DISSERTATION REPORT

ON

METHODOLOGICAL ASSESSMENT FOR SUSTAINABILITY OF WATER RESOURCE IN DEHRADUN

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September, 2017

CANDIDATE'S DECLARATION

I hereby declare that the work which is being presented in this dissertation entitled **'Methodological Assessment for Sustainability of Water Resource in Dehradun"** in partial fulfillment of the requirements for the award of degree of **Bachelor of Technology** in **Agricultural Engineering** submitted in the **College of Agricultural Engineering , Madakasira** is an authentic record of my own work carried out during the period from 1st June, 2017 to 30th September, 2017 under the supervision of Dr. N. Ashok Kumar, CAE, Madakasira and Dr. M.Someshwar Rao, Scientis 'E', National Institute of Hydrology, Roorkee.

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CERTIFICATE

This dissertation entitled " Methodological Assessment for Sustainability of Water Resource in Dehradun" submitted by Mr T.Vijay, (B. Tech), College of Agricultural Engineering, Madakasira as a part of the training programme, is an original work and has not been submitted so far in part or in full, for any other degree of any university or institution

This is to certify that the above statement made by the candidate is correct to the best of my knowledge

Date: 29/9/2017

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CHAPTER 1: INTRODUCTION

In this chapter, along with some basic information about river rejuvenation, water conservation , water conservation structures, watershed management , ground water recharge and also the literature on the subject is reviewed and the objective of work is discussed.

1.1 River Rejuvenation

Over a long time, a river forms a generally smooth profile (see below). In terms of transporting water and sediment it is the most efficient profile to have. Rivers that have this form of profile are in balance with the environment (equilibrium). Typically a river will always try to form a concave shaped profile.

From time to time something can occur that changes and de-stabilizes this equilibrium. This causes the river to vertically erode its channel to re-establish the its long, smooth concave profile. This renewed period is known as rejuvenation.

1.1.1 Knick point:

A knick point is a sudden break or irregularity in the gradient along the long profile of a river. Some knick points are shapely defined, for example waterfalls, whereas others are barely noticeable. Although a number of factors can cause such features to occur, they are most commonly attributed to rejuvenation.
When a river is rejuvenated, adjustment to the new base level starts at the sea and gradually works its way up the river's course. The river gains renewed cutting power (in the form of vertical erosion)., which encourages it to adjust its long profile. In this sense the knick point is where the old long profile joins the new. The knick point recedes upstream at a rate which is dependent on the resistance of the rocks, and may linger at a relatively hard outcrop. It can be difficult to determine whether a waterfall occurs due to variability in rock type or rejuvenation.

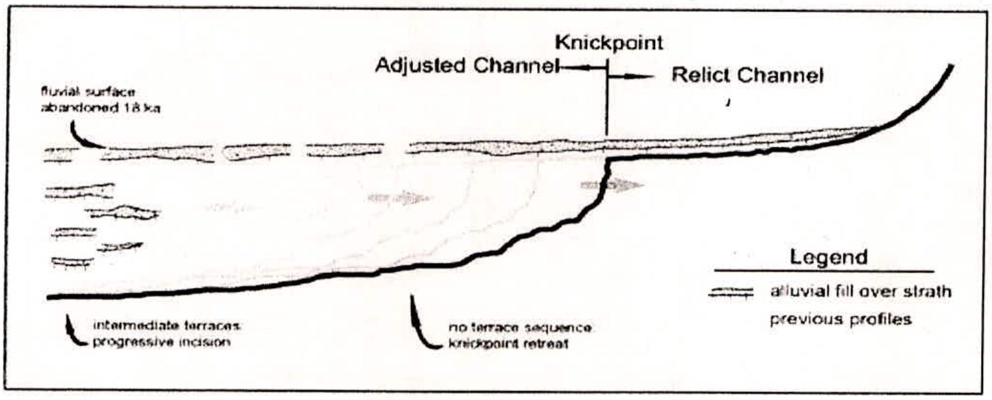

Figure1:knick point formation

1.2 Water Conservation:

Water conservation includes all the policies, strategies and activities made to sustainably manage the natural resource of fresh water, to protect the hydrosphere, and to meet the current and future human demand. Population, household size, and growth and affluence all affect how much water is used.

1.2.1 Why we go for water conservation

Conservation (WC) is defined as 'The minimization of loss or waste, care and protection of water resources and the efficient and effective use of water'. Water is the source of life for every living thing. Water conservation means using less water or recycling used water so that it can be used again. Water Demand Management is the strategy by which water conservation objectives are met and may be considered as its component. Water Conservation has three dimensions.

Water is the most precious of naturally occurring resources on planet Earth and one of the five eternal elements (viz. Earth, Water, Fire, Air and Ether). It is an essential part of the world's ecosystem and without it life would be impossible .Historically many of the great early civilizations flourished around rivers and major waterways:

Water has been central to human development, abating out thirst and watering our crops. Not only is water vital to the planet, it is also important to all living creatures and humans in particular. As a result water in many cultures has a divine and religious importance.

Figure2: Plants and Animals also require Water for Survival

Table1:sources of water and their availability in percentage

Type of water	Total water percent(%)	Available ground water(%)
1. Ice	80	
2. Water (Flowing)	20	-
(a)ponds	0 .2	1
(b)soil	0 .04	0 .2
(c)rivers	0.02	0 .1
(d)environment	0 .02	-
(e)Groundwater	19.7	98.4

1.2.2 Need for practicing water conservation and management.

When rain falls on the Earth, that water flows across or under the ground and begins The uneven distribution of rainfall has often threatened human welfare, livelihood and economic development. The growing scarcity of water is due to the rapid growth of population, rising demand for food and cash crops, increasing urbanization and rising standard of living. All these have increased the acuteness of the problem of water scarcity in future.

For efficient water conservation and management, the following points are to be kept in mind:

1. To aware people about the necessity of water and its conservation.
2. To involve people in all the activities of water management.

3. To make people aware that treated water should not be used in gardening, washing toilets and wash basins and so on.
4. Drying up of underground aquifers should be prevented.
5. Water-bodies should be kept pollution-free.
6. Different measures for specific area should be adopted for efficient water management, and active cooperation of the local people should also be sought in every measure. In spite of the fact that irrigation facilities in the country have improved considerably since independence, two-third of the cropped area is still rained. Increased use of tube wells and wells in recent years has lowered the water table and has caused depletion of underground water resources.

1.2.3 We can survive without food for a month but not more than 5 to 7 days without water

All plants and animals must have water to survive. If there was no water there would be no life on earth.
Agriculture is the largest user of water Aside from drinking it to survive; people have many other uses for water. These include the following:

- Washing one's body and clothes
- Washing, cooking and eating utensils;
- Keeping houses and communities clean
- Recreation; such as swimming pools
- Keeping plants alive in gardens and parks

Water is also essential for the healthy growth of farm crops and farm stock and is used in the manufacture of many products. This means that the water must be free of germs and chemicals and be clear. Water that is safe for drinking is called potable water.

1.3 Watershed Management

1.3.1 Watershed:

Watershed is defined as *a* geo hydrological unit draining to a common point by a system of drains. All lands on earth are part of one watershed or other. Watershed is thus the land and water area, which contributes runoff to a common point.

A watershed is an area of land and water bounded by a drainage divide within which the surface runoff collects and flows out of the watershed through a single outlet into à lager river (or) lake.**Watershed management** is a term used to describe the process of implementing land use practices and watermanagement practices to protect and improve the quality of the water and other natural resourceswithin a watershed by managing the use of those land and water resources in acomprehensive manner.

1.3.2 Types of watersheds

Watersheds are classified depending upon the size, drainage, shape and land use pattern.

- Macro watershed (> 50,000 Hect)
- Sub-watershed (10,000 to 50,000 Hect)
- Mille-watershed (1000 to10000 Hect)
- Micro watershed (100 to 1000 Hect)
- Mini watershed (1-100 Hect)

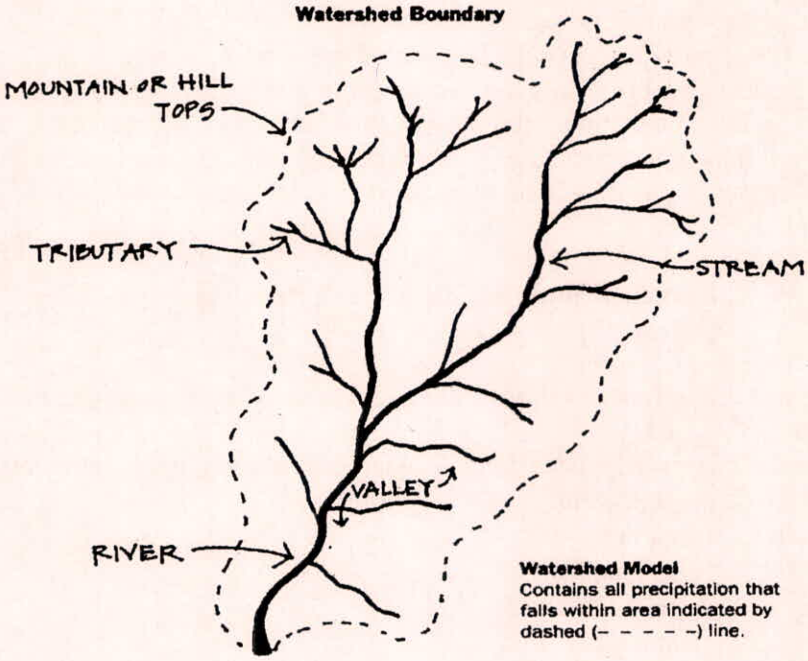

Figure3:Watershed Model (watershed boundary, streams, Tributaries)

1.3.3 Objectives of watershed management

The different objectives of watershed management programs are:

1. To control damaging runoff and degradation and thereby conservation of soil and water.
2. To manage and utilize the runoff water for useful purpose.
3. To protect, conserve and improve the land of watershed for more efficient and sustained production.
4. To protect and enhance the water resource originating in the watershed.
5. To check soil erosion and to reduce the effect of sediment yield on the watershed.
6. To rehabilitate the deteriorating lands.
7. To moderate the floods peaks at downstream areas.
8. To increase infiltration of rainwater.
9. To improve and increase the production of timbers, fodder and wild life resource.
10. To enhance the ground water recharge, wherever applicable

1.3.4 Factors affecting watershed management

a) Watershed characters

i) Size and shape
ii) Topography
iii) Soils
iv) Relief

b) Climatic characteristic

i. Precipitation
ii. Amount and intensity of rainfall

c) Watershed operation

d) Land use pattern

i. Vegetative cover
ii. Density

e) Social status of inability

f) Water resource and their capabilities.

1.3.5 Watershed management practices

1. In terms of purpose
   1. To increase infiltration
   2. To increase water holding capacity
   3. To prevent soil erosion
2. Method and accomplishments

   1. Vegetative measures (Agronomical measures)
      a. Strip cropping
      b. Pasture cropping
      c. Grass land farming
      d. Wood lands
   2. Engineering measures (Structural practices)
      a. Contour bunding
      b.Terracing
      c. Construction of earthen embankment
      d. Construction of check dams
      e. Construction of farm ponds
      f. Construction of diversion
      g. Gully controlling structure
         a. Rock dam
         b. Establishment of permanent grass and vegetation
      h. Providing vegetative and stone barriers

Influence of soil conservation measures and vegetation cover on erosion, Runoff and Nutrient loss. Rainwater harvesting is the main component of watershed management.

1.3.6 Watershed management structures

1. Broad beds and furrows

FUNCTION:
To control erosion and to conserve soil moisture in the soil during rainy days.

GENERAL INFORMATION:

The broad bed and furrow system is laid within the field boundaries. The land levels taken and it is laid using either animal drawn or tractor drawn ridges.

Figure4: Broad bed and furrow structure

FEATURES:

- Conserves soil moisture in dry land
- Controls soil erosion.
- Acts as a drainage channel during heavy rainy days.

2. Contour bund

FUNCTION: To intercept the run off flowing down the slope by an embankment. It helps to control run off velocity. The embankment may be closed or open, surplus arrangements are provided wherever necessary

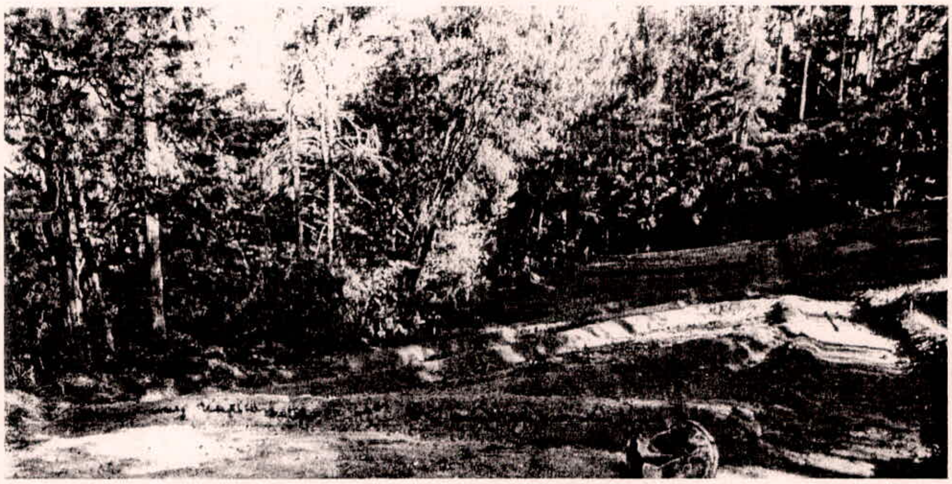

Figure5: Contour bund structure

FEATURES:

i. It can be adopted on all soils
ii. It can be laid up to 6% slopes.
iii. It helps to retain moisture in the field.

