, 0.00, 0.11 and 0.17 for Mn, Fe, Cu, Pb, Zn, Ni, Cr, Cd and As respectively.

The HQ values in Hundrap (Hundrap lake and related streams) (Table.7.7), indicated that the people who have consumed drinking water contaminated with trace and heavy metals had the HQ values ranged from 0.00-0.00, 0.00-0.02, 0.00-0.00, 0.00-0.04, 0.00-0.08, 0.00-0.00, 0.00-0.00, 0.07-0.22 and 0.07-0.51 with an average values of 0.00, 0.00, 0.00, 0.01, 0.03, 0.00, 0.00, 0.14 and 0.26 for Mn, Fe, Cu, Pb, Zn, Ni, Cr, Cd and As respectively. The HQ values in Khukosh (Baha lake and related streams), the calculated values of HQ (Table.7.8), indicated that people who have consumed drinking water contaminated with trace and heavy metals had the HQ values ranged from 0.00-0.00, 0.00-0.01, 0.00-0.00, 0.00-0.05, 0.00-0.05, 0.00-0.00, 0.00-0.00, 0.01-0.14 and 0.04-0.50 with an average values of 0.00, 0.00, 0.00, 0.01, 0.01, 0.00, 0.00, 0.06 and 0.20 for Mn, Fe, Cu, Pb, Zn, Ni, Cr, Cd and As respectively.

The above calculated values of HQ in the water of lakes and streams of the study area were compared with the USEPA, 1999 approach in order to assesst the chronic risk of trace and heavy metals (i.e., Mn, Fe, Cu, Pb, Zn, Ni, Cr, Cd and As), and it was found that all the trace and heavy metals had the average value HQ <1 except Fe, therefore, these metals have no any chronic health risk in the water of areas studied.

6.6.3. Cancer risk (CR)

Carsinogenically health risk assessment like cancer risk (CR) for As were calculated in the water of lakes and stream of the study area (Naltar wetland complex, Uttar, Hundrap and Baha lakes with their respective streams) which are given in the Table.7.5, 7.6, 7.7 and 7.8. The values of CR in the study area ranged from 3.07E-05-1.67E-04, 1.29E-05-2.11E-04, 15E-05-2.30E-04 and 1.90E-05-2.28E-04 with average values of 9.32E-05, 7.87E-05, 1.20E-04 and 9.23E-05 for Naltar wetland complex Uttar, Hardpan and Baha lakes with their related streams respectively, which were vary low (<1per 1,000,000 inhabitants) set by USEPA (1999), therefore As has no any carcinogenic risk in the water of study area.

Table.6.5. Health risk assessment (ADD, HQ and CR) of trace and heavy metals in Naltar (Naltar wetland complex, and their related stream)

Site 1 Naltar (Naltar wetland complex and its stream)	**Mn**	**Fe**	**Cu**	**Pb**	**Zn**	**Ni**	**Cr**	**Cd**	**As**
ADD (mg/kg-day)									
Range	0-2.97E-03	0-2.36E-02	0-2.26E-03	0-2.85E-04	0-1.62E-02	0-7.93E-04	1.08E-06-2.26E-04	0-1.29E-04	2.05E-05-1.11E-04
Average	1.17E-03	3.07E-03	2.37E-04	7.17E-05	1.26E-03	1.13E-04	4.99E-05	6.01E-05	6.21E-05
Std dev	2.84E-04	9.27E-03	3.32E-04	6.71E-05	1.10E-02	1.71E+04	2.25E-05	4.05E-05	4.81E-05
HQ									
Range	0.00-0.02	0.00-0.03	0.00-0.06	0.00-0.07	0.00-0.05	0.00-0.03	0.00-0.00	0.00-0.25	0.06-0.37
Average	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.12	0.20
Std dev	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.07	0.08
CR									
Range	ND	ND	ND	ND	ND	ND	ND	ND	3.07E-05-1.67E-04
Average	ND	ND	ND	ND	ND	ND	ND	ND	9.32E-05
Std dev	ND	ND	ND	ND	ND	ND	ND	ND	3.82E-05

*****ADD (Average daily dose)

*HQ (Hazard quotient)

* CR (Cancer risk)

*Std dev (Standard deviation)

* ND (Not determined)

Table.6.6. Health risk assessment (ADD, HQ and CR) of trace and heavy metals in Iskoman (Uttar lake and respective stream)

