A

Project Report

On

"APPLICATION OF ION CHROMATOGRAPHY TECHINIQUE FOR ANALYSIS OF GANGOTRI GLACIER MELT WATER"

Carried out at

NATIONAL INSTITUTE OF HYDROLOGY (NIH)

ROORKEE

Submitted on partial fulfilment of the requirements for the award of the degree of

MASTER OF SCIENCE IN CHEMISTRY

(Commercial Methods of Chemical Analysis)

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2015-16

forwarded to
Head, RMOD,

19/8/16

DECLARATION

I hereby declare that the work being presented in this project report entitled "An Application of Ion Chromatography in the analysis of Gangotri Glacier Melt Water" for the partial fulfillment of the award of degree of Master of Science in Chemistry (Commercial Methods of Chemical Analysis) of Gurukul Kangri University, Hardwar under the guidance of Dr. Anjali Goel, Associate Professor, Department of Chemistry, KanyaGurukul Campus, Haridwar is an authentic record of my own work carried out during the period of 18-01-2016 to 31-03-2016 at National Institute of Hydrology, Roorkee.

The matter embodied in this report has not been submitted by me for the award of any other degree.

Neha Praveen

Date: 19/May/16

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TO WHOM IT MAY CONCERN

This is certified that Ms. Neha Praveen, Student of M. Sc. (Chemistry), IV Semester, Kanya Gurukul Mahavidyalaya, Jwalapur, Haridwar has carried out the project work on the topic titled "Application of Ion Chromatography Technique for Analysis of Gangotri Glacier Meltwater" for the duration of 3 months (18 January to 31 march 2016) in Water Quality Laboratory, National Institute of Hydrology, Roorkee under the guidance of the undersigned. I wish for her bright future.

8/4/16
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CERTIFICATE

This is to certify that work incorporated in this project entitled **"APPLICATION OF ION CHROMATOGRAPHY TECHNIQUE FOR ANALYSIS OF GANGOTRI GLACIER MELT WATER"** has been carried out by **"NEHA PRAVEEN"** D/o Mr. Sanavvar Ali during 18 jan 2016 to 31 march 2016 under my supervision **DR. ANJALI GOEL** , Gurukul kangri Unversity Haridwar for the partial fulfillment of the requirements of the award of the degree of master science in chemistry (commercial of methods of chemical analysis) at the **National institute Hydrology (NIH) Roorkee**, has been carried out under my guidance.

Date 19|May|16

Anjali

Dr. Anjali Goel

(supervisor)

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I welcome this opportunity to express my deep sense of gratitude to Dr. ANJALI GOEL, associate professor (head of the department) for the guidance, intelligence, suggestions and devoting her valuable time for the project work.

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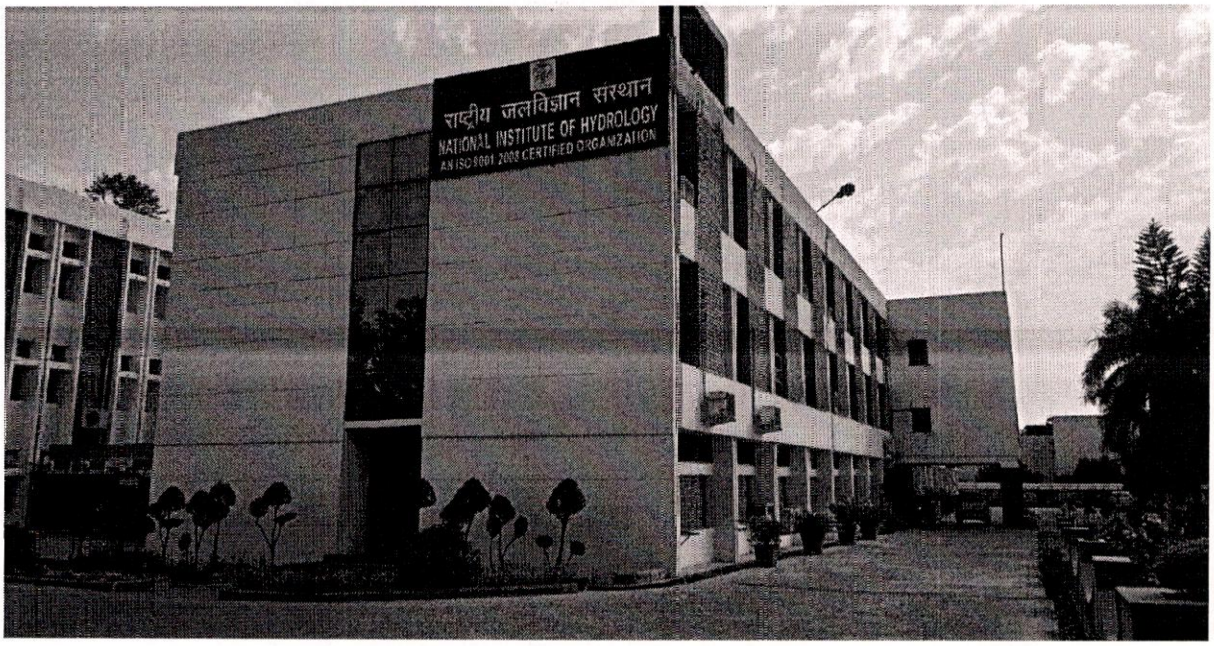
I pay my sincere thanks to Dr. ABHA SHUKLA for guidance and all necessary valuable help. I also acknowledge Dr. M.K SHARMA, scientist (D) of NATIONAL INSTITUTE OF HYDROLOGY (NIH), Roorkee for giving me chance to work upon this project.

Finally, I am not getting the suitable words to express my heartfelt gratitude to my venerated and intelligent parents who has not only support me materially but also helped me to maintain my calm all throughout the study.

Neha Praveen

ABOUT NIH



NATIONAL INSTITUTE OF HYDROLOGY, the premier institute in the area of hydrology and water resources in India. The institute was established in 1978 with the main objective of undertaking, aiding, promoting and coordinating systematic and scientific work in all aspects of hydrology. The institute has its headquarters at roorkee (UTTARAKHAND), four regional centres at belgaum, jammu, Kakinada and sagar and two centres for flood management studies at guwahati and patna. The institute is well equipped to carry out computer, laboratory and field oriented studies.

The institute is located at roorkee in haridwar district, uttarakhand, india. Roorkee, the historic town, is a well known educational and research centre with the I.I.T., roorkee and a number of R & D organisations viz. central building research institute, irrigation reaearch institute and army's Bengal engineering group. The studies and research activities at the NIH roorkee are carried out under five scientific divisions. As part of the technology transfer program of the institute, various training courses/workshops are also organized by the divisions. The five divisions are as follows:

1. Hydrology division
2. Groundwater hydrology division
3. Hydrological investigations division
4. Surface water hydrology division
5. Resources systems division

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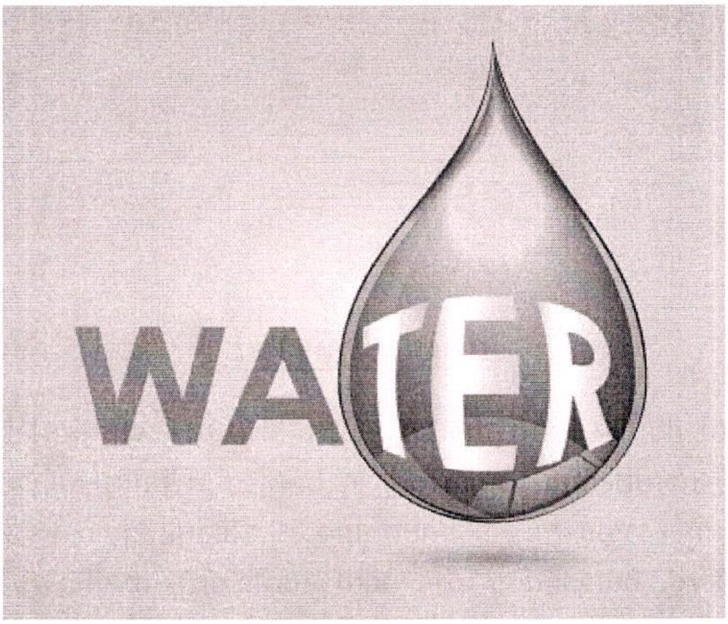
CHAPTER-1

INTRODUCTION

- WATER
- WATER QUALITY ANALYSIS
- GLACIER

Introduction

Water (chemical formula: H_2O) is a transparent fluid which forms the world's streams, lakes, oceans and rain, and is the major constituent of the fluids of organisms. As a chemical compound, a water molecule contains one oxygen and two hydrogen atoms that are connected by covalent bonds. Water is a liquid at standard ambient temperature and pressure, but it often co-exists on Earth with its solid state, ice; and gaseous state, steam (water vapour).