3. Bench terracing

It consists of construction of step like fields along contours by half cutting and half filling. Original slope is converted into level fields. The vertical & horizontal intervals are decided based on level slope.

FUNCTION: It helps to bring sloping land into different level strips to enable cultivation.

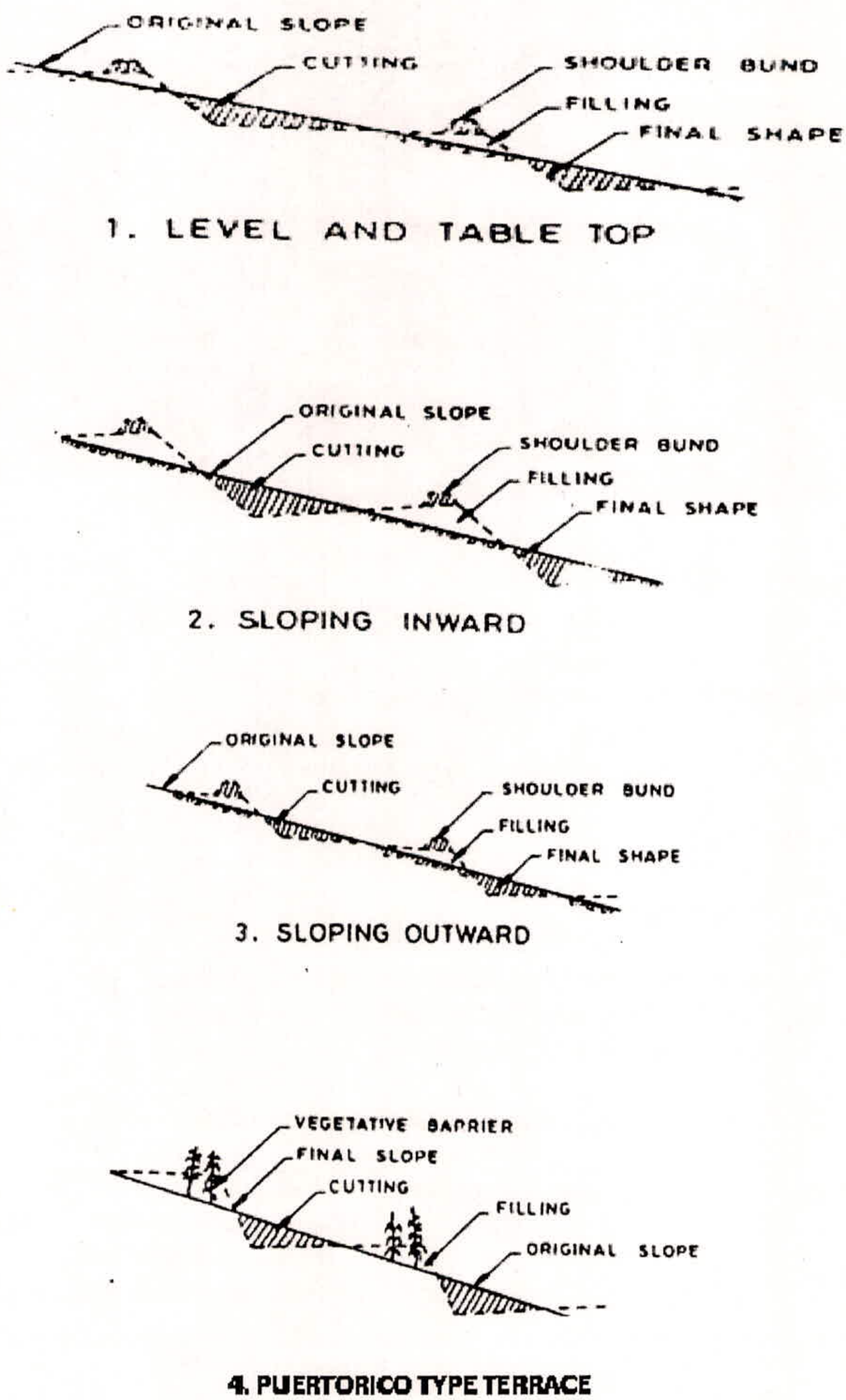

Figure6: Line diagram of terraces (level,inward,outward,puertorico types)

FEATURES:

- Suitable for hilly regions.
- The benches may be inward sloping to drain off excess water.
- The outward sloping benches will help to reduce the existing steep slope to mild one.
- It is adopted in soils with slopes greater than 6%

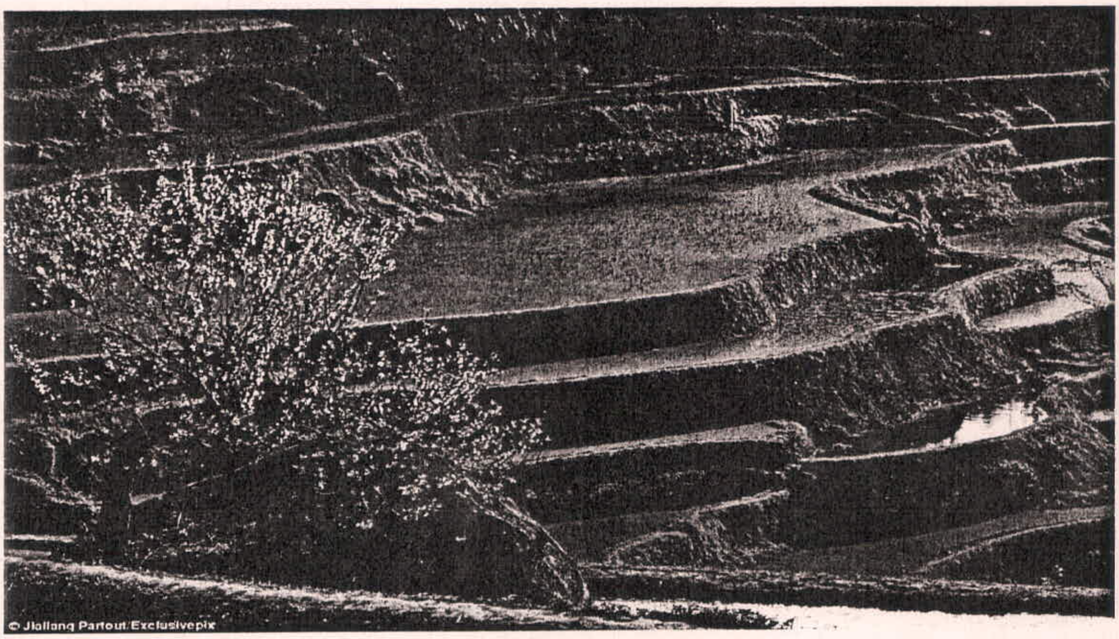

Figure7: terraces structure

4. Micro catchments for sloping lands

It is useful for in situ moisture conservation and erosion control for tree crops.

FEATURES:

- Slope ranges from 2 –8%
- Soil type – Light to moderate texture
- In situ moisture conservation with staggered planting
- Suitable for dry land Horticulture & Agro forestry
- Bund height – 30 to 45 cm.

Table2: General information of micro catchments for sloping lands

Technique	**Storage capacity per unit (m3)**	**Annual run-off contribution to soil moisture Additional water stored per ha (m3)**	**Estimated surface Run-off control (%)**
Triangular catchments (V-Bunds)	13	5200	80
Crescent bunds	10.2	4080	73

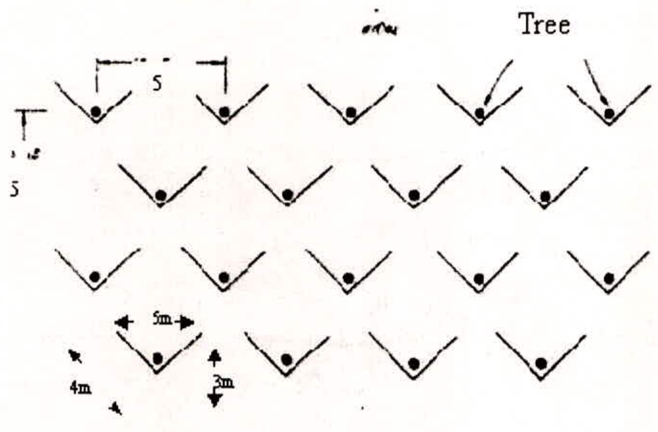

Figure8: Micro catchments for sloping lands

5. Check dam

A check dam is a small, sometimes temporary, dam constructed across a swale, drainage ditch, or waterway to counteract erosion by reducing water flow velocity. Check dams themselves are not a type of new technology; rather, they are an ancient technique dating all the way back to the second century A.D.

Features:

- A low weir normally constructed across the gullies
- Constructed on small streams and long gullies formed by erosive activity of flood water
- It cuts the velocity and reduces erosive activity
- The stored water improves soil moisture of the adjoining area and allows percolation to recharge the aquifers

- Spacing between the check dams water spread of one should be beyond the water spread of the other
- Height depends on the bank height, varies from a meter to 3 meter and length varies from less than 3m to 10m

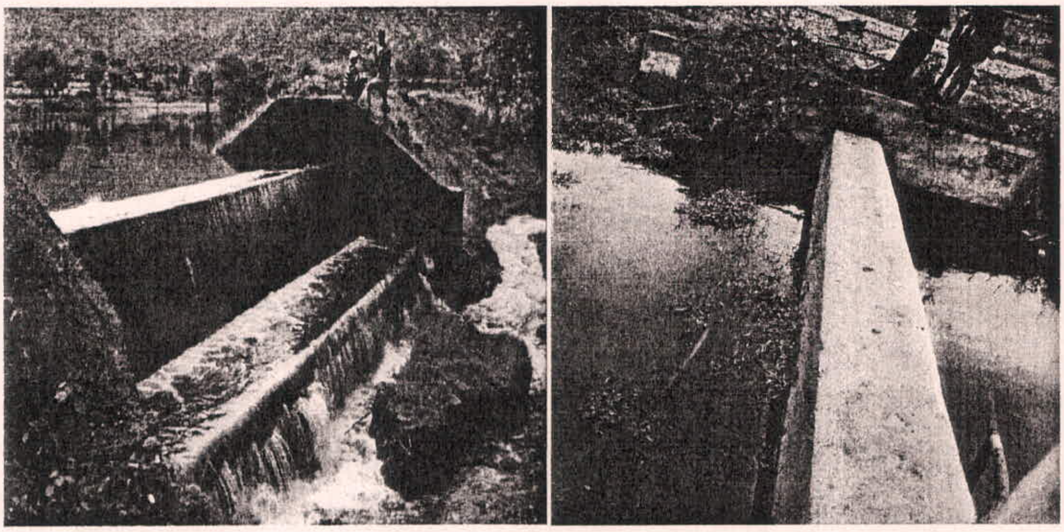

Figure9: check dam view

6. Percolation pond:

Function: To augment the ground water recharge

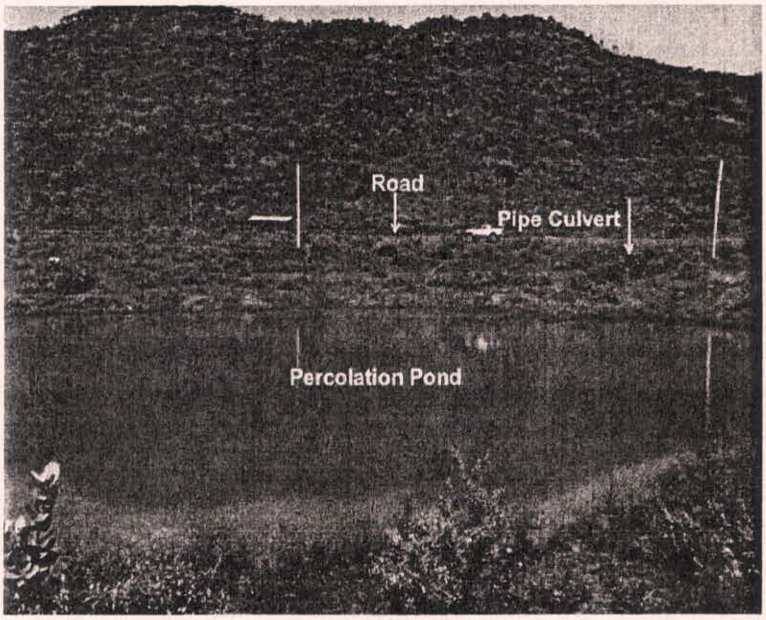

Figure10: Image of percolation pond

Salient features:

- Shallow depression created at lower portions in a natural or diverted stream course
- Preferable under gentle sloping stream where narrow valley exists
- Located in soils of permeable nature
- Adaptable where 20-30 ground water wells for irrigation exist with in the zone of influence about 800 – 900m
- Minimum capacity may be around 5000 m3 for the sack of economy
- Also act as silt detention reservoirs
- Cost varies from Rs. 60000 to 150000 per unit

7. Stone Barriers

Stone barriers are used to resist the erosion and used as the wall of the terraces and bunds

Figure11: stone barrier in field

8. Grassed Waterways

A grassed waterway is a vegetated channel that carries runoff at a non erosive velocity to a stable outlet. Grassed waterways can be enhanced by including filter strips to filter runoff and to trap sediment outside of the waterway. Vegetation in the channel should be lay down to convey water while vegetation in the filter strips should be tall and stiff to avoid submergence and to filter sediment from runoff.