Site 2 Iskoman (Uttar lake and its streams)	**Mn**	**Fe**	**Cu**	**Pb**	**Zn**	**Ni**	**Cr**	**Cd**	**As**
ADD (mg/kg-day)									
Range	0-8.10E-04	0-2.11E-02	0-8.47E-04	0-1.79E-04	2.21E-04-3.46E-02	0-4.49E-04	1.18E-05-8.20E-05	1.02E-05-1.33E-04	8.64E-06-1.40E-04
Average	3.37E-04	6.99E-03	2.28E-04	5.96E-05	6.93E-03	1.10E-04	3.80E-05	5.72E-05	5.25E-05
Std dev	2.84E-04	9.27E-03	3.32E-04	6.71E-05	1.10E-02	1.71E-04	2.24E-05	4.05E-05	4.81E-05
HQ									
Range	0.00-0.00	0.00-0.03	0.00-0.02	0.00-0.04	0.00-0.11	0.00-0.02	0.00-0.00	0.02-0.26	0.02-0.46
Average	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.11	0.17
Std dev	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.08	0.16
CR									
Range	ND	ND	ND	ND	ND	ND	ND	ND	1.29E-05-2.11E-04
Average	ND	ND	ND	ND	ND	ND	ND	ND	7.87E-05
Std dev	ND	ND	ND	ND	ND	ND	ND	ND	7.21E-05

*****ADD (Average daily dose)

*HQ (Hazard quotient)

* CR (Cancer risk)

*Std dev (Standard deviation)

* ND (Not determined)

Table.6.7. Health risk assessment (ADD, HQ and CR) of trace and heavy metals in Hundrap (Hundrap lake and respective stream)

Site 3 Hundrap (Hundrap lake and its streams)	**Mn**	**Fe**	**Cu**	**Pb**	**Zn**	**Ni**	**Cr**	**Cd**	**As**
ADD (mg/kg-day)									
Range	0-1.08E-03	1.62E-04-1.69E-02	4.64E-05-2.22E-04	0-1.53E-04	4.70E-04-2.50E-02	0-1.05E-04	1.62E-05-6.88E-05	3.69E-05-1.14E-04	2.10E-05-1.53E-04
Average	4.20E-04	4.44E-03	1.01E-04	5.46E-05	9.76E-03	2.64E-05	4.84E-05	7.36E-05	8.04E-05
Std dev	3.84E-04	5.30E-03	6.71E-05	6.27E-05	9.60E-03	3.78E-05	1.90E-05	2.96E-05	4.44E-05
HQ									
Range	0.00-0.00	0.00-0.02	0.00-0.00	0.00-0.04	0.00-0.08	0.00-0.00	0.00-0.00	0.07-0.22	0.07-0.51
Average	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.14	0.26
Std dev	0.00	0.00	0.00	0.01	0.03	0.00	0.00	0.05	0.14
CR									
Range	ND	ND	ND	ND	ND	ND	ND	ND	3.15E-05-2.30E-04
Average	ND	ND	ND	ND	ND	ND	ND	ND	1.20E-04
Std dev	ND	ND	ND	ND	ND	ND	ND	ND	6.66E-05

*****ADD (Average daily dose)

*HQ (Hazard quotient)

* CR (Cancer risk)

*Std dev (Standard deviation)

* ND (Not determined)

Table.6.8. Health risk assessment (ADD, HQ and CR) of trace and heavy metals in Khukosh (Baha lake and respective stream)

Site 4 Khukosh (Baha lake and its streams)	**Mn**	**Fe**	**Cu**	**Pb**	**Zn**	**Ni**	**Cr**	**Cd**	**As**
ADD (mg/kg-day)									
Range	0-8.10E-04	0-8.98E-03	0-1.19E-04	0-1.86E-04	5.27E-04-1.68E-02	0-1.27E-04	0-3.51E-05	8.10E-06-7.37E-05	1.26E-05-1.52E-04
Average	5.01E-04	2.26E-03	6.11E-05	3.74E-05	4.60E-03	2.73E-05	1.99E-05	3.74E-05	6.15E-06
Std dev	3.95E-04	3.34E-03	4.44E-05	7.12E-05	5.91E-03	4.85E-05	1.37E-05	2.20E-05	5.43E-05
HQ									
Range	0.00-0.00	0.00-0.01	0.00-0.00	0.00-0.05	0.00-0.05	0.00-0.00	0.00-0.00	0.01-0.14	0.04-0.50
Average	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.07
Std dev	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.04
CR									
Range	ND	ND	ND	ND	ND	ND	ND	ND	1.90E-05-2.28E-04
Average	ND	ND	ND	ND	ND	ND	ND	ND	9.23E-05
Std dev	ND	ND	ND	ND	ND	ND	ND	ND	8.15E-05