Even today man has brought about changes whether through urbanisation and growth of population centre by introduction and employment of auxiliary means in agriculture which has disturbed or destroyed the natural healthy quality of water bodies.

Water is one of the most important of the five elements to which human life owns its physical existence.Earth contains**97.5%** oceanic water and **2.5%** global fresh water. The composition of fresh water is:

- 68.9% glacial and permanent ice.
- 29.9% fresh ground water.
- 0.3% fresh lake and river.
- 0.9% soil moisture

Fresh water= 68.9+29.9+0.3+0.9=**100%**

From total **Fresh Water**, **69%** water is utilised in agriculture purposes, **23%** in industrial and**8%** in domestic use.

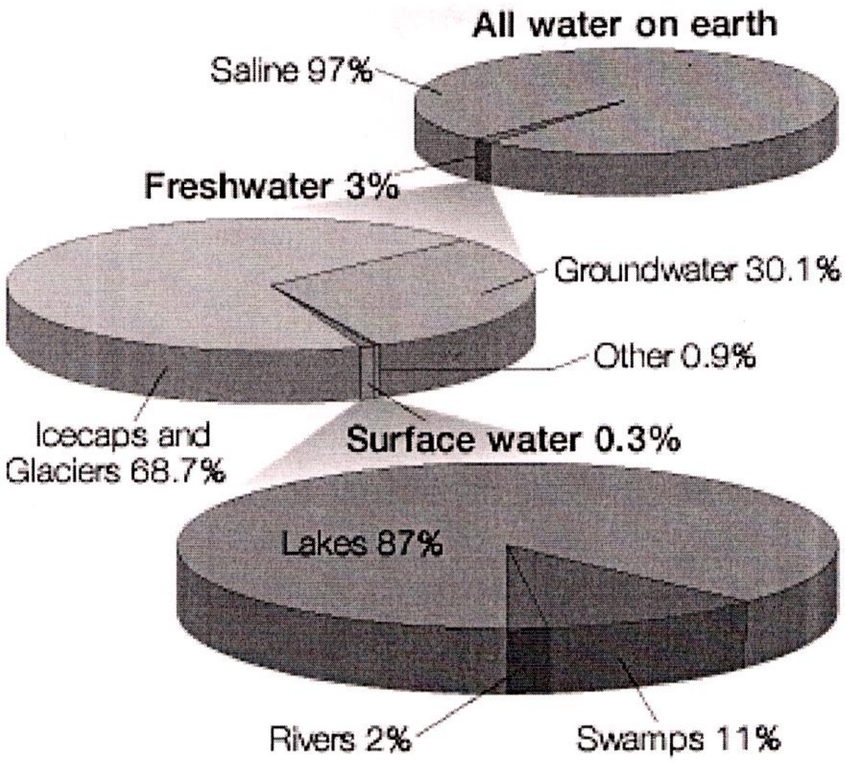


Fig. 01

Glaciers occupy about 10% of the Earth's land surface (~ 16 million Km^2) but hold roughly 77% of its fresh water. More than 96% of glacier ice lies in the Polar Regions (Antarctica and Greenland). The lofty mountains of the Himalaya are home to the largest ice mass outside the polar regions, aptly termed as third pole. The Indian portion of the Himalayas (21°57' to 37°05' N, 72°40' to 97°25' E) above 1060 MSL covers an area of 0.35 million Km^2, out of which 0.19 Km^2 lies in J&K, Himachal, Uttarakhand and rest in the eastern part of Himalayas (Shankar and Srivastava, 2001).

Concentration of glaciers in the Himalaya occur on high mountain peaks. Some of these are Nanga Parbat, Kolohai, Nun-Kun, the Dibibokri- Chowkhamba - Nanda Devi area, Dhaulagiri-Annapurna-Manasulu area, Everest- Makalu-Kanchenjunga and NamcheBarwa areas. It is estimated that the Himalayan glaciers provide around $8.6*10^6$ m^3 of water annually. The three great rivers of India – the Indus, the Ganges and the Brahmaputra collectively provide close to 50% (320 Km^3) of the total country's utilizable surface water resources (690 Km^3). Gangotri glacier originating from Chaukhamba peaks (7138 MSL) is 30.2 Km long with a glacierised area of about 143.58 Km^2.

WATER QUALITY ANALYSIS

Water quality refers to the chemical, physical, biological, and radiological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact and drinking water. Therefore, it is used to assess the physical, chemical and biological characteristics of water.

Water quality analysis including following parameters:

- **PHYSICAL PARAMETERS**
- **CHEMICAL PARAMETERS**
- **BIOLOGICAL PARAMETERS**

PHYSICAL CHARACTERISTICS OF WATER:

1. **Smell/order**
2. **Taste**
3. **Colour**
4. **Solids**
5. **Turbidity**
6. **Temperature**
7. **Conductivity**

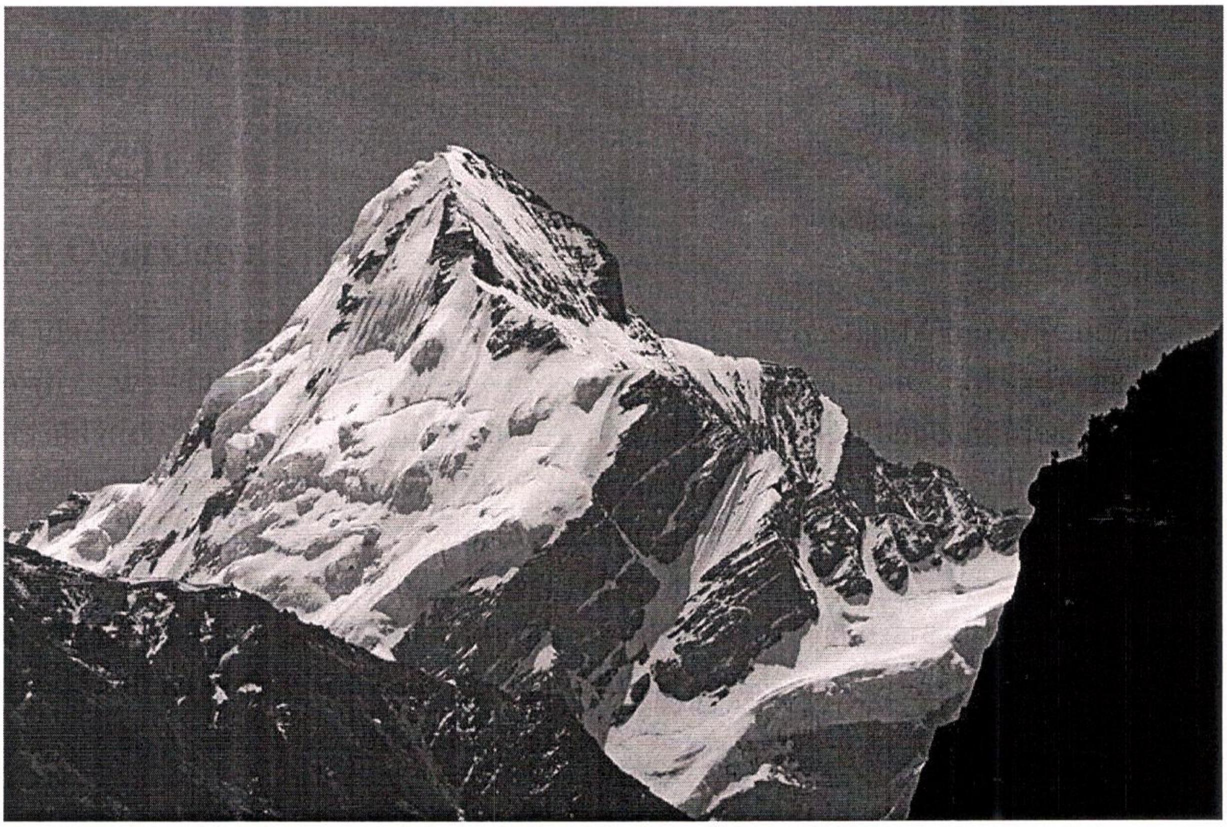
CHEMICAL CHARACTERISTICS OF WATER:

1. **Hardness**
2. **Alkalinity**
3. **pH**
4. **Nitrate**
5. **Nitrite**
6. **B.O.D.**
7. **C.O.D.**
8. **D.O.**
9. **Major Cations (Na, K, Ca, Mg)**
10. **Major Anions (Cl, SO_4, NO_3, HCO_3)**

GLACIER

An Overview:

A glacier is a persistent body of dense ice that is constantly moving under its own weight, it forms where the accumulation of snow exceeds its ablation (melting and sublimation) over many years, often centuries. Glaciers slowly deform and flow due to stresses induced by their weight, creating crevasses, seracs, and other distinguishing features. They also abrade rock and debris from their substrate to create landforms such as cirques and moraines. Glaciers form only on land and are distinct from the much thinnersea ice and lake ice that form on the surface of bodies of water.