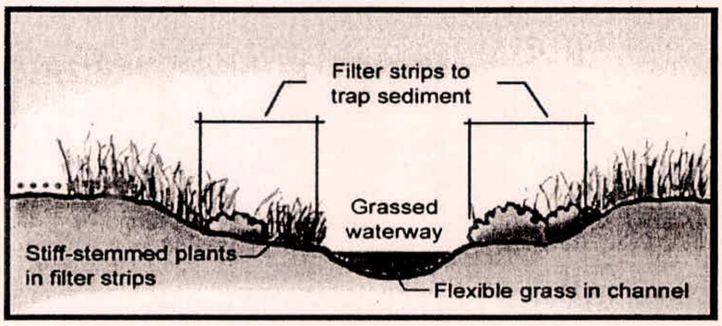

Figure12:Digram of grassed waterways

Types of Plain Water Storage Structures

In agriculture water storage, water is stored for later use in natural water sources, such as aquifers, soil water, natural wetlands, and small artificial ponds, tanks and reservoirs behind major dams

9. Wetlands

A wetland is a land area that is saturated with water, either permanently or seasonally, such that it takes on the characteristics of a distinct ecosystem. The primary factor that distinguishes wetlands from other land forms or water bodies is the characteristic vegetation of aquatic plants, adapted to the unique hydric soil. Wetlands play a number of roles in the environment, principally water purification, flood control, carbon sink and shoreline stability. Wetlands are also considered the most biologically diverse of all ecosystems, serving as home to a wide range of plant and animal life.

Figure13: wetland

10. Ponds and tanks

Ponds and water tanks can be defined as community-built or household water stores, filled by rainwater, groundwater infiltration or surface runoff. They are usually open, and therefore exposed to high levels of evaporation. They can be a great help to farmers in helping them overcome dry spells. However, they can promote vector-borne diseases such as malaria or schistosomiasis.

11. Dams and reservoirs

In the past, large dams have often been the focus of water storage efforts. Many large dams and their reservoirs have brought significant social and economic benefits. For example, Egypt's

Aswan High Dam, built in the 1960s, has protected the nation from drought and floods and supplies water used to irrigate some 15 million hectares. However, dams can also have great negative impacts. Because sediment is trapped by the Aswan High Dam, the Nile no longer delivers nutrients in large quantities to the floodplain. This has reduced soil fertility and increased the need for fertilizer.

DESCRIPTION ABOUT WATER CONSERVATION STRUCTURES

Table3: Description about water conservation structures

TYPE OF STRUCTURES	SLOPE /MEASUREMENTS	USE OF STRUCTURES / FEATURES
1.Broad beds and furrows		• Conserves soil moisture in dry land • Controls soil erosion. • Acts as a drainage channel during heavy rainy days.
2.Contour bunds	Up to 6% slope	• It can be adopted on all soils • It helps to retain moisture in the field.
3.Bench terracing	>6%	• Suitable for hilly regions. • The benches may be inward sloping to drain off excess water. • The outward sloping benches will help to reduce the existing steep slope to mild one.
4.Micro catchment for sloping lands	2-8%	• Soil type – Light to moderate texture • In situ moisture conservation with staggered planting • Suitable for dry land Horticulture & Agro forestry
5.Check dams	the bank height, varies from a meter to 3 meter and length varies from less than 3m to 10m	• A low weir normally constructed across the gullies • Constructed on small streams and long gullies formed by erosive activity of flood water • It cuts the velocity and reduces erosive activity • The stored water improves soil moisture of the adjoining area and allows percolation to recharge the aquifers • Spacing between the check dams water spread of one should be beyond the water spread of the other
6.Percolation ponds	Minimum capacity may be around 5000 m3 for the sack of economy	• Shallow depression created at lower portions in a natural or diverted stream course • Preferable under gentle sloping stream where narrow valley exists • Located in soils of permeable nature • Adaptable where 20-30 ground water wells for irrigation exist within the zone of influence about 800 – 900m • Also act as silt detention reservoir

		• To augment the ground water recharge
7.Stone barriers		• Stone barriers are used to resist the errosion and used as the wall of the terraces and bunds
8.Grassed waterways		• Grassed waterways are broad, shallow and typically saucer-shaped channels designed to move surface water across farmland without causing soil erosion.
9.Wet lands		• Water purification, flood control, carbon sink and shoreline stability. Wetlands are also considered the most biologically diverse of all ecosystems, serving as home to a wide range of plant and animal life.
10.Ponds and tanks		• It collects excess runoff during rainy period. • Stored water can be used for supplemental irrigation to crops. • It is useful as drinking water for cattle's during drought situation. • It can be used for spraying pesticides. • It conserves soil and moisture.
11.Dams and reservoirs		• In the past, large dams have often been the focus of water storage efforts. Many large dams and their reservoirs have brought significant social and economic benefits • This has reduced soil fertility and increased the need for fertilizer.

1.4 Water Balance:

In hydrology, a water balance equation can be used to describe the flow of water in and out of a system. A system can be one of several hydrological domains, such as a column of soil or a drainage basin.] Water balance can also refer to the ways in which an organism maintains water in dry or hot conditions. It is often discussed in reference to plants or arthropods, which have a variety of water retention mechanisms, including a lipid waxy coating that has limited permeability.

A general water balance equation is:

$$P = R + E + \Delta S$$

Where

P = Precipitation, E= Evapotranspiration

R= Stream flow, Δ S= change in storage (in soil or the bedrock/ground water)

This equation uses the principles of conservation of mass in a closed system, whereby any water entering a system (via precipitation), must be transferred into either evaporation, surface runoff (eventually reaching the channel and leaving in the form of river discharge), or stored in the ground. This equation requires the system to be closed, and where it isn't (for example when surface runoff contributes to a different basin), this must be taken into account.

Extensive water balances are discussed in agricultural hydrology.

1.5 Reducing Water Loss:

From the surface of the reservoirs large quantities of water are lost through evaporation. Average annual evaporation from water bodies in India varies from 1 to 3.5 m. At an average annual loss of 2.25 m, evaporation from existing water 3 bodies turns out to 27000 million cubic meters. This is equivalent to the domestic needs for an urban population of nearly 140 crores. It may not, however, be possible to take remedial measures of evaporation retardation on all storages/water bodies. Assuming even 20% of the above area falls in scarcity and drought areas, it may be necessary to tackle around 2400 sq.km of surface area. It is further seen that about 30% of evaporation retardation may be achieved by known retardation methods. Thus it may perhaps be possible 3 to effect a saving to the extent of 1620 mm.

1.6 Reducing Water Demand:

Reducing water consumption in the home is a simple and easy way to decrease water and energy bills and reduce your household's impact on the environment. Conserving scarce water resources helps reduce the need to dam rivers, reduce 144 wastewater produced and treated at sewage plants, lower energy requirements for treating and transporting water and wastewater, and reduce greenhouse gas emissions.

Low cost water reduction can take place in every household, often with costs recouped through water and energy savings within one year.

1.7 Causes of water scarcity:

Over-extraction has its most straightforward manifestation in the level of aquifers, underground reserves charged by the passage of water through soil and rocks. If withdrawals exceed the natural rate of recharge, the level of an aquifer will fall, eventually drying up altogether. Human intervention degrades the natural supply of freshwater and occurs in three principal ways. Firstly, there are approximately 3,200 dams constructed in India, with many more under construction. Dams alter the natural flow of a river, often improving water and energy security for some, at the expense of others including environmental and societal concerns. Can building of smaller dams be a solution to this problem.

1.8 Recharging ground water aquifers

Ground water aquifers can be recharged by various kinds of structures to ensure percolation of rainwater in the ground instead of draining away from the surface.

Commonly used recharging methods are:-

- Recharging of bore wells
- Recharging of dug wells.
- Recharge pits
- Recharge Trenches
- Soak ways or Recharge Shafts
- Percolation Tanks

a) Recharging of bore wells

Rainwater collected from rooftop of the building is diverted through drainpipes to settlement or filtration tank. After settlement filtered water is diverted to bore wells to recharge deep aquifers. Abandoned bore wells can also be used for recharge.
Optimum capacity of settlement tank/filtration tank can be designed on the basis of area of catchement, intensity of rainfall and recharge rate as discussed in design parameters. While recharging, entry of floating matter and silt should be restricted because it may clog the recharge structure. "first one or two shower should be flushed out through rain separator to avoid contamination. This is very important, and all care should be taken to ensure that this has been done."

b) Recharge Pits

Recharge pits are small pits of any shape rectangular, square or circular, contracted with brick or stone masonry wall with weep hole at regular intervals. to of pit can be covered with perforated covers. Bottom of pit should be filled with filter media. The capacity of the pit can be designed on the basis of catchment area, rainfall intensity and recharge rate of soil. Usually the dimensions of the pit may be of 1 to 2 m width and 2 to 3 m deep depending on the depth of pervious strata. These pits are suitable for recharging of shallow aquifers, and small houses.

c) Soak away or Recharge Shafts

Soak away or recharge shafts are provided where upper layer of soil is alluvial or less pervious. These are bored hole of 30 cm dia. up to 10 to 15 m deep, depending on depth of pervious layer. Bore should be lined with slotted/perforated PVC/MS pipe to prevent collapse of the vertical sides. At the top of soak away required size sump is constructed to retain runoff before the filters through soak away. Sump should be filled with filter media.

d) Recharging of dug wells

Dug well can be used as recharge structure. Rainwater from the rooftop is diverted to dug wells after passing it through filtration bed. Cleaning and desalting of dug well should be done regularly to enhance the recharge rate. The filtration method suggested for bore well recharging could be used.

e) Recharge Trenches

Recharge trench in provided where upper impervious layer of soil is shallow. It is a trench excavated on the ground and refilled with porous media like pebbles, boulder or brickbats. it is usually made for harvesting the surface runoff. Bore wells can also be provided inside the trench as recharge shafts to enhance percolation. The length of the trench is decided as per the amount of runoff expected. This method is suitable for small houses, playgrounds, parks and roadside drains. The recharge trench can be of size 0.50 to 1.0 m wide and 1.0 to 1.5 m deep.

Project in Dehradun:

Himalayan region is known for its abundance in natural wealth and scenic beauty. It is considered to be one of the most ideal tourist places with its great weather, dense vegetation and especially, good water quality. Many of the sacred Indian rivers like Ganga originate in the Himalayas.
The State of Uttarakhand is divided into two main administrative divisions

- **Garhwal division**: Chamoli, Dehra Dun, Hardwar, Pauri Garhwal, Tehri Garhwal & Uttarkashi districts
- **Kumaun division**: Almora, Bageshwar, Champawat, Nainital, Pithoragad, Rudraprayag, Udham Singh Nagar districts.

Himalaya, the youngest fold mountain chain in the world passes through Uttarakhand. The Himalayas form one of the highest mountain chains of the world with more than 30 peaks, rising to the height of 7300m above mean sea level(msl).
The Himalayas are divided longitudinally into six tectonic zones. These zones, ranging from the south to the north are:

1. Sub Himalaya (Main Frontal thrust to Main Boundary Thrust
2. Lesser Himalaya (Main Boundary Thrust to Main Central Thrust)
3. Higher Himalaya
4. Tethys Himalaya
5. Indus Suture zone
6. Trans Himalaya

1.10 Objective

Rivers and lakes are a major source of drinking water supply, but surface water (SW) can be contaminated due to its susceptibility to pollution. Conservation of the environment maintaining the quality and quantity of water has become a big challenge. Alluvial aquifers which are hydraulically associated with a water system have come into consideration for production of drinking water. Bank filtration (BF), a water treatment method, is a natural approach to extract water from rivers through wells Installed in neighboring alluvial aquifers. Usually alluvial aquifers are a potential source of groundwater (GW) due to their properties such as high production potential and economy of extraction1. The SW flows through the river bed and banks by hydraulic gradient to the pumping well adjacent to the river.
\ Water is essential for humans, animals, and also plants. Water is included daily activities like cooking, washing , irrigation and also industrialization. Depleting of water is reduced by water conservation methods.

The specific objective of project are

1. To access the water availability in study area and their conservation by using all over the water conservation methods
2. select the study area in Dehradun and digitize the area by using GIS
3.Field visit and note the problems of study area
3.Sampling and their analysis (both hydro chemical and isotope analysis)
Last but not least Management measures can be applied as to minimize the problems of the area. Management measures should be economically sound and environmentally benefits.