*****ADD (Average daily dose)

*HQ (Hazard quotient)

* CR (Cancer risk)

*Std dev (Standard deviation)

* ND (Not determined)

CONCULSIONS

The conclusions of the study area are as follows:

- The physical parameters such as T, pH, EC, resistivity, TDS, turbidity, and salinity in the water of the studied lakes and streams (Naltar wetland complex, Uttar, Hundrap, and Baha lakes with their respective streams), were found within the permissible limit set by WHO (2008) and USEPA (2009).

- The concentrations of anions (Cl^-, SO_4^{-2}, NO_3^- and HCO_3^-) in all the water samples of the studied lakes with their relevant streams of the study area were found within the permissible limit set by WHO (2008) and USEPA (2009), however, HCO^-_3 concentration was found above their permissible limit in 5% of water samples. On the basis of Piper classification scheme the water of the areas was classified as HCO_3 type (i.e., $CaHCO_3$ and $NaCaHCO_3$).

- The concentrations of light elements (Na, K, Ca^{+2}, Mg^{+2}) in all the water samples of studied lakes and streams in the study area were found within the permissible limit set by WHO (2008).

- The concentrations of heavy metals (i.e., Mn, Fe, Cu, Pb, Zn, Ni, Cr, Cd and As) in all the representative water samples of the studied lakes and their respective streams of the Gilgit and Ghizar Districts Northern Areas of Pakistan were found within the permissible limits however, in 5% of the water samples, the concentration of Mn, Fe and Cd were found slightly higher than the permissible limits set by WHO (2008).

- Pearson's correlation matrixes (Table.6.1, 6.2, 6.3 and 6.4) for Naltar wetland complex, Uttar, Hundrap and Baha lakes with their respective streams indicated that most of the physio-chemical parameter pairs have strong positive (r = $\geq$ .50) and strong negative(r = $\geq$ -.50) interrelationships.

- Health risk assessments chronical (i.e., ADD and HQ) indices for trace and heavy metal in the water of lakes and streams of areas studied were calculated and it was found that the average values of HQ were below 1 which suggested that no any chronic risk related trace and heavy metals exist in the studied water. The values of carcinogenic risk (CR) for As in the water showed very low (<1per 1,000,000 inhabitants) risk. Therefore no any cancer risk in the water of study area is noted.

- The negligible or no contamination from the rocks in the water of the study area can be attributed to the less contact time for excavenging of toxic metals in the glacial melting water percolating through the rocks of the area and also due to the very low temperature which render the dissolution of toxic metals in the water

- As there is no extensive tourism involved in the area, therefore, no contamination from anthropogenic sources is notice.

- This study revealed that the water of high altitude Alpine lakes and related streams have no any health related risks as for as the physio-chemicals parameters are concerned.

RECOMMENDATIONS

Following recommendations are made to design the framework for water quality assessment of high altitude alpine lakes in the Northern Areas of Pakistan.

- The present study showed no health risk involved with the waters of the studied lakes and their streams but in future, if these lakes attracted tourists in the area then the contamination from the anthropogenic source may cause health related problem in the area. Therefore proper monitoring of the quality of water from the alpine lakes on regular basis should be carried out seasonally (i.e., autumn, winter, spring and summer) to assess the contamination from the anthropogenic and geogenci sources.
- A detailed geological study is required to understand the geology of the surrounding areas and its role in contaminating the water of these lakes.
- The community should be encouraged carry out forestation along the feeder streams to minimize the siltation in these lakes.
- A light boat is required for future water quality monitoring programme for sampling from inside the lakes from a desirable depth to collect representative samples for analysis.
- The present study was concerned with investigation of the phyio-chemical parameters of lake’s water. However, it is suggested that the biological parameters should also be determined to get information about microorganisms in the high altitude lakes.