Formation of glaciers:

Glaciers form where the accumulation of snow and ice exceeds ablation. The area in which a glacier forms is called a cirque (corrie) - a typically armchair-shaped geological feature (such as a depression between mountains enclosed by aretes) - which collects and compresses through gravity the snow which falls into it. This snow collects and is compacted by the weight of the snow falling above it forming nave. Further crushing of the individual snowflakes and squeezing the air from the snow turns it into 'glacial ice'. This glacial ice will fill the cirque until it 'overflows' through a geological weakness or vacancy, such as the gap between two mountains. When the mass of snow and ice is sufficiently thick, it begins to move due to a combination of surface slope, gravity and pressure. On steeper slopes, this can occur with as little as 15 m (50 ft) of snow-ice.

Glacial ice has a distinctive blue tint because it absorbs some red light due to an overtone of the infrared-OH stretching mode of the water molecule. Liquid water is blue for the same reason. The blue of glacier ice is sometimes misattributed to Rayleigh scattering due to bubbles in the ice.

Recession rates of Gangotri glacier estimated from rapid static GPS Survey:

Gangotri glacier is one of the best documented glaciers in the Indian Himalaya as far as its snout position demarcation is concerned. The snout of the glacier "Gaumukh" is about 18 Km from the holy shrine of Gangotri. The glacier snout has been under the state of continuous recession since 1935 (Auden, 1937). Geological Survey of India (GSI) has monitored snout of the glacier since 1935 till 1996.

Table 1.1: Recession rates of Gangotri glacier estimated from rapid static GPSSurvey:

Duration (years)	**Total recession (m)**	**Period (years)**	**Rate (ma^{-1})**
1935-1971	954.14	36	26.50
1971-2004	564.99	33	17.15

CHAPTER-2

LOCATION AND METHODOLOGY

- STUDY AREA
- SAMPLING AND PRESERVATION TECHNIQUES

Study Area

Gangotri glacier, which is one of the largest glacier of the Himalayas was selected for the study. It is a north-westerly flowing 'compound basin' type valley glacier and occupies longitudinal U-shaped valley.

Location and Accessibility

The Gangotri glacier is located in the Uttarkashi district of Uttarakhand state in Garhwal Himalayan region. The study area lies within the latitudes 30°43'N - 30°01'N and longitudes 79°0'E - 79°17'E. The pro glacial melt water stream, known as Bhaghiratiriver, emerges out from the snout of the Gangotri glacier at an elevation of 4000m. the snout of the Gangotri glacier is known as, "Gomukh". The approach to the snout of the glacier includes a tracking of about 18km starting from the Gangotri town. The major part of the trekking is along the right bank of Bhaghiratiriver.