Note: All the references used in the report are given at the end as an appendix to the report

CHAPTER2:STUDY AREA

2.1 Dehradun profile

Dehradun is the administrative centre and the interim capital of the new state of Uttarakhand. Dehradun is situated at the Himalayan foothills in the fertile Doon Valley. The valley is well known for its salubrious climate and natural beauty. It is due to this reason Dehradun has been one of the favorite residential cities. Dehradun is also one of the most beautiful resort centers in India, it is well known for its scenic natural beauty, beautiful forests, waterfalls and surroundings. It is also an important educational centre of the country. India's some of the best public schools and convents are located here. The Indian Military Academy, Forest Research Institute,ONGC and many more offices of Central and State Govt are located here. Dehradun is well linked with rail, road and air routes to all the parts of the state and the country. Main languages spoken in the district are Hindi, Garhwali Sindhi, Punjabi, and Urdu.

Garhwal is drained almost entirely by Ganga and its tributaries, the various drainage systems present here are: (a) The Alaknanda drainage system

(b) The Ganga drainage system,

(c) The Bhagirathi drainage system,

(d) The Yamuna drainage system.

Water is the most abundant and at the same time the least managed resource of the region. Steep gradient with rapid runoff is the major obstacle to a productive utilization of water resource. Sub-surface flow from spring has been a traditional source of drinking water in the region. However, with the growing scarcity of ground recharge and drying up of the springs, people have to walk down slope distances to collect water.

2.1.1 Location

The study area of this project lies in 'Western Himalaya' agro-ecological region of the sub-humid ecosystem at elevation of 720 m to 2350 m. Climate in this region is warm with air temperature 30 ^{0}C to 35^{0}C sub-humid to humid with average annual rainfall 900 to 1200 mm. Soils are shallow and medium, loamy, brown forest and podzolic soils with low and medium available water content (AWC); and deep loamy Tarai soils with high AWC. Water deficit is generally low (300-500 mm), and length of growing period of crops is 180-210 days. Type of forest is moist, temperature, subtropical, pine and subalpine forests.

The Dehadun is situated between 30.33°N &78.06°E .The total area is 300 km^2.

2.1.2 Historical Background

The name Dehradun is a combination of two words "Dehra" which means Camp and "Dun" which means valley. Its history goes back to the 17th century. It was annexed by the British in 1815 and had been one of their favorite places due to its location and climate.

2.1.3 City and its Surroundings

Nestled in Doon Valley, Dehradun has several attractions, many of which are academic institutions and research centers of national importance

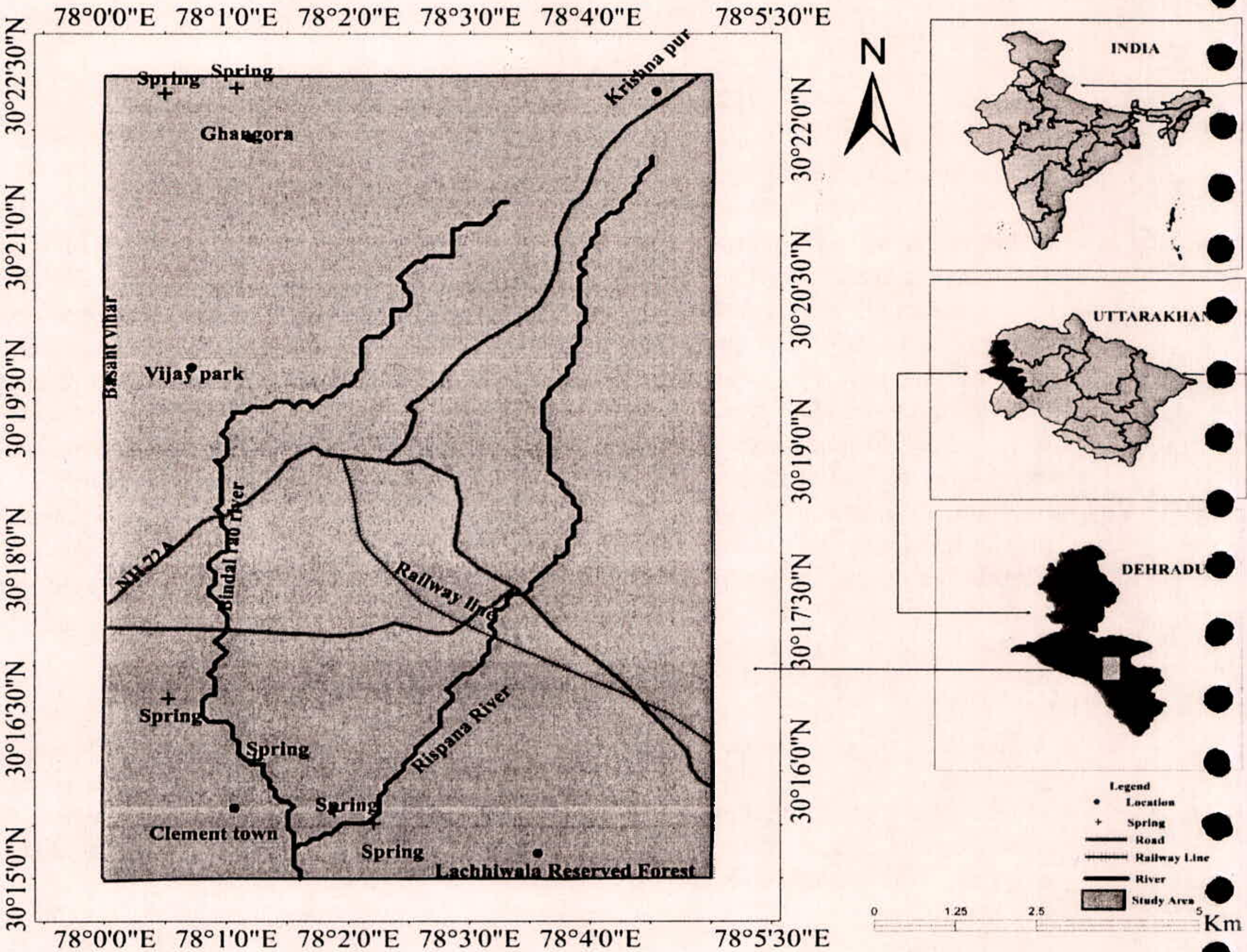

Figure14: Study area separated from Dehradun, by using Arc GIS9.3

2.1.5 Institutional Attractions

Many institutions of national importance like the Forest Research Institute; Oil and Natural Gas Commission; Indian Military Academy; Indian Institute of Petroleum, Indian Institute of Remote Sensing, Zoological Survey of India, Wadia Institute of Himalyan Geology and Survey of India, National Institute of Visually Handicapped etc are located in Dehradun.

2.1.4 Climate and Rainfall

Dehradun is situated at an altitude of 2,200 feet above sea level. Dehradun enjoys a salubrious climate due to its location in the hilly part of the state. During the summer months, the temperature ranges between 36°C and 16.7° C. The winter months are colder with the maximum and minimum temperatures touching 23.4°C and 5.2° C respectively. Dehradun experiences heavy to moderate showers during late June to mid-August. Most of the annual rainfall of about 2000mm in the district is received during the months from June to September, July and August being the rainiest months in the season.

Table4: Dehradun annual temperature and rainfall data

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature (°C)	12.6	14.8	19.3	24.5	28.9	29.4	26.8	26	25.5	22.1	17.3	13.9
Min. Temperature (°C)	6.2	8.2	12.4	17	21.6	23.6	23.1	22.6	21.3	16.1	10.2	7
Max. Temperature (°C)	19	21.4	26.3	32.1	36.2	35.3	30.5	29.5	29.7	28.2	24.5	20.8
Avg. Temperature (°F)	54.7	58.6	66.7	76.1	84.0	84.9	80.2	78.8	77.9	71.8	63.1	57.0
Min. Temperature (°F)	43.2	46.8	54.3	62.6	70.9	74.5	73.6	72.7	70.3	61.0	50.4	44.6
Max. Temperature (°F)	66.2	70.5	79.3	89.8	97.2	95.5	86.9	85.1	85.5	82.8	76.1	69.4
Precipitation / Rainfall (mm)	63	42	56	16	45	149	545	567	276	96	17	24

2.1.6 Tourist Attractions

Dehradun, the headquarters of the district is visited by a large number of tourist every year, many of them enroute to Mussoorie. There are a number of places worth-seeing in Dehradun and its surroundings in terms of their tourism attractions such as Gurudwara temple, Sahastradhara, Robbers Cave, Dakpatthar, Tapkeshwari Mahadeo temple, Malsi Deer Park, Raipur spring, etc.Jhanda Fair is held every year at the historic Guru Ram Rai Darbar in Dehradun City in memory of the Guru. Kalsi is an archaeological site situated close to River Yamuna on the way from Dehradun to the hill station of Chakrata.

Rajaji National Park is situated at the edge of the sprawling Dehradun valley, was founded in 1966 and spreads over an area of about 820 sq. km.Nestled in a lush valley of the Sivalik Range, the park is an ideal holiday resort with its many picnic spots and excursion sites for the nature lover. Rajaji National Park is one of the most famous national parks of India.

2.1.7 Linkages and Connectivity

Dehradun is well connected by road to New Delhi and other major towns in north India. Road distances to some important centres in the region are: Delhi 255 km; Chandigarh 130 km; Haridwar 54 km; Mussoorie 34 km; Rishikesh 43 km; Agra 382 km; Shimla 221 km; Yamunotri 279 km; Kedarnath 270 km; Nainital 297 km. The city is well connected by daily direct trains coming in from Delhi, Calcutta, Mumbai, Varanasi, Lucknow and other places. The nearest airport from Dehradun is the Jolly Grant Airport situated on the outskirts of the town, around 25 km away from the city.

2.2 Land use:

The Himalayan hills and Shiwalik hills covered the northern portion of the state and from the base of the Himalayas the Garwal devision begins that consists the huge amount of grassland, forest and wetland. The Ganga deltaic regions cover the large portion of state. Many tributaries and streams are originate from the river Ganga.

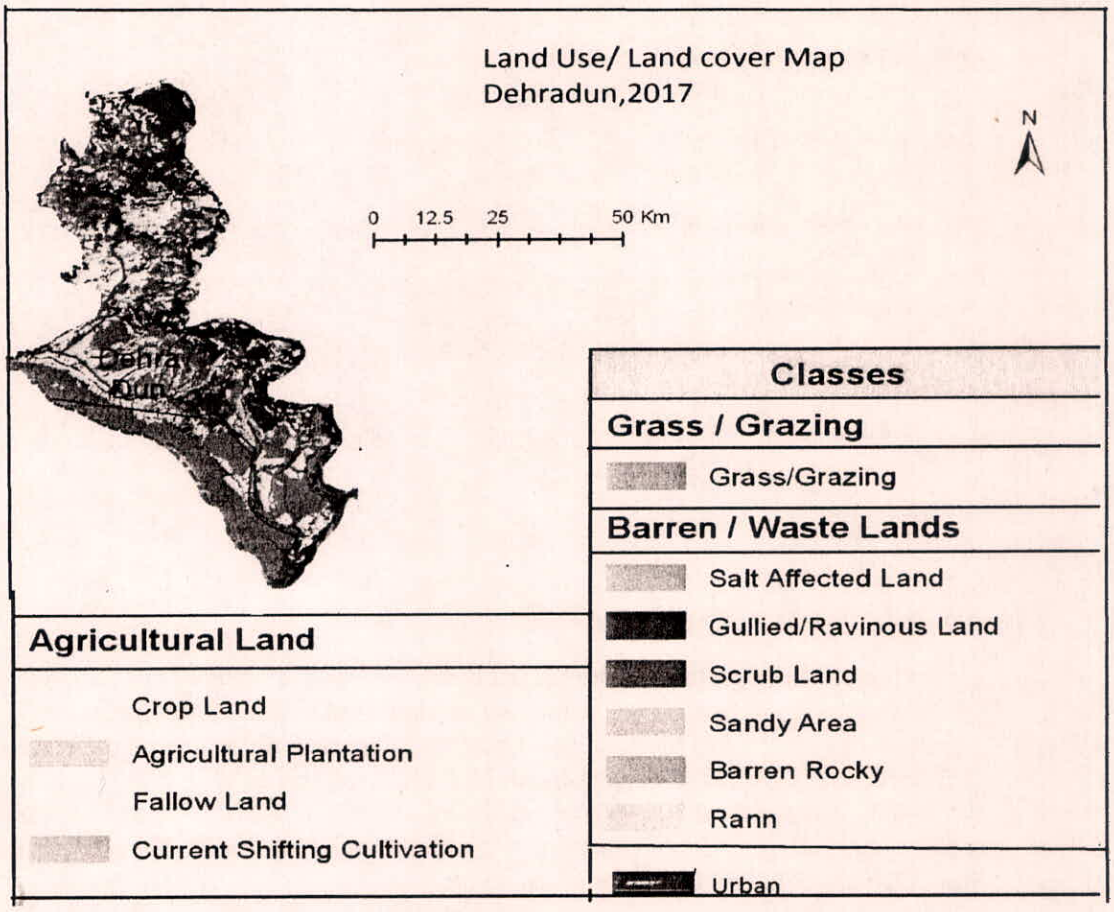

Figure15: Land use map of Dehradun Distict

Table5: category wise distribution of land use

Agricultural		Dehradun(Area in Km^2)
	Crop Land	762.94
	Plantation	47.08
Barren/Uncultivable/Waste land	Salt Affected Land	Very less(.125)
	Gullied/Ravinos Land	
	Scrub land	96.62
	Sandy area	.03
	Barren rocky	.19
	Rann	
Built-up	Urban	125.74
Forest	Ever Green Forest	623.52(only Ever green)
Grass/Grazing	Grass/Grazing	22.23

The (Table5) land use values are taken from Bhuvan website(www.Bhuvan.com). This is the survey of Dehradun during 2011-2012, From above result the Dehradun total area having more agricultural land and forestry, but study area of this project having urban is more.