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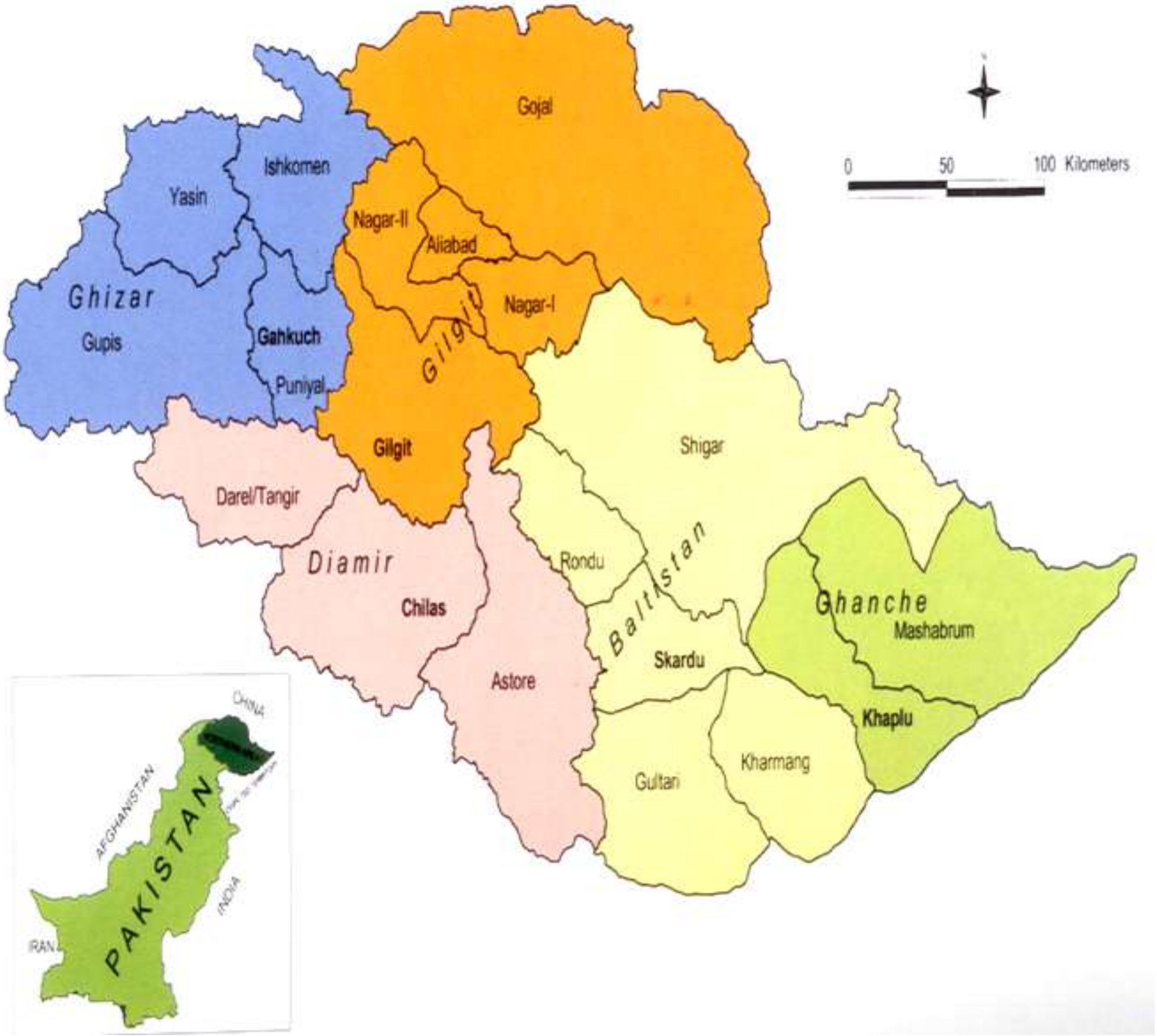
ANNEXURE



Map Gilgit Baltistan (After NASED, 2003).