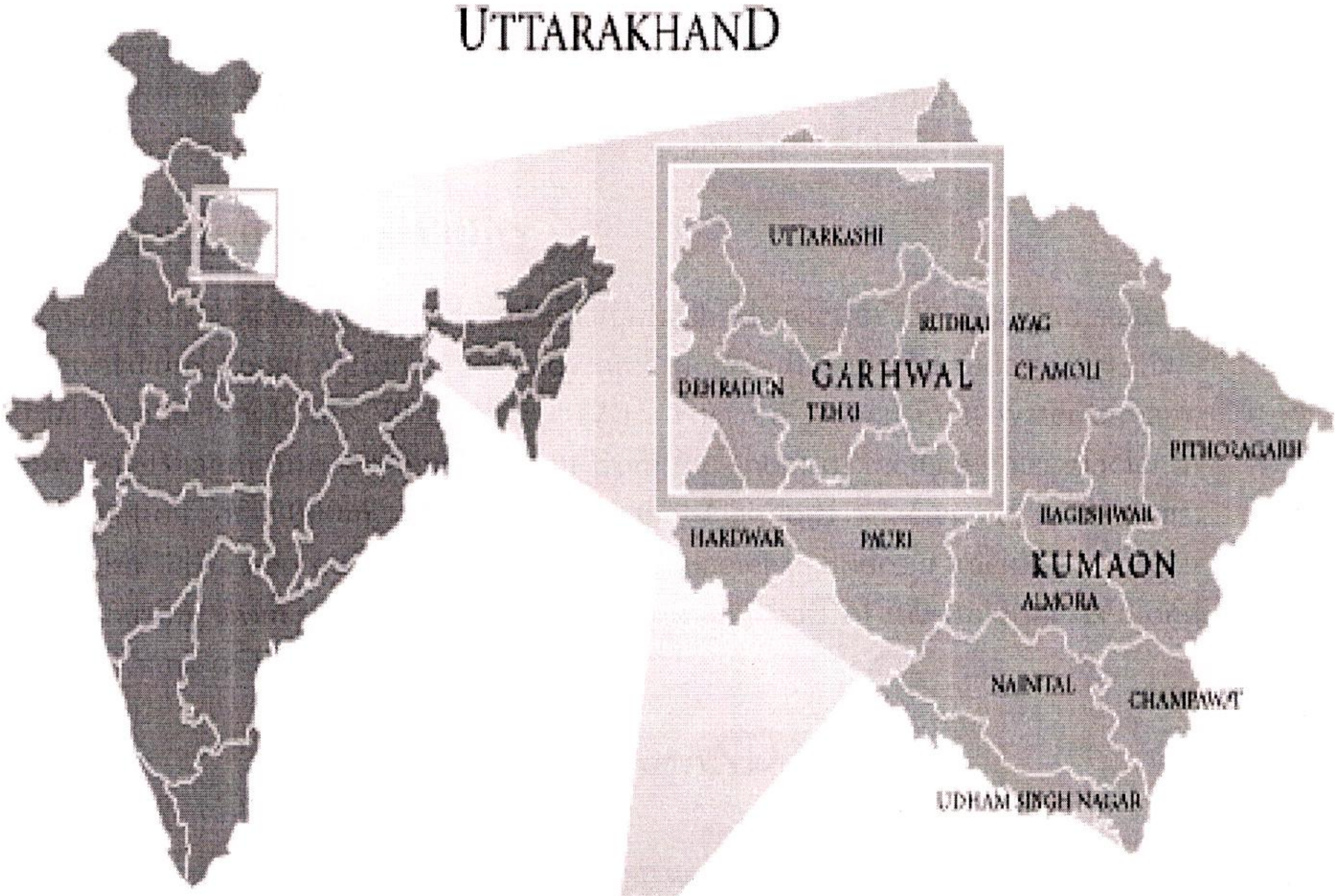


Fig No. 2.1

Gangotri Glacier Systems

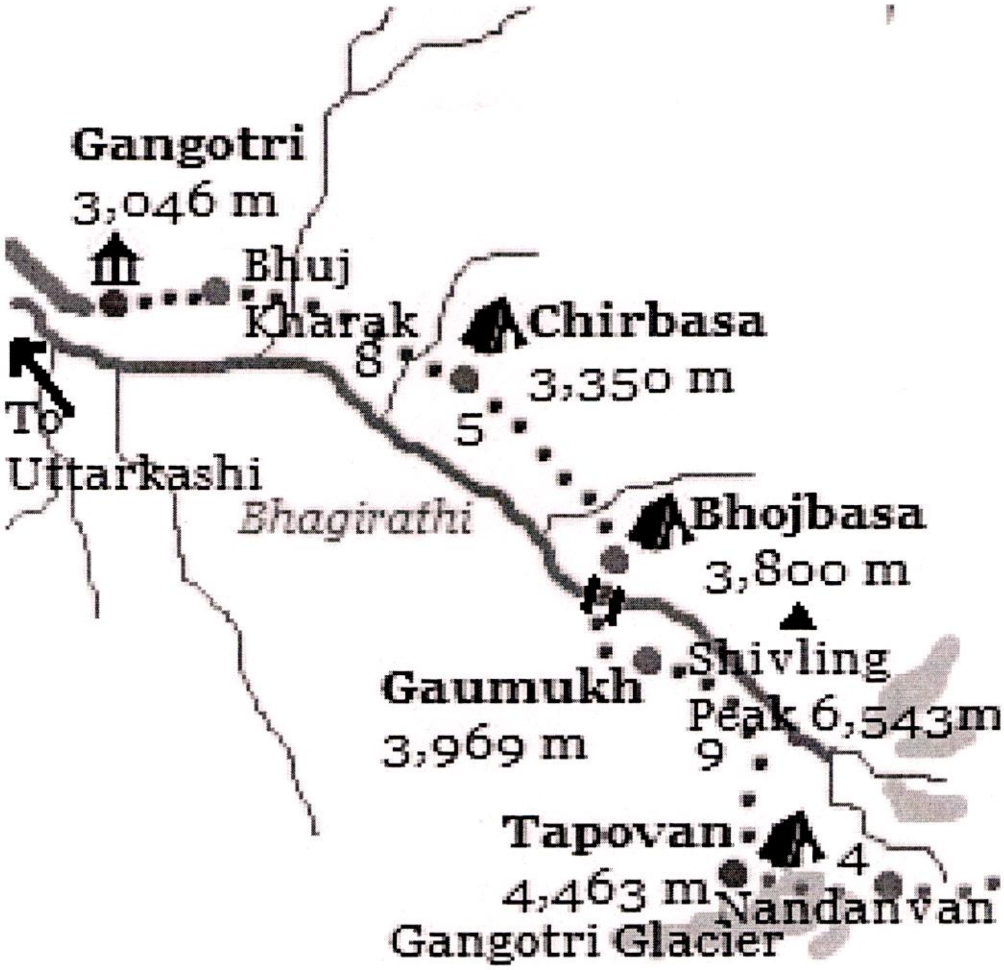


Fig No. 2.2

Gangotri Glacier Systems most commonly known as Gangotri Glacier, is a cluster of many glaciers consisting of main Gangotri glacier (Length: 30.20km, Width: 0.20-2.35km^2) as main part of the system. It flows in the northwest direction. The major glacier tributaries of the Gangotri glacier system are Raktvarn glacier, Chaturangi glacier, Kirti glacier, Swachand glacier, Ghanohim glacier, Meru glacier, Maindi glacier and few other glaciers. The Raktvarn, Chaturangi, Swachand and Maindi glaciers are merging with trunk glacier form Northeast while the Meru, Kirti and Ghanohim glaciers are meeting the trunk glacier from south-west (Naithani 2001). The Gangotri glacier is a valley type glacier system with total glacierized area of about 279.3 km^2. The elevation ranges of the Gangotri glacier varies from 4000m to 7000m.

Sampling and Preservation techniques:

Sampling is the first step leading to the generation of water quality data and is an exceedingly important; care must be taken to ensure obtaining a sample that is truly representative. Thoroughly cleaned plastic or glass bottles fitted with screw caps may be used for water sample collected with depth integrating samplers, plastic container are generally preferred for inorganic samples and glass is preferred for organic samples.

Compact system for routine analysis of anions, cations and polar substances are in the range of µgm/L to gm/L. The samples of water were collected weekly at 8:30 am on every Sunday. The displacement between each sampling site is 2km (approx.).

Determination of pH should be done in the field. Sample for metal analysis can be preserved by addition of Nitric acid, sample for organic constituent's determination by chilling or freezing. A list containing method of sample preservation and time allowed between sample collection and analysis is presented in following table:

TABLE 2.1: Adopted preservation technique

Parameter	**Preservative**	**Maximum Storage Time**
Colour	Cool to 3-4°C	24 hours
Turbidity	Cool to 3-4°C	7 days
pH		Immediately
Alkalinity	Cool to 3-4°C	24 hours
Hardness	Add 2ml HNO_3/L, Cool to 3-4°C	7 days
Sulphate	Cool to 3-4°C	7 days
Chloride		7 days
Phosphate	Cool to 3-4°C	7 days
Nitrogen, Nitrate	Add 2ml H_2SO_4/L, Cool to 3-4°C	7 days
B.O.D.	Cool to 3-4°C	6 hours
Metals	Add 5ml HNO_3/L	6 months

TABLE 2.2: Sample Location and Identity

S. No.	**Place of water collection site**	**Sample Id**	**Source**	**Date**	**Volume of sample collection**
1	Gangotri Region	GNT-1	River bank	29/06/14	1L
2	Gangotri Region	GNT-2	River bank	06/07/14	1L
3	Gangotri Region	GNT-3	River bank	13/07/14	1L
4	Gangotri Region	GNT-4	River bank	20/07/14	1L
5	Gangotri Region	GNT-5	River bank	27/07/14	1L

CHAPTER-3

PURPOSE OF STUDY

PURPOSE OF STUDY

In India, 12% of people get clean drinking water, the rest 88% quench their thrust from polluted lakes, tanks, rivers and well due to which more than 3 million people get affected or die from enteric diseases every year. This surface water and ground water mainly get polluted by anthropogenic activities like urbanisation, industrialisation and disposing garbage etc.

Water quality of lakes is deteriorating due to solid and liquid disposal of water. Lakes being stagnant water bodies, are more prone to pollution than the rivers, as in lakes self purification process are less effective than river. Any contamination of lakes affects greatly the flora and fauna and also the human health, if the water is used for domestic supply. The environmentalhealth of any lake system depends upon the nature of that lake and its exposure to various environmental factors such as temperature, depth of water and wind speed, soil type and land use of the catchment.

Most people do not really understand that the drinking water comes from sources like the Himalayan Gangotri glacier, and in the coming years there is a high likelihood that water shortages will ensue due to melting of these glaciers. According to WWF (**W**orld **W**ide **F**und for Nature) studies, due to the rise in temperature, the river flow will increase by 20% initially because of more snow melt. But, ultimately, the flow will decrease by 20%. Alarmingly, a population equal to Europe lives in the Ganges basin and their livelihoods are dependent on the river. Himalayan glaciers are rapidly retreating, with a gradual increase in droughts, flash floods, and landslides, but these are not the only issues to worry about. Just when power companies are planning more hydro energy sources to power India's growing economy, a rising level of sediment in regional rivers is creating havoc for many grids.The present study aims at evaluating the water quality of **GANGOTRI SAMPLES**.

CHAPTER-4

INSTRUMENTATION

- ION EXCHANGE CHROMATOGRAPHY
- AUTO TITRATION
- APPLICATIONS

ION-EXCHANGE CHROMATOGRAPHY

Ion-exchange chromatography (IEC) is part of Ion Chromatography (IC) which is an important analytical technique for the separation and determination of ionic compounds, together with ion-partition/interaction and ion-exclusion chromatography.

Ion chromatography separation is based on ionic (or electrostatic) interactions between ionic and polar analytes, ions present in the eluent and ionic functional groups fixed to the chromatographic support. Two distinct mechanisms as follows; ion exchange due to competitive ionic binding (attraction) and ion exclusion due to repulsion between similarly charged analyte ions and the ions fixed on the chromatographic support, play a role in the separation process in Ion Chromatography.

History of Ion Exchange Chromatography:

The boom of Ion exchange chromatography primarily began between 1935-1950 and it was through the "Manhattan project" that applications and IC were significantly extended. It was in the fifties and sixties that theoretical models were developed for IC for further understanding and it was not until the seventies that continuous detectors were utilized, paving the path for the development from low-pressure to high-performance chromatography. Not until 1975 was "ion chromatography" established as a name in reference to the techniques, and was thereafter used as a name for marketing purposes. Today IC is important for investigating aqueous systems, such as drinking water. It is a popular method for analyzing anionic elements or complexes that help solve environmentally relevant problems. Likewise, it also has great uses in the semiconductor industry. Because of the abundant separating columns, elution systems, and detectors available, chromatography has developed into the main method for ion analysis.

Ion exchange has been the predominant form of ion chromatography to date. This chromatography is one of the most important adsorption techniques used in the separation of peptides,

Proteins, nucleic acids and related biopolymers which are charged molecules in different molecular sizes and molecular nature.