2.3 Digital Elevation Model (DEM):

The representation of continuous elevation values over a topographic surface by a regular array of z-values, referenced to a common vertical datum. DEMs are typically used to represent the bare-earth terrain, void of vegetation and manmade features.

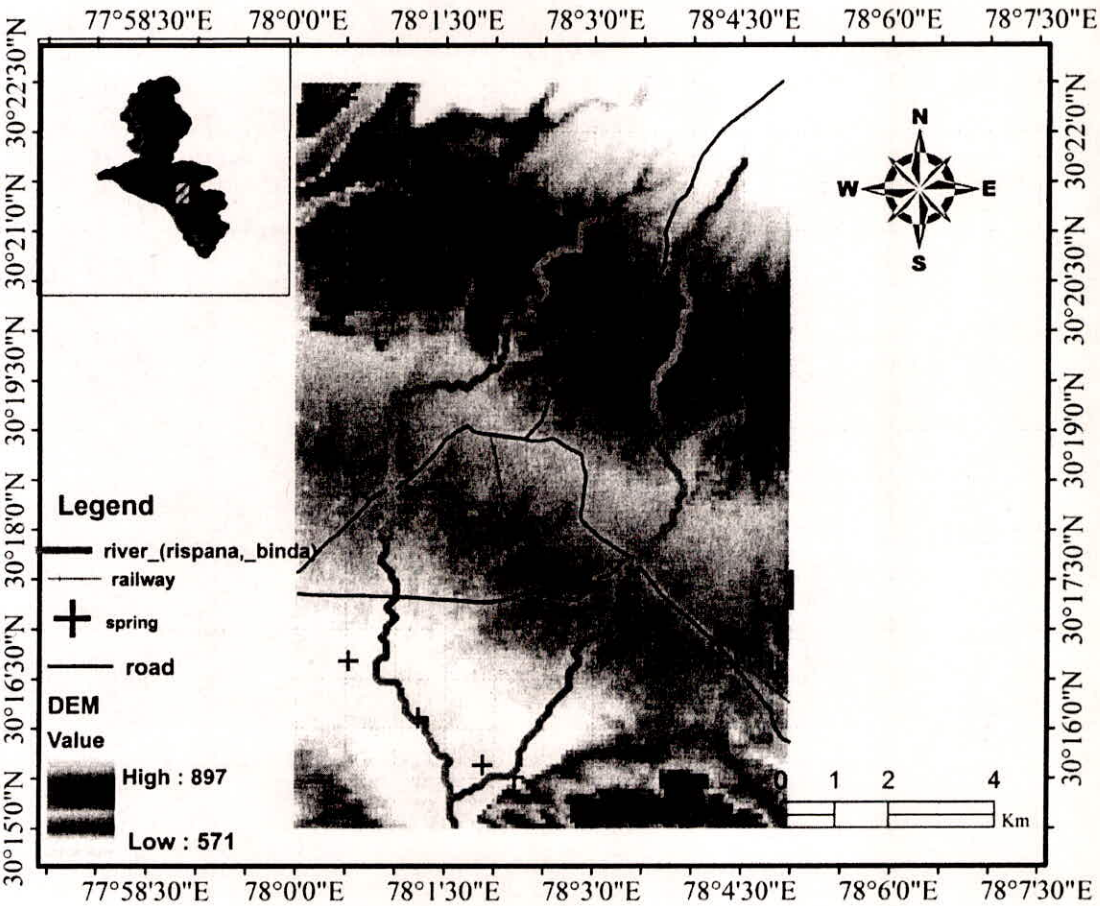

Figure16: Digital Elevation Model (DEM) map of study area

As observation of DEM map, Red color indicates more mean sea level, White and green indicates less mean sea level, the study area fall in the range 897m

2.4 Drainage Network:

The special arrangement of the river and its tributary are referred to as drainage pattern of study area. The investigation of drainage network systems would seem to address the essential focus of a geographical approach to landform analysis. Drainage networks identify organized transport systems in space, and also operate as dynamic space-filling systems in temporal landscape evolution.

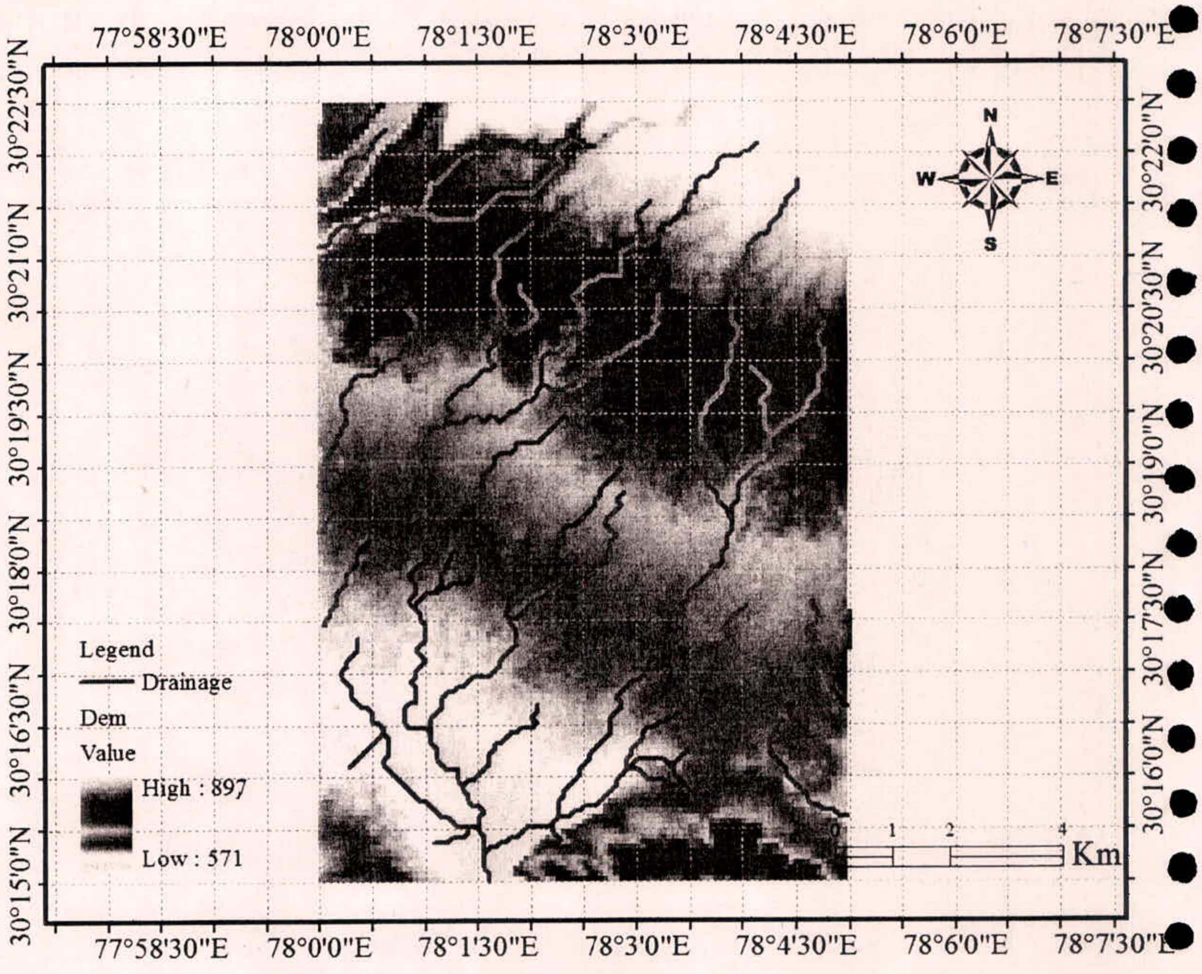

Figure17: Drainage network map of study area

The drainage network map (Figure17) shows the interconnected streams of Bindal and Rispana watersheds draining from altitude of 900m and joining in the plains at elevation ~ 570m

2.5 Slope:

Slope is the percent change in that elevation over a certain distance. Slope is measured by calculating the difference in the elevation from one point to another divided by the lateral distance between those points.

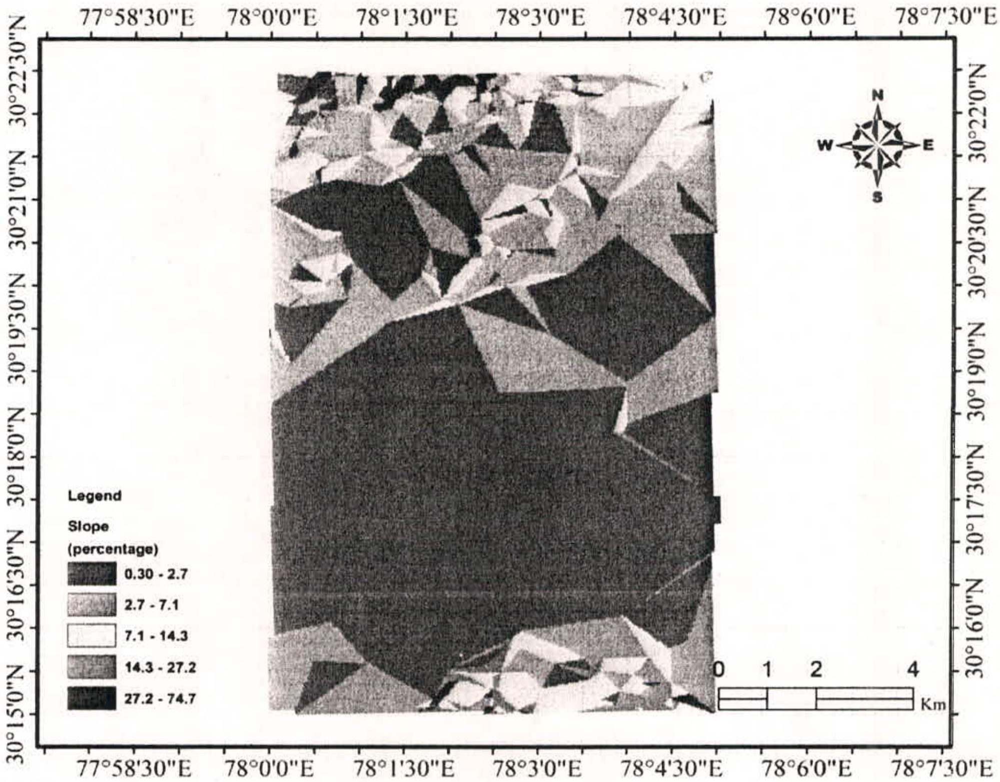

Figure18:Slope map of study area

In that study .30- 2.7 is normal slope it is suitable for cultivation ,then 2.7-7.1 slope is undulating , in this slope we go for water conservation structures like bunds, terraces . The slope is more than 8 %, the land is not suitable for farming, and it is steep and burial land. The figure18 shows that the major part of the study area (approximately 40% of the area mainly the lower half region) falls in the category of Flat region as for the slope classification (Table4)

Table4: Regional slope classification

	Original SOTER	Quantitative procedure
Flat	0-2 %	0-2 %
Gently undulating	2-5 %	2-5 %
Undulating	5-8 %	5-8 %
Rolling	8-15 %	8-15 %
Moderately steep	15-30 %	15-30 %
Steep	30-60 %	30-60 %

2.6 Watershed:

We are already discuss, what is watershed and also watershed management in first chapter (**1.3**).the below watershed map represent the watershed points and also drainage line of study area.