Description of Water Samples and their GPS Coordinates of in the study area

Sample#	Source	Y_Axses	X_Axese
	Site.1 Naltar Nalat wetland complex		
W1	Lake.1 (Bodorok bari) inlet	36 14 28.35	74 04 39.30
W2	Centre	36 14 14.89	74 04 48.04
W3	outlet	36 14 25.30	74 05 11.51
W4	Lake 2 (Singo bari) inlet	36 14 15.48	74 05 59.04
W5	Centre	36 14 09.91	74 05 58.16
W6	Outlet	3614 06.12	74 06 04.63
W7	Lake 3 (Chakar Bari) inlet	36 14 14.14	74 06 15.97
W8	centre	36 14 09.14	74 06 14.60
W9	Outlet	36 13 54.19	74 06 05.77
W10	Lake 4 (Chemo bari) inlet	36 13 50.65	74 06 23.88
W11	Centre	36 13 54.14	74 06 21.94
W12	Outlet	36 13 32.64	74 06 29.44
W13	Lake 5 (Small bari) inlet	36 14 37.37	74 05 53.52
W14	Centre	36 14 40.70	74 05 55.48
W15	Outlet	36 14 37.98	74 05 56.72
W16	Lake 6 (Koto Bari) inlet	36 14 20.02	74 06 06.21
W17	Centre	36 14 15.46	74 06 10.04
W18	Outlet	36 14 18.22	74 06 15.21
	Naltar Streams		
W28	Nalatar stream at Beshgiri.	36 12 41.05	74 07 33.07
W29	Naltar 4 View Hotel	36 09 54.95	74 10 45.86
W30	Nalatar stream at Beshgiri.	36 08 25.00	74 12 48.36
W31	Naltar home 1 at Cote muhallah.	36 07 58.02	74 13 31.86
W32	Naltar home 2 at Galieng.	36 07 51.72	7413 22.61
W33	Naltar home 3 at Daas muhallah.	36 07 45.57	74 13 57.59
W34	Nomal	36 05 28.45	74 16 54.21
	Site. 2 Ishkoman (Utter lake)		
W19	Utter lake inlet	36 38 38.68	73 38 02.52
W20	centre	36 38 46.40	73 39 18.40
W21	outlet	36 38 33.09	73 39 33.24
	Iskoman Stream		
W41	Iskoman stream at local huts.	36 38 12.29	73 41 47.17
W42	Iskoman stream at Matintar.	36 38 03.86	73 43 26.85
W43	Iskoman stream at Gotolti.	36 34 00.91	73 46 48.30
W44	Iskoman Jamatkhana	36 32 33.55	73 48 53.98
W45	Iskoman Masjid	36 30 43.87	73 51 01.63
W46	At the end of Iskoman stream.	36 30 23.82	73 50 59.20
	Site.3 Hundrap (Hundrap lake)		
W22	Hundrap lake inlet	36 03 48.89	72 44 41.48
W23	centre	36 04 16.52	72 44 38.10
W24	outlet	36 04 20.57	72 45 03.85
	Hundrap Stream		
W35	Hundrap stream at Chukarrari.	36 05 54.19	72 46 23.44
W36	Hundrap stream at Hirzdam.	36 07 22.36	72 47 16.98
W37	Hundrap home 1	36 08 56.74	72 48 00.56
W38	Hundrap home 2	36 09 28.16	72 47 58.14
W39	Hundrap home 3	36 10 12.59	72 47 54.39
W40	At the end of Hundrap stream.	36 10 07.35	72 48 28.24

	Site.4 Khokus (Baha lake)		
W25	Baha lake inlet	35 58 22.63	72 36 02.5
W26	centre	35 59 22.84	72 36 33.00
W27	outlet	36 01 02.71	72 37 23.46
	Khukosh Stream		
W47	Khokus stream just below the lake	36 0330.64	72 38 18.67
W48	Khokus stream at longe valley.	36 09 37.81	72 41 57.55
W49	Khokus stream below the loner.	36 10 18.07	72 44 39.05
W50	Khukosh stream at Barsad	36 10 32.17	72 47 57.03

Trace elements with their RfD and Slope Factor

Element	RfD (mg/kg/day)	Slope Factor (Risk/mgkg/day)
Mn	.14	Not listed.
Fe	0.07	Not listed.
Cu	0.037	Not listed.
Pb	0.0036	Not listed.
Zn	0.3	Not listed.
Ni	.020	Not listed.
Cr	1.5	Not listed.
Cd	0.0005	Not listed.
Hg	0.0003	Not listed.
As	0.0003	1.5

PICTURES

Pic.1. Naltar Valley

Pic.2. Bodorok bari at Naltar.

Pic.3. Singo bari at Naltar.

Pic.4. Naltar twin lake (Chakar bai) at Naltar.

Pic.5. Chemo bari at Naltar.

Pic.6. Kotou bari at Naltar .

Pic.7 Uttar lake at Iskoman.

Pic.8 Local huts near the Uttar Lake.

Pic.9 Hundrap lake at Hundrap.

Pic.10 Water sampling at Hundrap.

Pic.11 Khukosh nallah.

Pic.12 Baha lake at Khukosh.