The separation is based on the formation of ionic bonds between the charged groups of biomolecules and an ion-exchange gel/support carrying the opposite charge. Biomolecules display different degrees of interaction with charged chromatography media due to their varying charge properties. The earliest report of ion-exchange chromatography date back to 1850, Thompson studied the

adsorption of ammonium ions to soils. Spedding and Powell published a series of papers describing practical methods for preparative separation of the rare earths by displacement ionexchange chromatography in 1947. Beginning in the 1950s, Kraus and Nelson reported numerous analytical methods which are used for metal ions based on separation of theirchloride, fluoride, nitrate or sulphate complexes by anion chromatography. In order to separate proteins an ion exchange chromatographic method was reported by Peterson and Sober in 1956. In modern form ion exchange chromatography was introduced by Small, Stevens and Bauman in 1975. Gjerde et al. published a method for anion chromatographyin 1979 and this was followed by a similar method for cation chromatography in 1980. Ion- exchange chromatography has been used for many years to separate various ionic compounds;cations and anions and still continues to be used. The popularity of ion exchange chromatography has been increased in recent years because this technique allows analysis of wide range of molecules in pharmaceutical, biotechnology, environmental, agricultural and otherindustries.

ION EXCHANGE MECHANISM:

Ion-exchange chromatography which is designed specifically for the separation of differently charged or ionizable compounds comprises from mobile and stationary phases similar to other forms of column based liquid chromatography techniques. Mobil phases consist an aqueous buffer system into which the mixture to be resolved. The stationary phase usually made from inert organic matrix chemically derivative with ionizable functional groups (fixed ions) which carry displaceable oppositely charged ion. Ions which exist in a state of equilibrium between the mobile phase and stationary phases giving rise to two possible formats, anion and cation exchange are referred to as counter ion. Exchangeable matrix counter ions may include protons (H^+), hydroxide groups (OH^-), single charged mono atomic ions (Na^+, K^+, Cl^-), double charged mono atomic ions ($Ca2^+$, $Mg2^+$), and polyatomic inorganic ions (SO_4^{2-}, PO_4^{3-}) as well as organic bases (NR_2H^+) and acids (COO^-). Cations are separated on cation-exchange resin column and anions on an anion exchange resin column. Separation based on the binding of analytes to positively or negatively charged groups which are fixed on a stationary phase and which are in equilibrium with free counter ions in the mobile phase according to differences in their net surface charge.

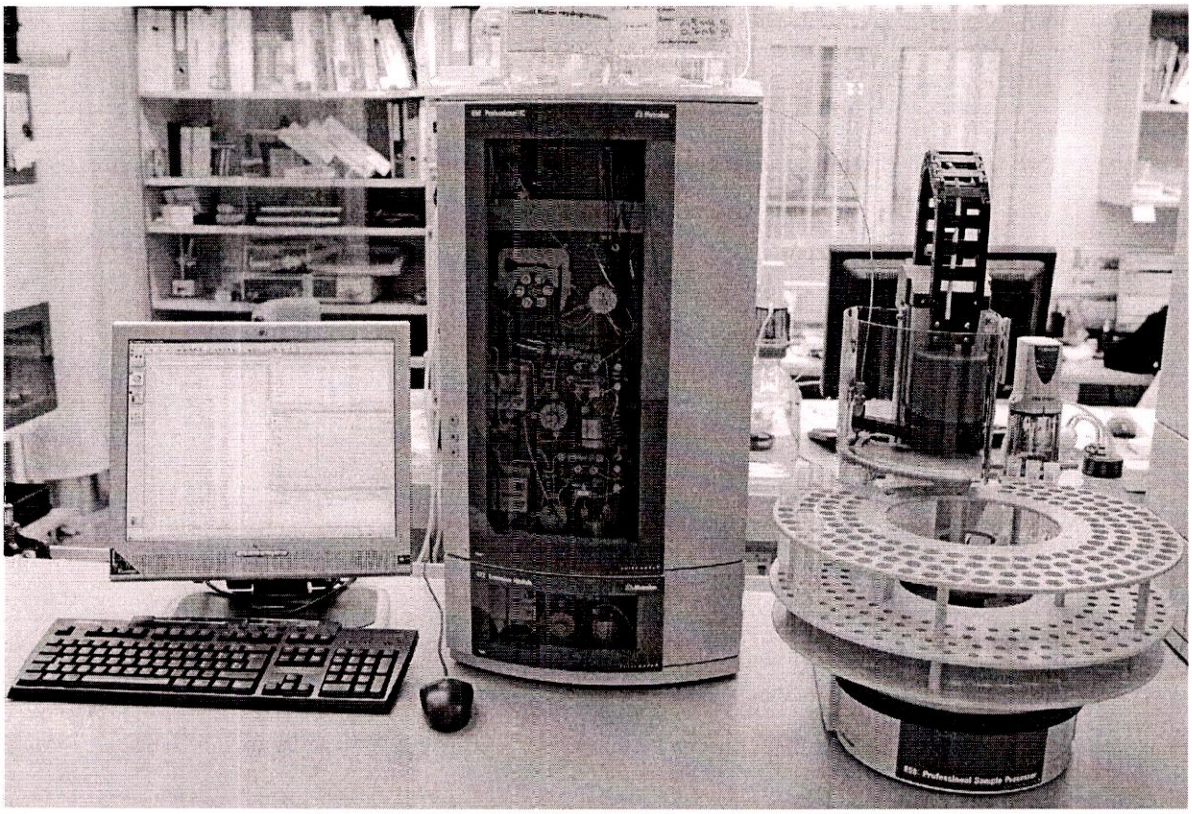


Fig No. 4.1**ION-EXCHANGE CHROMATOGRAPH**
MODEL NAME- METROHM-930 COMPACT IC FLEX

Working of Ion-Chromatography:

Ion Chromatography, a form of liquid chromatography, measures concentration of ionic species by separating them based on their interaction with a resin. Ionic species separates differently depending on species type and size. Sample solution pass through a pressurized chromatographic column where ions are absorbed by column constituents. As an ion extraction liquid, known as eluent runs through the column, the absorbed ions begin separating from the column. The retention time of different species determines the ionic concentration in the sample.

Methodology of Ion-Chromatography:

Ion Chromatography is used for water-chemistry analysis. Ion chromatographs are able to measure major cations and anions. It is the separation and quantitative analysis of anions and cations in an ionic solution using the ion exchange method of liquid chromatography.

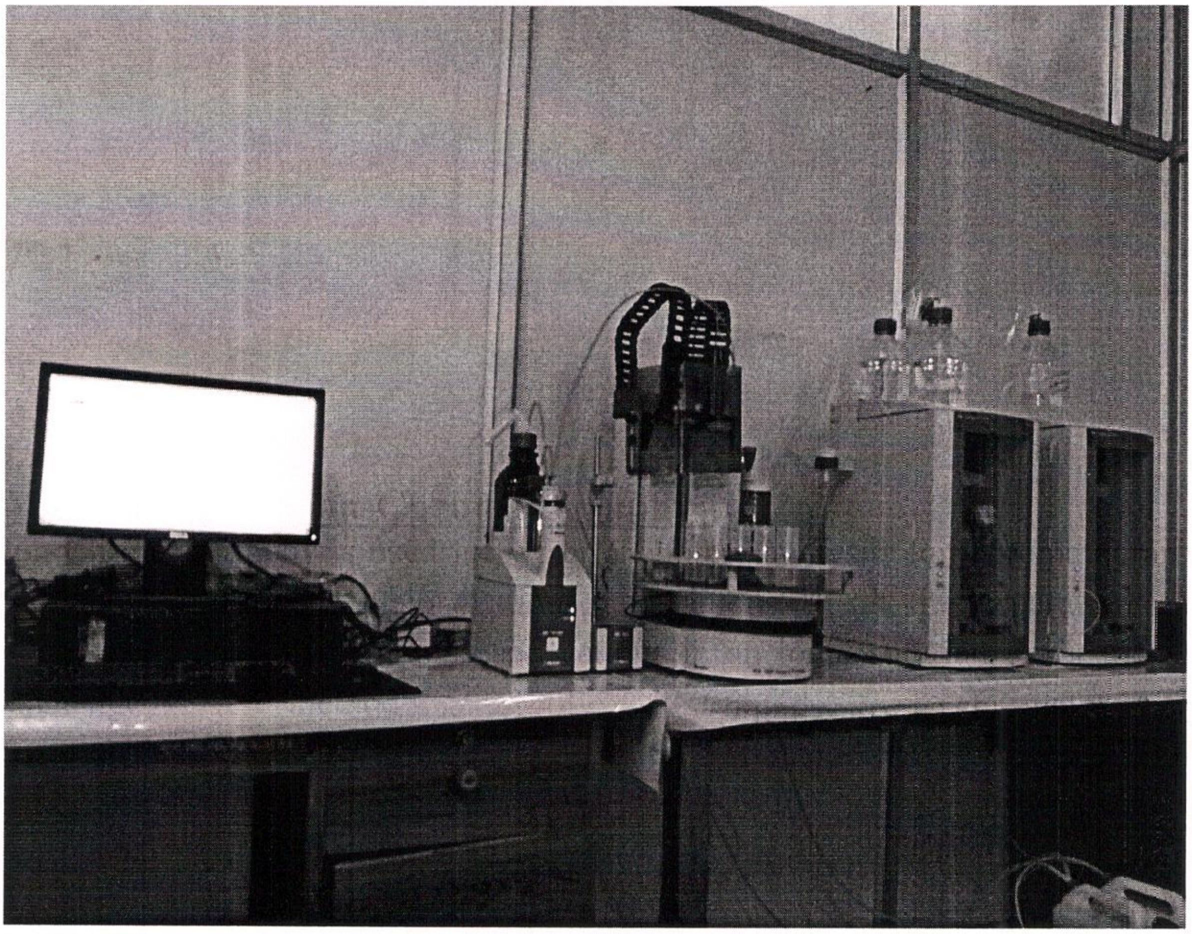


Fig No. 4.2

The chromatography process seperates the different ions within the sample.