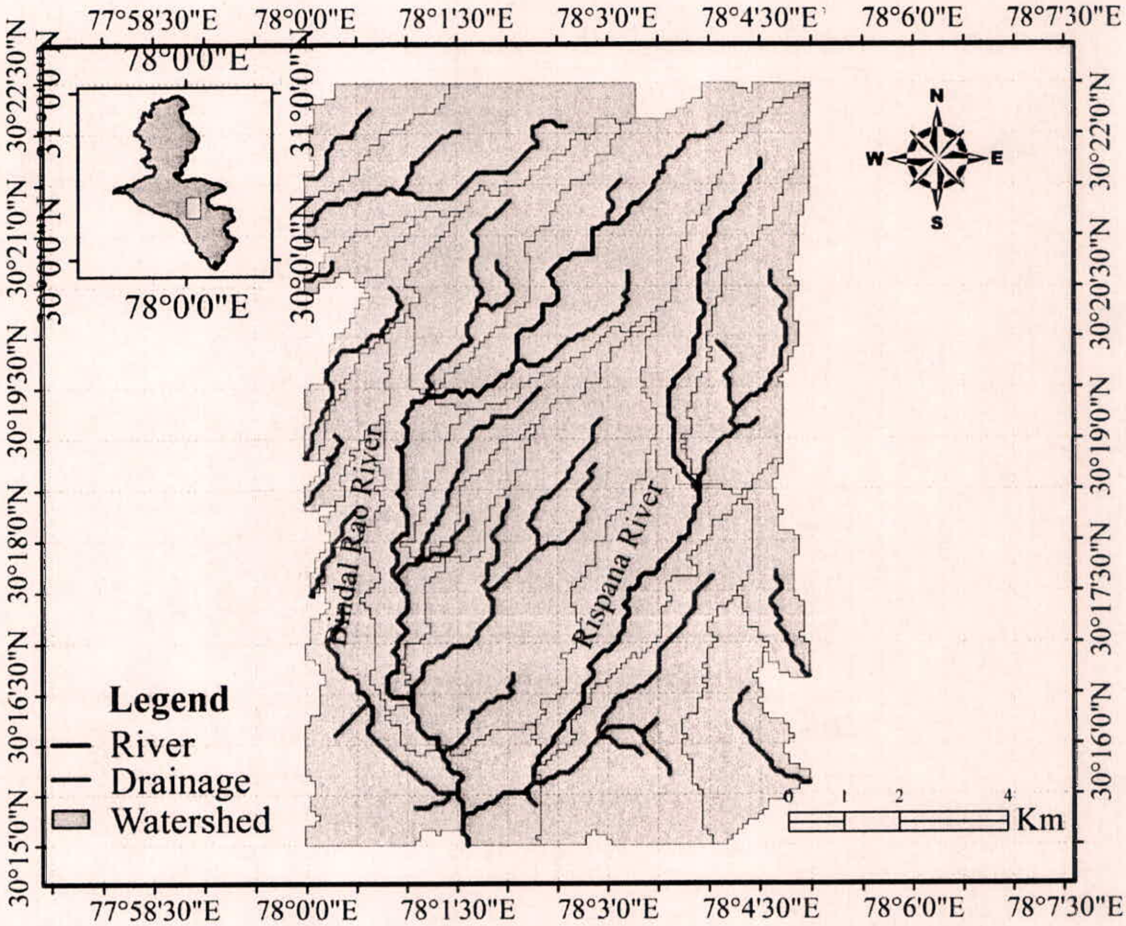

Figure19: Watershed of study area

The watershed map study area (Figure19) shows about 53watersheds of which 4 are milli watersheds 36 are micro watersheds and the remaining are mini watersheds(definitions of watershed classifications is given in the sections 1.3.2) . The largest of these watersheds is 2000 hectare. The largest watershed falls between main cource of Bindal and Rispana rivers . The other two large watersheds include (i) The main course of Rispana river and (ii) The upper segment of Rispana river

2.7 Catchment:

A catchment is an area of land where water collects when it rains, often bounded by hills. As the water flows over the landscape it finds its way into streams and down into the soil, eventually feeding the river. Some of this water stays underground and continues to slowly feed the river in times of low rainfall. Every inch of land on the Earth forms part of a catchment.

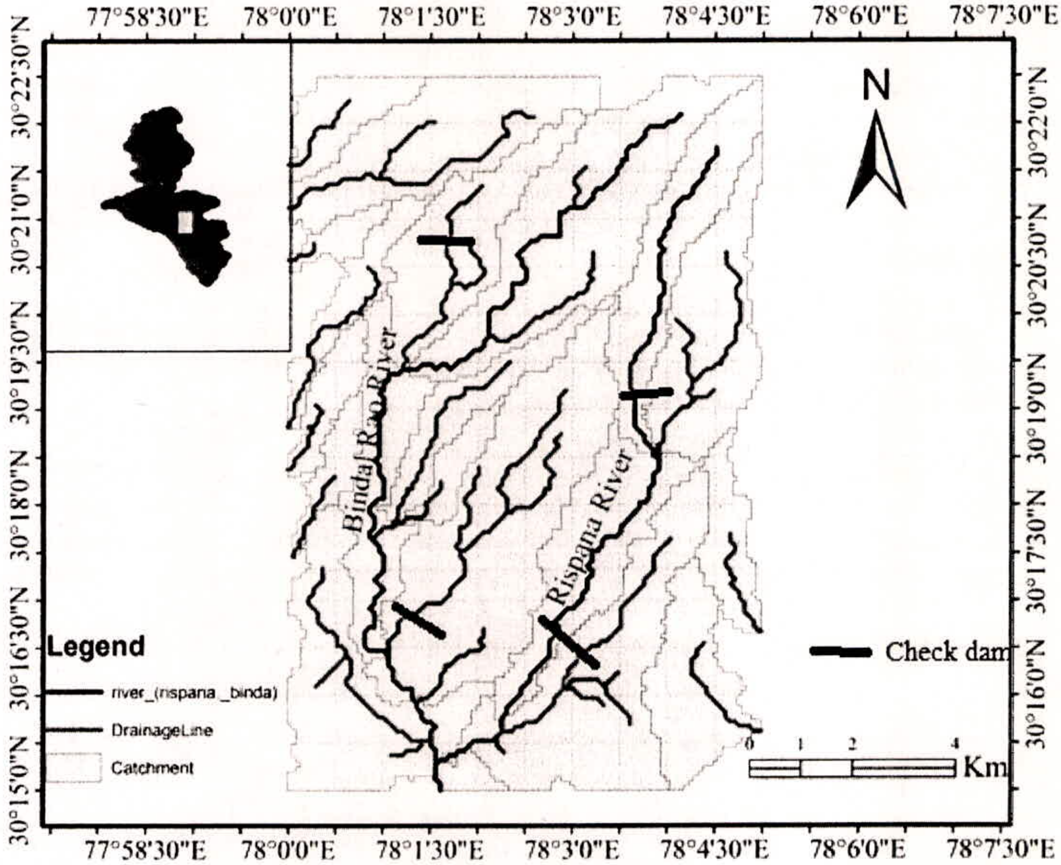

Figure20: Catchment map of study area

By integrating the watershed map, catchment area looking at the sinuosity of drains end river confluence locations in the drainage map 6 positions for constructions of check dams have been identified (Figure20). These 6 check dams can be appropriately managed to augment major watersheds (ground water and surface water) of Bindal and Rispana rivers. also the identify locations of these check dams falls in the northern and southern sides of the urbanized zone of Dehradun city .Therefore, these check dams can also be used for flood control measures ,pollution washout ,riverfront development, minimum flow requirements of these streams ect..

- This all GIS maps , various structures are discussed, using this appropriate water storage structures like farm ponds ,percolation ponds ,check dams ect

2.8 Pollution of Water Bodies (Taking under study area):

No major river flows through the city. There are no perennial rivers within the city limits. Seasonal rivulets such as Bindal, Rispana flow during the monsoon. They then join the Suswa, which in turn flows into the Ganga after a distance of 20 km. In the rest of the year these rivulets mostly remain dry or carry wastewater. Quality monitoring of these rivulets is not done. There is encroachment along the river bed over a long stretch of the river within the city limit. The major causes of pollution in the river are:

- Dumping of garbage into the rivers on a routine basis
- Encroachment due to Malin Bastis along the water way of the river causing Discharge of human excreta directly into the river
- Illegal discharge of sewage and sullage into the river

As a matter of fact the rivers are more of an eye sore and health hazard due to them above reasons.

2.9 Sampling Site

Samples are collected to proceed the chemical and isotopic analysis of groundwater so that the concentration or abundance of any element is found that leads to create problems in the quality and quantity of river water, spring water and also groundwater.

The samples are collected from the Dehradun district of the state and collection is done from the seven different areas. The samples collected from the sites are Kudkawala bridge road(Markham grant), 20MLD STP(Mothrowala), Nagal hatnala, Makarti,Bunjara.The source of collection of sample is through the Rispana ,Bindal rivers ,springs, and also hand pumps in that area.

Table5: Sampling data with all over the required parameters

S. No.	Sample code/ ID	Date of collection	Source	Location Details	EC	pH	Lat	Long
1	1DDN-1	3.08.17	Rispana River	Kudkawala Bridge road,Markham Grant	660	8.4	30.15981	78.09658
2	1DDN-2	3.08.17	Hand Pump	Kudkawala Bridge road,Markham Grant	660	8.4		
3	1DDN-3a	3.08.17	Bindal River	20MLD STP,Mothrowala	1150	7.4	30.26289	78.04183
4	1DDN-3b	3.08.17	STP	20MLD STP,Mothrowala	690	7.6		
5	1DDN-4	3.08.17	SPRING-1	Nagal hatnala	90	6.6	30.3871	78.108
6	1DDN-5	3.08.17	SPRING-2	makarti	90	7	30.4092	78.101
7	1DDN-6	3.08.17	Hand Pump	Bunjara	720	6.7		

In above table 1DDN indicates the first sampling in Dehradun, EC means electric conductivity in $\mu s/cm$,STP means sewage treatment plant

Chapter 3: Methodology & Results

To know the exact current condition of groundwater and surface water quality, the analysis of the samples are required and the analysis is isotopic studies and hydrochemistry. Isotopic study is done by mass spectrometry with the help of instrument dual inlet mass spectrometer. Hydrochemistry is done with the help of ion chromatography. From the both analysis the concentration of ions are separated and detected. In this chapter field work is also included.

3.1 Measurement & Analysis

3.1.1 Current Meter:

Quick stream flow measuring is best done with a water current meter to measure water current velocity. Stream flow measuring is easily accomplished using a water current meter and a tape measure. The current velocity meter allows you to measure stream flow velocity in feet or meters per second and measure water depth in hundredths of a foot up to three feet. The average stream flow velocity times the cross-sectional area of the stream determines the stream flow measurement in cubic feet or meters per second. The area for of a channel is known for pipes, or is determined for a stream flow measurement by measuring the distance from shore and water depth at various points across the stream flow to construct a channel profile. The water current meter offers two unique methods for determining average water velocity:

1) For small stream flows and pipes, the current velocity meter may be moved smoothly and uniformly throughout the stream flow profile until a steady average reading is displayed. This steady reading is the true average velocity for the stream flow.

2) For larger streams, the current velocity meter may be used to measure a vertical profile of water velocity at several points across a stream channel. The stream flow measurement for the profile is the sum of the average velocity of each subsection of stream flow times its cross-sectional area.

Figure21: Stream flow calculated by using current meter(above photos are taken from Rispna river during field visit)

3.1.2 Spring Flow Measurement

The measurement of time required for a specific amount of water coming out of the spring was the method for spring flow measurement. During high flow season in monsoon months, the quantity of water measured was 5.0 liters and in non-monsoon months the amount was reduced to 1.0 liters. Through analysis the flow rate was estimated. Since, the springs are throughout distributed in the watershed. A view of the springs discharging water and data recording is shown in figure22

Figure22: Spring discharge measurement

3.1.3 Isotopic Study: Mass Spectrometry

Mass spectrometry is an analytical technique that used to generate ions from organic, in-organic compounds in by any suitable methods. This is done by mass spectrometer.

In mass spectrometer, the ions are generated by ionization, separation by their mass to charged ration (m/z) and detection of ion in the gas phase and measured the isotopes of the sample. The major component of mass spectrometer is ion source, mass analyzer and detector and these are operated under high vacuum condition.

Principle:

During analysis of compound the first step is the production of gas phase of compound through ionization source by inducing either gain or loss of a charge. These molecular ions are gone under fragmentation and the product ions are derived from molecular ion and it so on. The ions are separated according to their mass-charge ratio and are detected in proportion to their abundance, these are shown in Fig7. The atmospheric pressure is around 760torr (mm of mercury) and the pressure under which ions may be detected at approximately 10^{-5} to 10^{-8}.

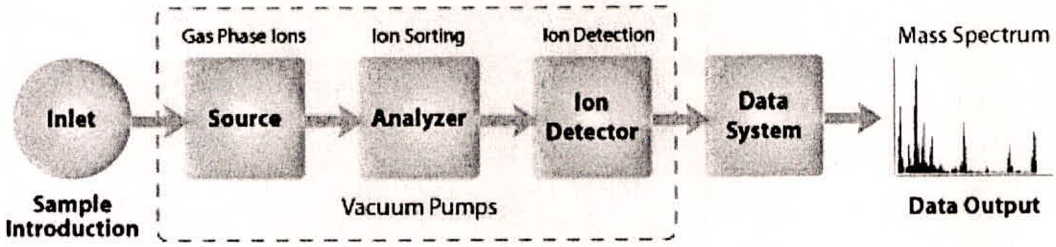

Figure 23: Components of mass spectrometer along with sampling and outcome processes. (Premier biosoft article on the research for glycan and lipid detection.)

Working:

Mass spectrometer converts individual molecules to ions so that they can be moved and manipulated by electric and magnetic fields. Because ions are very reactive and short-lived, their formation and manipulation occurs in the highly vacuum conditions.

Each of three processes maybe done in different ways. Ionization is effected by a high energy beam of electrons; ion separations occur by accelerating and deflecting the ions in beam; ions are detected electronically; and the results are stored in computer.

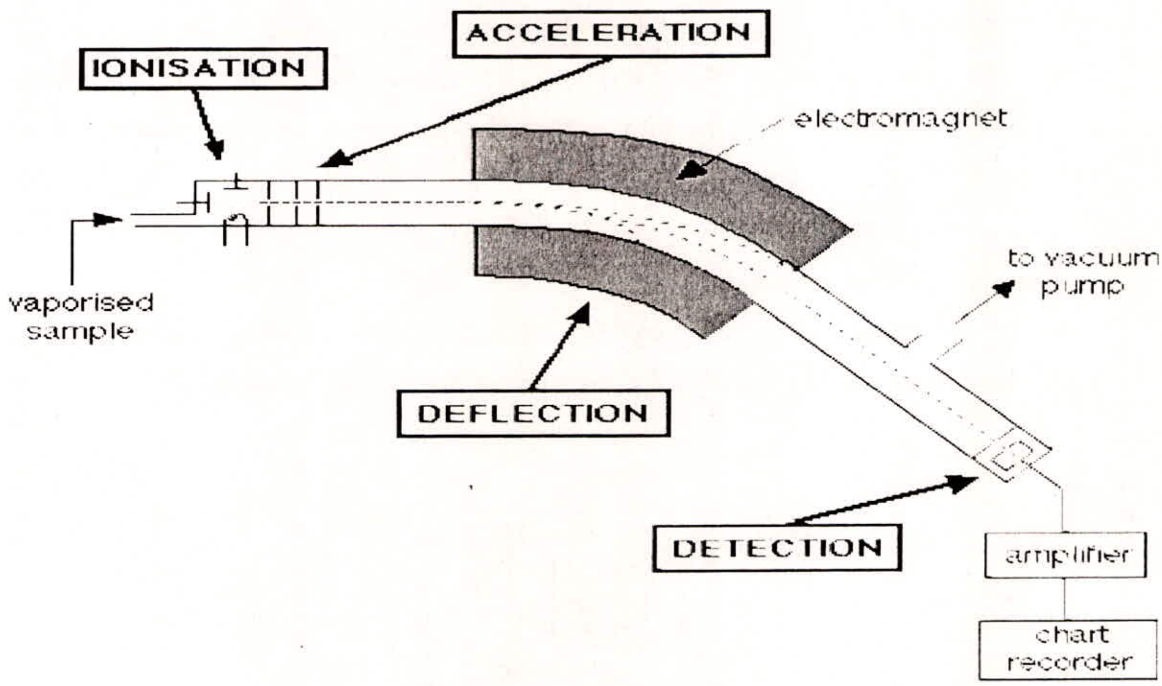

Figure 24: The representation of working of mass spectrometer (Clark J. 2000)

Ionization:

The vaporized sample passes into the ionization chamber. The electrically heated metal coil gives off electrons which are attracted to the electron trap which is a positively charged plate.

The particles in the sample (atoms or molecules) are therefore bombarded with a stream of electrons, and some of the collisions are energetic enough to knock one or more electrons out of the sample particles to make positive ions (Fig 9). These positive ions are persuaded out into the rest of the machine by the ion reseller which is another metal plate carrying a slight positive charge.

Separation:

Acceleration*:* The positive ions are repelled away from the very positive ionization chamber and pass through three slits, the final one of which is at 0volts. The middle slit carries some intermediate voltage. All the ions are accelerated into a finally focused beam.

Deflection*:* Different ions are deflected by the magnetic field by different amounts. The amount of deflection depends on: The mass of the ion, lighter ions are defected more as compare to heavier ions. The charge on the ion, ions with two or more positive charge deflects more than single positive charge. These two factors are combined into the mass-charge ratio (m/z).

Detection: The beam of ions passing through the machine is detected electrically. When an ion hits the metal box, its charge is neutralized by an electron jumping from the metal on to the ion. That leaves a space amongst the electrons in the metal, and the electrons in the wire shuffle along to fill it. A flow of electron in the wire is detected as an electric current which can be amplified and recorded.

Outcome of mass spectrometer:

The result of analysis by ionization, separation and detection are displayed by mass spectrum Fig25. The results are displays by peaks, bar graph, histogram, stick diagrams.

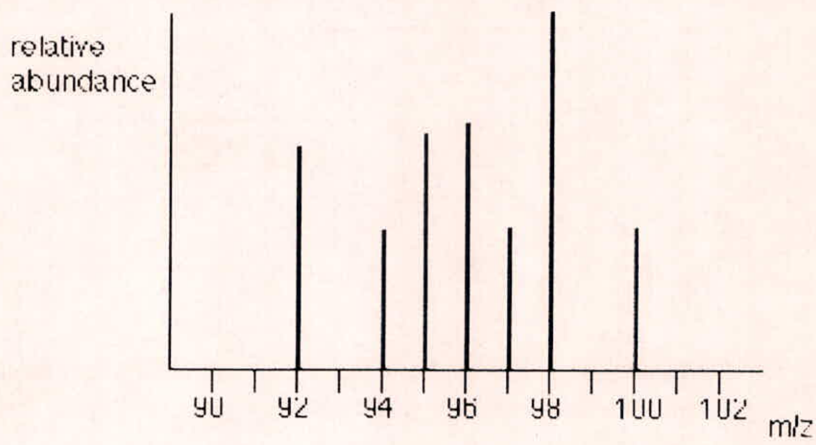

Figure 25: The graph representation of working of mass spectrometer

The outcome of analyte is shown in the inform of stick diagrams by the mass spectrum. The sticks in spectrum show the peaks of the abundance of ions.

Mass Spectrum*:* Mass spectrum is the two dimensional representation of signal intensity versus mass charge ratio (m/z). The intensity of peak as signal reflects the abundance of ions of that respective m/z ratio which has been created from analyte within the ion source.

3.1.4 Dual Inlet Mass Spectrometer

Dual inlet mass spectrometer allows ratio measurement on both a sample and a standard by alternating between inlets. It has the measurement techniques of preference for isotope ratios of most of the light elements (H,C,N,O,S). Reference gases are used in analytical method for the conversion of different sample compound. The reference gases are carbon dioxide, nitrogen, helium etc.

Samples are placed in highly pumped vacuum condition and sample gases are injected and at the same time reference gas are passed into the ion source. In ion source, a heated tungsten coated iridium filament inside the source block cavity ionizes a laminar steam of gas entering the ultrahigh vacuum source. The gas molecules are stripped of one electron, producing positive ions which are then accelerated through a voltage gradient and focused into the flight tube upon existing the source. The ion beam bends as it passes through the field of a magnet installed over the flight tube.

Here, the beam separates into spectrum of masses where faraday cup collectors measure each ion current. By collecting two or three ion beams simultaneously the ion currents can be expressed as mass ratio.

3.1.5 Hydrochemistry: Ion Chromatography

Ion chromatography is used for water analysis. The measurement of concentration of major anions such as fluoride, chloride, nitrate, nitrite and sulfate as well as major cations such as lithium, sodium , ammonium , potassium, calcium and magnesium in the parts-per-billion.

The analyzer, suppressor, column, detector are the component of ion chromatography, Fig10. In ion chromatography, As an ion extraction liquid runs through the column, the absorbed ions begin separating from the column (Monica Z. Bruckner,2007). The retention time of different species determines the ionic concentration in the sample.

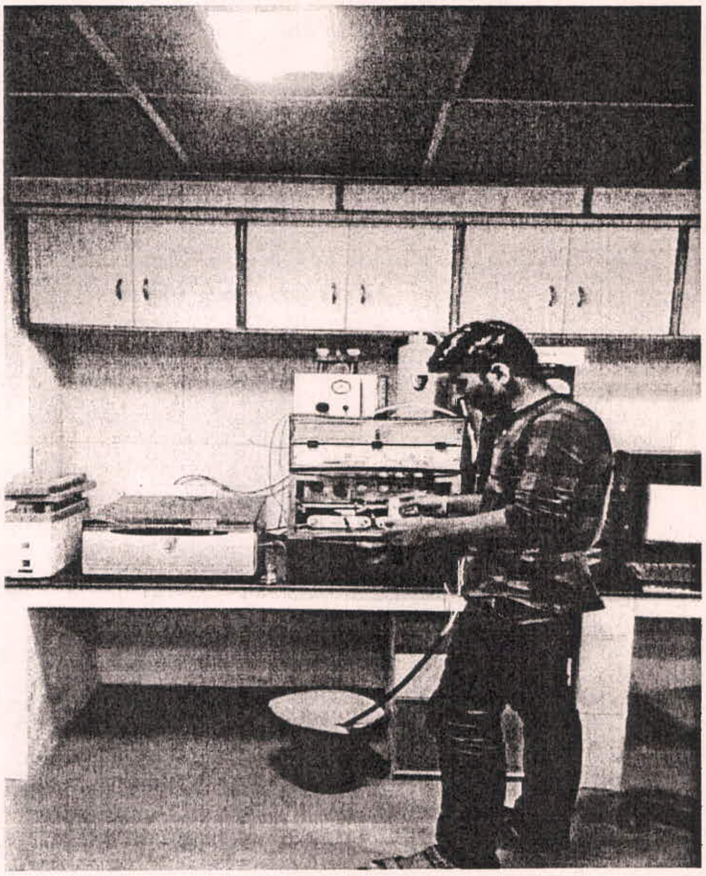

Figure26: Setting samples in Ion Chromatographer at NIH nuclear lab

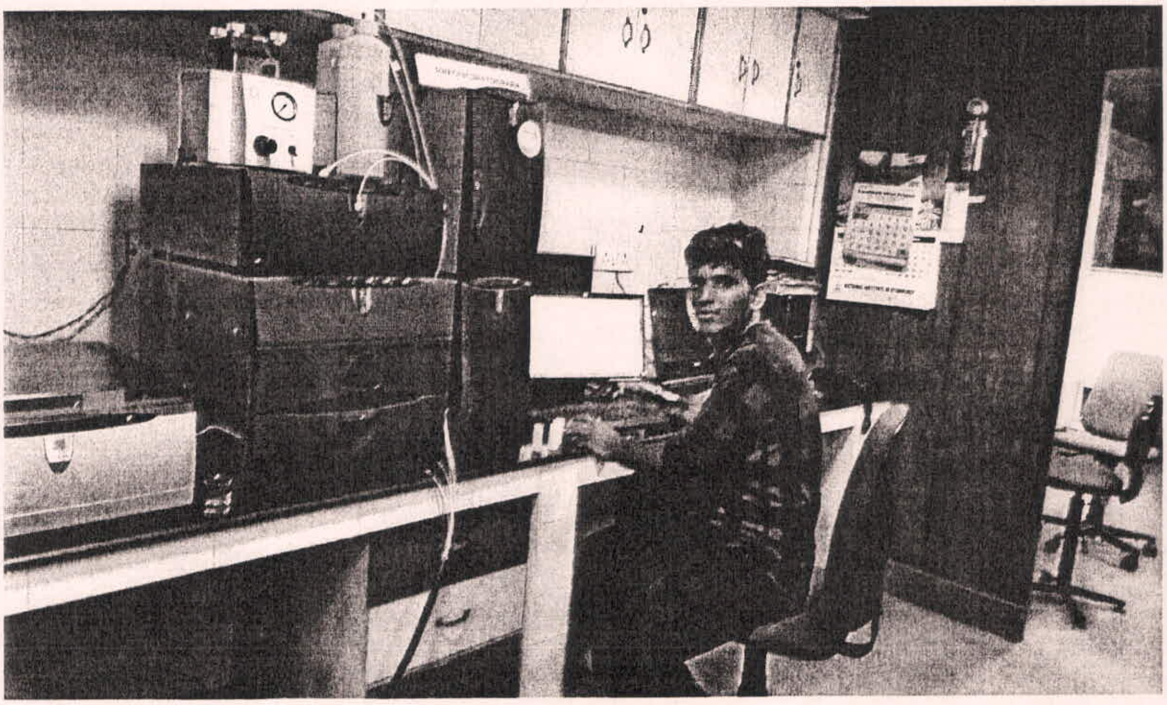

Figure27: Ion Chromatograph with their components suppressor, column and analyzer.(Image from the nuclear laboratory of NIH)

Working:

In ion chromatography, the samples are passed through analyzer where the mixtures of sample are injected into a carrier fluid (eluent) shown in Fig11. Then the solutions are passed to suppressor where the conductance of eluent is reduced and at the same time it enhances the conductance of the sample. Then the sample solutions passed through a pressurized chromatographic column where ions are absorbed by column constitutes i.e. adsorbent. Different materials are adhere to adsorbent with different forces. As the eluent are flows through column the components of analyte are moved down the column at different speed and therefore they separate from one another. As the analyte are emerge from the column, the detector gives the output at the end of column Fig28.