Following major anions such as:

- Flouride
- Chloride
- Nitrate
- Nitrite
- Sulphate

As well as major cations such as:

- Ammonium
- Sodium
- Potassium
- Calcium
- Magnesium
- Lithium

It measures the anions and cations in ppb range. Concentration can also be measured through ion chromatography.

Ion exchange chromatography can be represented in 5 steps:

- Fluent loading
- Sample injection
- Seperation of sample
- Elution of alalyte

Elution is the process where the compound of interest is moved through the column. This happens because the elunt, the solution used as the solvent in chromatography, is constantly pumped through the column. The chemical reactions below are for an anion exchange process.

Ion chromatography, is a form of liquid chromatography measures concentrations of ionic species by separating them based on their interactions with a resin. Ionic species seperates differently depending on species type and size.

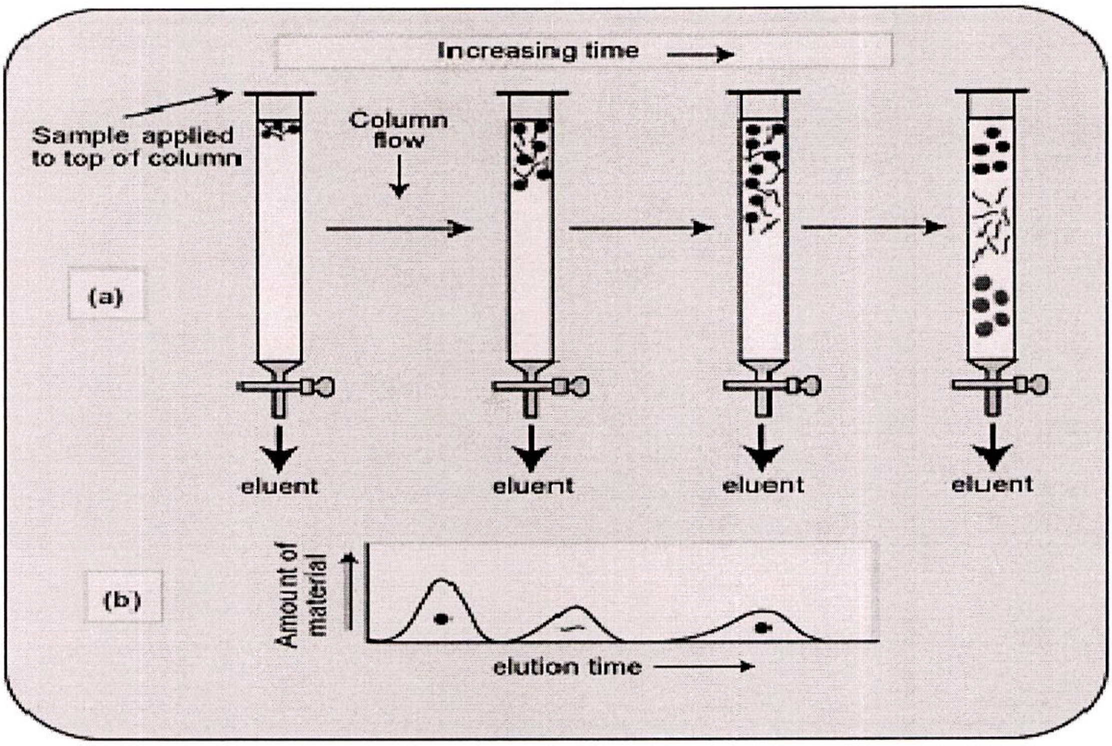


Fig No. 4.3

Sample solution pass through a pressurized chromatographic column, where ions are absorbed by column. As an ion extraction liquid, known as eluent, runs through the column, the absorbed ion begin separating from the column. The retention time of different species determines the ionic concentration in the sample.

Ion chromatography is a part of ion chromatography which is an important analytical technique for the sepertion and determination of anionic compounds, together with ion partition or interaction and ion exclusion chromatography. Ions present in the eluent and ionic functional group fixed to the chromatographic support.This chromatography is one of the most important adsorption technique used in the separation of:

- Peptides
- Proteins
- Nuclic acids
- Bio-polymers

Which are charged groups or molecules in different molecular size and nature.

Preparation of mobile phase

For cations: 2-7 mg Dipiclonic acid in ultra pure water and heat to dissolve, now cool and then add 1.7 ml HNO_3 (1M) and make upto 1L withultra pure water.

For anions: Take 339 mg of Sodium carbonate and 84mg of sodium bicarbonate. Dissolve it in ultra pure water and make up to 1L. Now filter with 0.45mm filter paper.

Mobile Phase

1. Na_2CO_3 = 0.3408g in 1L distilled water.
2. $NaHCO_3$=0.0848g in 1L distilled water.

For titration=0.01M H_2SO_4

AUTO-TIRATION

A **titration** is a technique where a solution of known concentration is used to determine the concentration of an unknown solution. Typically, the titrant (the know solution) is added from a buret to a known quantity of the analyte (the unknown solution) until the reaction is complete.

The whole process of titration is made much easier by making it automated. You simply add a predetermined amount of reactant and the machine will add the other reactant and measure the products to find the end point. Many samples can be done in no time at all. The accuracy is increased due to the finely calibrated computer instead of your eyes. The amount of hands-on interaction is drastically reduced. The Auto-Titration was carried out in the laboratory using **888-Titrando Metrohm**, shown below:

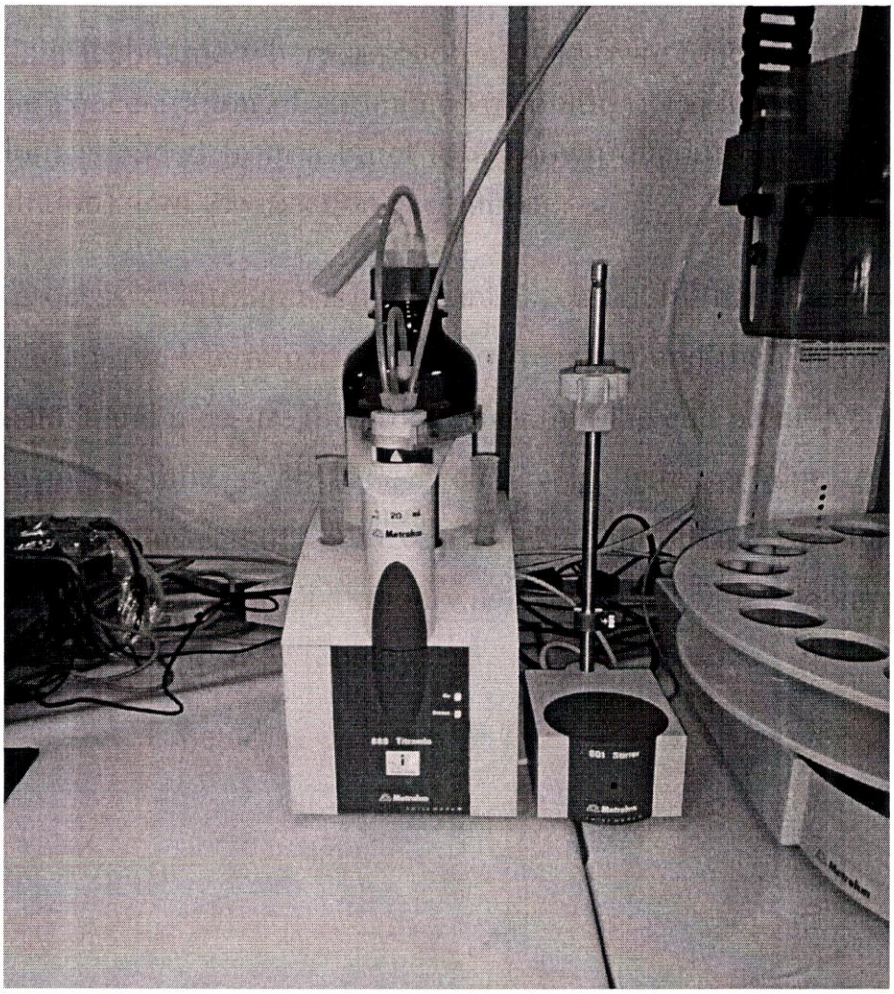


Fig4.4: 888-Titrando Metrohm

APPLICATIONS OF ION CHROMATOGRAPHY

Industry is one of the most important sources of not only environmental pollutions. In recent years, the importance of monitoring and controlling environmental pollutants has become apparent in all parts of the world. As a result, chemical analysts have increased their efforts to identify and determine toxic substances in air, water, waste waters, soils and other sectors of the environment. Every day in thousands of laboratories around the world, millions analysis of different substances are carried out. The development of new methods and improvement of existing ones are major tasks for analytical chemists. Advances in analytical instrumentation, detection systems and separation techniques have, in many instances, provided analytical chemists the tools required to continually lower detection limits and improving methods reliability. The most often determined analytes are inorganic and organic ions. In this range ion chromatography is a dominant instrumental analytical technique. There are two main types of ion chromatography: suppressed ion chromatography and non-suppressed ion chromatography. Ion exchange remains the primary separation mode used in ion chromatography today, although the apparatus used for the separation of the ionic species includes ion pairing and ion exclusion chromatography. Different types of ion chromatography can be used for the determination of ions such as inorganic anions and cations (including alkaline metals, alkaline earth metals, transition metals, and rare earth metals); carboxylic, phosphonic and sulfonic acids; detergents, carbohydrates, organic bases (e.g. amines) and ionic forms of metal/ metalloids on different oxidation states.

The advantages of ion chromatography are:

- short time of analysis
- sensitivity on the µg/L level
- high separation selectivity, even in samples with complex matrix
- simple method for preparing a sample for analysis
- small sample volume
- simultaneous determination of anions and cations, or inorganic and organic ions
- speciation analysis (e.g. NO2 - /NO3 - /NH4 +; SO3 2-/SO4 2-/S2-; H2 PO4 - /HPO4 2-/PO4 3-; Br- /BrO3 - [8]; Cl- /ClO2 - /ClO3 - /ClO4 - ; Cr(III)/Cr(VI); Fe(II)/Fe(III))
- usage of cheap, safe and environmentally friendly chemicals

For these reasons ion chromatography is an attractive technique, especially for laboratories that need to determine numerous anions and cations in several thousand samples but do not have automatic analyzers that are usually based on colorimetric procedures.

Some typical applications of ion chromatography include:

- Drinking water analysis for pollution and other constituents
- Determination of water chemistries in aquatic ecosystems
- Determination of sugar and salt content in foods
- Isolation of selected proteins.
- Softening of hard water.
- Demineralisation of water.
- To analyze base composition of nucleic acid

- To concentrate the metal ions in the sample
- To measure the additives in food and drug sample
- To separate protein mixture
- Useful in preconcentration of trace components of a solution to obtain enough for analysis.
- Water polishing equipments used in many laboratories uses several ion exchange cartridges.

Traditionally, these ice cores are analyzed by first removing the outer layers, as they may be contaminated with present-day atmospheric compounds, and then slicing them into 5cm-thick sections. These sections are melted and the resultant melt water analyzed by various different techniques, with IC used to determine the concentration of ionic species.

IC is well established as regulatory method for the analysis of inorganic anions in environmental samples as there are few alternative methods which can determine multiple anions in a single analysis.

IC has been approved for compliance monitoring of the common inorganic anions in drinking water. In addition to the use of IC for environmental water and waste analysis, a considerable number of IC methods are employed for air analysis.

CHAPTER-5

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The following results were obtained after the water quality analysis of Gangotri Glacier Water:

TABLE 5.1-RESULTS OF PHYSIOCHEMICAL CHARATERISTICS OF VARIOUS SAMPLES:

S. No.	Sample Id	pH	Hardness	Alkalinity
1	GNT-1	6.6	26.570	18.678
2	GNT-2	6.6	30.539	8.450
3	GNT-3	7.1	36.792	7.479
4	GNT-4	6.5	35.710	56.169
5	GNT-5	7.0	33.380	7.113

TABLE 5.2- RESULTS OF CONCENTRATIONS OF ANIONS IN VARIOUS WATER SAMPLES OF GANGOTRI GLACIER

	ANIONS									
Sample Id	**Fluoride**		**Chloride**		**Phosphate**		**Sulphate**		**Nitrite**	
	R.T. (min)	Conc. (mg/L)	R.T. (min)	Conc. (mg/L)	R.T. (min)	Conc. (mg/L)	R.T. (min)	Conc. (mg/L)	R.T. (min)	Conc. (mg/L)
GNT-1	6.20	0.396	9.86	0.425	23.67	0.402	29.79	23.702	n.d.	n.d.
GNT-2	6.20	0.413	9.88	0.469	n.d.	n.d.	29.67	26.534	n.d.	n.d.
GNT-3	6.17	0.382	9.86	1.061	n.d.	n.d.	n.d.	n.d.	12.10	0.189
GNT-4	6.15	0.485	9.72	0.581	n.d.	n.d.	28.86	32.297	n.d.	n.d.
GNT-5	6.22	0.458	9.93	0.714	n.d.	n.d.	29.67	29.629	n.d.	n.d.

R.T. - Retention Time (in min)

Conc. - Concentration (in mg/L)

n.d. – Not Detected

TABLE 5.3- RESULTS OF CONCENTRATIONS OF CATIONS IN VARIOUS WATER SAMPLES OF GANGOTRI GLACIER

	CATIONS							
Sample Id	**Sodium**		**Potassium**		**Calcium**		**Magnesium**	
	R.T. (min)	Conc. (mg/L)	R.T. (min)	Conc. (mg/L)	R.T. (min)	Conc. (mg/L)	R.T. (min)	Conc. (mg/L)
GNT-1	12.69	0.748	24.31	1.764	34.47	8.223	45.81	1.471
GNT-2	12.72	0.866	24.44	1.771	34.32	9.325	45.76	1.767
GNT-3	12.78	0.935	24.72	1.901	33.98	12.243	45.80	1.518
GNT-4	12.68	0.840	24.26	2.055	34.32	10.911	45.66	2.063
GNT-5	12.76	0.917	24.63	2.180	34.07	10.330	45.65	1.849

R.T. - Retention Time (in min)

Conc. - Concentration (in mg/L)

FIG No.5.1BAR-GRAPH DEPICTING CONCENTRATION OF VARIOUS CATIONS PRESENT IN SAMPLES:

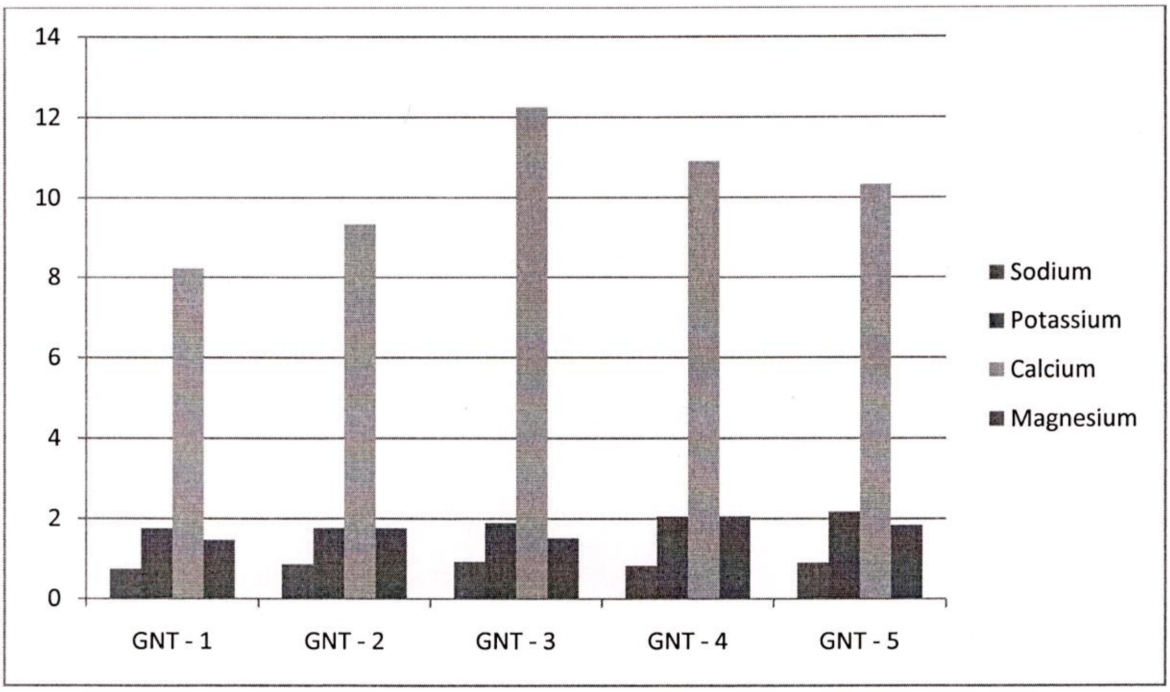


Fig No. 5.2 BAR-GRAPH DEPICTING CONCENTRATION OF VARIOUS ANIONS PRESENT IN SAMPLES:

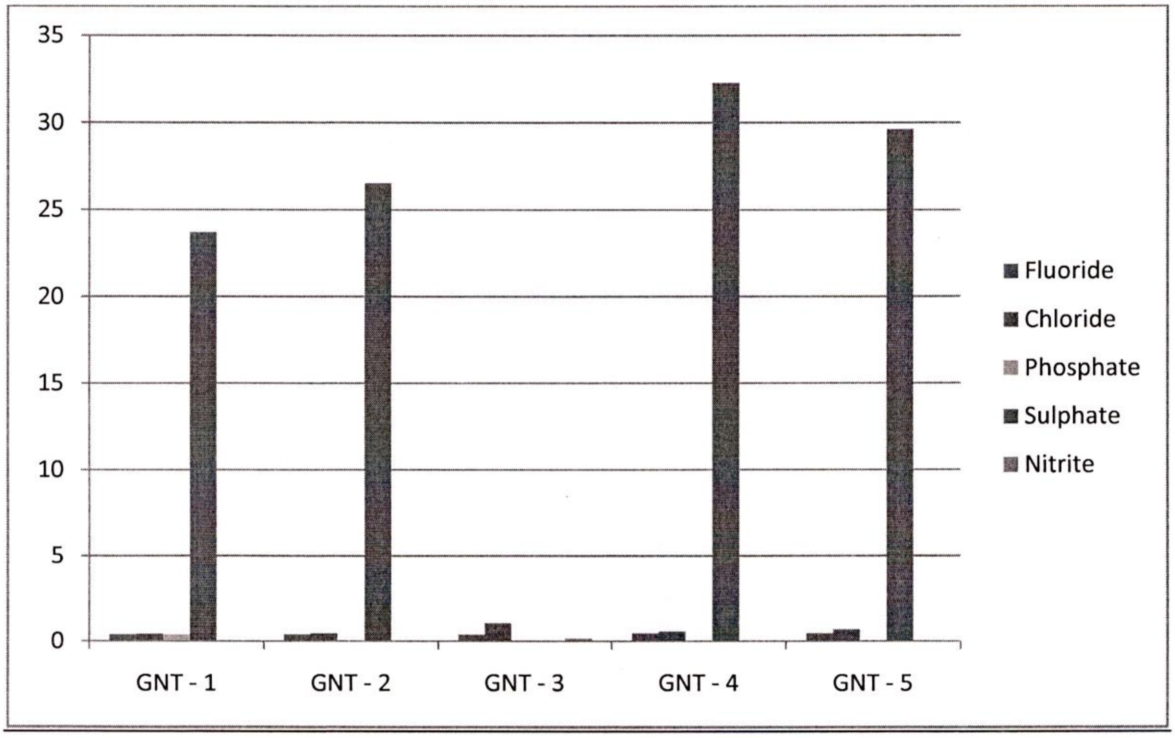


TABLE 5.4- OBTAINED CONCENTRATION AND STANDARD CONCENTRATION:

S. No.	Component	Max	Min	Average	Std. Conc.
	Anions				
1	Fluoride	0.485	0.382	**0.4268**	15.145
2	Chloride	1.061	0.425	**0.65**	15.866
3	Phosphate	0.402	n.d.	**0.402**	15.173
4	Sulphate	32.297	23.702	**22.4324**	15.844
5	Nitrate	12.10	n.d.	**12.10**	15.157
	Cations				
1	Sodium	0.935	0.748	**0.8612**	14.991
2	Potassium	2.180	1.764	**1.9342**	14.943
3	Calcium	10.911	8.223	**10.2064**	14.902
4	Magnesium	2.063	1.471	**1.7336**	14.918

n.d. – Not Detected

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Anion&

Anion

Component name	Retention time min	Height µS/cm	Area (µS/cm) x min	Concentration mg/L
Fluoride	6.40	24.800	4.404	15.145
Chloride	10.33	11.647	2.382	15.886
Nitrite	12.69	4.664	1.454	15.157
Nitrate	19.51	35.072	15.282	19.117
phosphate	26.48	1.206	0.636	15.173
Sulfate	31.79	3.191	1.922	15.844

Cation

Component name	Retention time min	Height µS/cm	Area (µS/cm) x min	Concentration mg/L
Sodium	13.08	10.191	3.863	14.991
Ammonium	15.36	8.390	3.280	15.009
Potassium	26.02	2.232	1.399	14.943
Calcium	33.19	2.126	2.254	14.902
Magnesium	45.12	2.884	4.977	14.918

Sample pH--n.d.

Total Hardness by IC-----------------------------0.986

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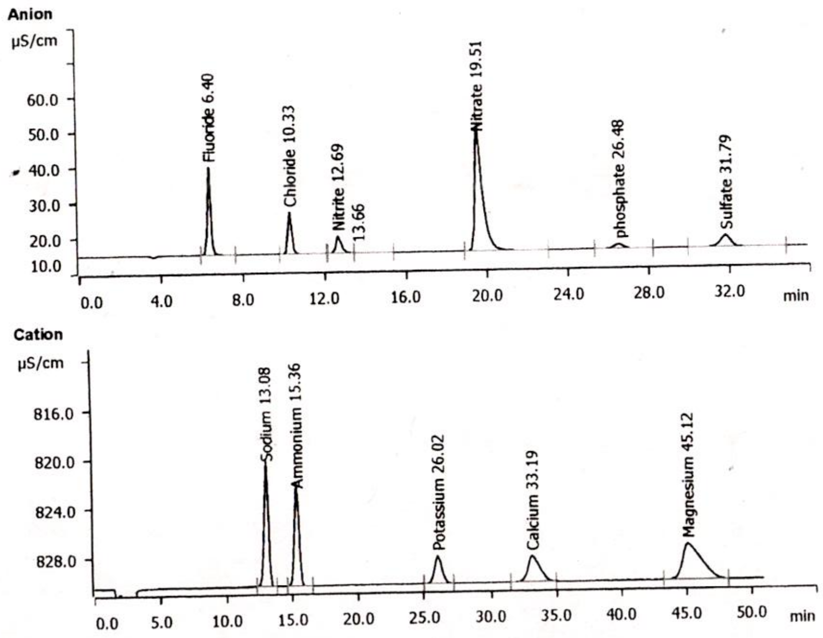

CHAPTER-6

CONCLUSION

CONCLUSIONS

The purpose of the present study was to characterize the glacier water of different regions of Gangotri Glacier. Five samples named GNT-1, GNT-2, GNT-3, GNT-4, GNT-5 having pH=6.6, 6.6, 7.1, 6.5, 7.0, hardness= 26.570, 30.539, 36.792, 35.710, 33.380 mg/L and alkalinity= 18.678, 8.450, 7.479, 56.169, 7.113 mg/L respectively were analyzed as per IS Specifications. The anions and cations were determined by Ion Chromatography, specifically by Titrimetric method.

We observed from the test result that the Hydrogen ion concentration in all the collected water samples were not very high and neither too low. The concentration obtained was within the permissible limit, i.e, approximately 6.8~7 (pH for drinking water).Some anions and cations are also high in the water sample. While the other parameters within the range as per IS Specification (10500).

Hydro-chemistry of glacial melt waters of the Gangotri Glacier was studied. The nature of pH, hardness, variable alkalinity and concentration of anions/cations were observed typically of bank water samples. There has been an increase in the concentration of cations from the past few years, which may be due to increase in chemical weathering due to temperature rise in the glacier.

CHAPTER-7

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