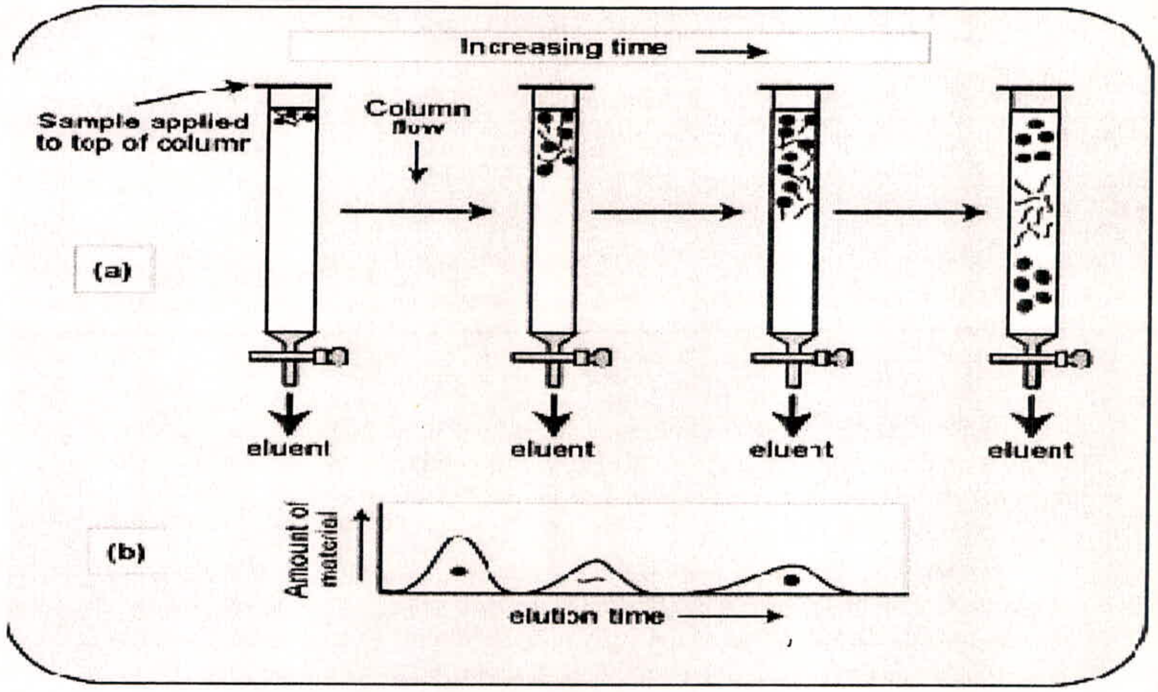

Figure 28: Working of component of ion chromatograph

Outcome of ion chromatography:

The outcome of ion chromatography is given by detector. Detector generates a measurable signal when the analyte are emerges from the column. These signals are represented as the peaks on the chromatogram Fig13.

Chromatogram is the record of the outcome of detector as in the form of electrical conductivity versus time of the analyte passes through the chromatographic system.

3.1.6 Titration

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.

Knowing the volume of titrant added allows the determination of the concentration of the unknown. Often, an indicator is used to usually signal the end of the reaction, the endpoint.

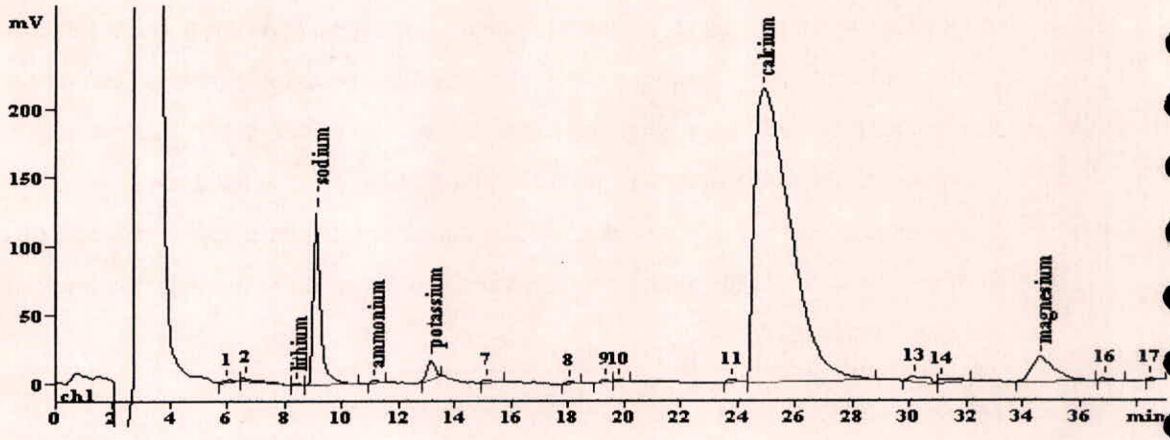

Figure29: Representation of outcome of analysis in the form of peaks in chromatogram (cation analysis of glacial water, Monica Bruckner)

Procedure

When performing the scout titration, you will most likely overshoot the endpoint. The purpose of this titration is to give you a rough idea how much titrant is needed before you begin the actual titration.

- Use a pipet to deliver a known amount of the analyte to the appropriate container (usually an Erlenmeyer flask) which has been cleaned and rinsed with distilled water. Since you are concerned with the number of moles in the volume of analyte dispensed from the pipet, the flask does not need to be completely dry before adding the analyte.
- If you are going to be using a magnetic stir plate, put a clean, dry stir bar into the flask and place the flask on the stir plate. Adjust the water flow so that the stir bar is spinning but not splashing solution onto the walls of the container.
- Record the initial buret reading in your notebook. Add titrant from the buret to the flask while stirring magnetically or swirling the flask with your hand. Close the stopcock when the endpoint is seen. Record the final buret reading in your notebook. Calculate the amount of titrant needed to reach the endpoint.

3.1.7 GIS Study:

Geographical Information System (GIS) is a piece of software that captures the geographical data purpose for manipulation, viewing and analysis in whichever context and parameters user desire or needs. GIS gives good information about Dehradun study area.

The captured data provided in the form of shape file and they are plots in the surfer software. From the surfer image we get the information of the sample site and their exact location of the sampling site. the information provided from the surfer image helps in study the condition of that sampling site and their ranges near to rivers (Rispana, Bindal). For the study in surfer and GIS, the correct latitude and longitude is needed, otherwise the chance of error in data and result will be increases.

The use of GIS application helps in the getting the complete scenario of any area. The past and present scenario of any area can be obtained from this application. So for the management or monitoring purpose this application is being in use.

GIS is providing integrating technology, bringing together geospatial data and knowledge, providing methods for analysis and collaboration and making them widely accessible. GIS applies the geographic approach, providing tools, methods and works flows that support collaboration and action. This leads to better decisions, greater efficiency, more effective communications, thus improving the way of work.

3.1.8: Field Parameters

Some parameters are measured in the field at the time of sample collection and parameters like electric conductivity, pH and current meter readings and also water flow depth. Parameters like electric conductivity and pH can be analyzed at some interval of time but measurement of current meter reading and depth of water flow happen at the time of sample collection.

Electrical Conductivity is the measurement of amount of total dissolved solids in the water, it measured in the unit of microSimen/centimeter. The flow of water is calculated by the electric conductivity (Lenntech BV, 1998).

By using current meter to find velocity of water, we already discussed in 3.1

pH measures the concentration of hydrogen, the property of acidic and basic nature of water is measured by pH analysis.

3.2: Result

Sampling(1DDN-1) at kudkawala bridge road(markham grant)

The longitude is E- 078.09658° and latitude is N-30.15981°.

Observations:

- The water contain more dissolved solids .
- The water is not good for drinking
- Water flow depth is not more than 45cm and also length is 25 meters .
- The surrounded area is totally slum, the water is suitable for irrigation

Calculations:

Current meter readings

Reading -1

Time	revolutions	velocity
30sec	81	68.9
30sec	85	72.3
30sec	86	73

Average velocity=71.4 cm/sec

Reading-2

Time	revolutions	velocity
30sec	127	108.2
30sec	118	100.5
30sec	139	118.5

Average velocity =109.067 cm/sec

Reading-3

Time	revolutions	velocity
30sec	117	99.7
30sec	100	85.1
30sec	109	92.8

Average velocity= 92.53 cm/sec

Total velocity = 90.999 cm/sec

Area $=45\times25\times100/2=56250cm^2$

Discharge $Q=A\times V$

$=56250\times90.999$

$=5118693cm^3/sec$ (approximately)

Second Sampling (1DDN-3a,1DDN-3b) at 20MLD STP(Mothrowala)

Observations:

- The river Bindal is highly contaminated ,the EC is 1050 .latitude N -30.26289^0 ,longitude E- 078.04183^0.this water need treatment plant
- Total width of river is 11meters, total average depth is 21.45cm

Calculations:

Current meter readings

	Time	revolutions	velocity
Reading1	30sec	46	39.1
	30sec	46	39.1
	30sec	46	39.1

Average velocity= 39.1

	Time	revolutions	velocity
Reading2	30sec	96	81.8
	30sec	102	86.9
	30sec	101	85.9

Average velocity= 84.86

Total velocity =61.98cm/sec

Total Area $=21.45\times11\times100/2$

$=11797.5cm^2$

Discharge $Q=A\times V$

$=11797.5\times61.98$

$=731209cm^3/sec$

Titration result:

Table7: Titration result

Norm of H2SO4	Sample wtr vol	Titrated volume using indicator		CO3=30	HCO3=61
	ml	Phenolphth	Meth Orng	mg/l	mg/l
N	Vs	A ml	B ml	(2ANx30x1000)/Vs	[(B-2A)Nx61)x1000]/Vs
0.02	20	0	5.6	0	341.6
0.02	20	0	6	0	366
0.02	20	0	10.36	0	631.96
0.02	20	0	4.77	0	290.97
0.02	20	0	1.3	0	79.3
0.02	20	0	0.6	0	36.6

Isotope laboratory result:

The samples were measured for stable isotope and hydro chemical details. The result of the analysis is presented in the table below:-

Table 8 : Isotopic composition of samples from Dehradun study area

Site ID	$\delta^{18}O$(%)
1DDN-1	-6.99
1DDN-2	-6.51
1DDN-3A	-6.96
1DDN-3B	-7.07
1DDN-4	-7.08
1DDN-5	-6.46
1DDN-6	-6.76

Hydrochemistry laboratory results:

Table9 : The result of analysis of Cations ions

Site ID	**F^- (mg/l)**	**Cl^- (mg/l)**	**NO_2^- (mg/l)**	**SO_4^- (mg/l)**	**NO_3^- (mg/l)**
1DDN-1	0.09	25.76	6.19	77.00	10.31
1DDN-2	0.60	25.72	ND	82.37	8.99
1DDN-3 A	0.19	55.21	15.67	19.20	ND
1DDN-3 B	0.54	31.35	16.10	78.33	11.13
1DDN-4	0.15	2.64	1.49	4.72	4.31
1DDN-5	0.24	1.86	1.24	9.01	1.95
1DDN-6	0.21	14.49	15.42	26.56	3.16

Table10 : The result of analysis of anion ions

Site ID	Na^{+} (mg/l)	NH_4^{+} (mg/l)	K^{+} (mg/l)	Mg^{+2} (mg/l)	Ca^{+2} (mg/l)
1DDN-1	290.38	ND	12.36	30.38	80.61
1DDN-2	297.51	11.43	2.61	25.48	81.92
1DDN-3 A	327.03	26.16	22.09	33.62	100.30
1DDN-3 B	306.47	6.15	6.74	26.06	75.96
1DDN-4	11.82	16.21	29.23	14.07	28.20
1DDN-5	20.12	24.08	49.94	25.53	50.09
1DDN-6	316.20	1.67	32.73	26.96	101.92

The measurements of EC, Temperature, pH and radon analysis conducted in-situ at the time of sample collection is tabulated below:

The statistical range of the measured parameters is given in the table

Table 11: Measured parameters, value range and location name:

Parameters	Minimum & Maximum concentration & the Observed place		
	Minimum	Maximum	Average
EC (μS/cm)	90	1150	580
Temp(^{0}C)	20	27	23.5
Ph	6.6	8.4	7.5
$\delta^{18}O$	-7.08	-6.46	-6.77
F (mg/l)	0.0916	0.5975	0.288814
Cl (mg/l)	1.8564	55.2107	22.43084
Nitrite (mg/l)	1.2427	16.0985	9.351917
Nitrate (mg/l)	1.95	11.1275	6.64155
Sulphate (mg/l)	4.7174	82.3701	42.45633
Na (mg/l)	11.824	327.0276	224.2178
K (mg/l)	2.6085	49.9377	22.2417
Mg (mg/l)	14.07	33.62	26.01
Ca (mg/l)	28.20	101.92	74.14

The above waste's chemical analysis thus authenticates that Waste to Energy projects i.e. either converting waste to compost or waste incineration combined with recovery of recyclable resources will help in reducing the load on landfills and can make project environment friendly and sustainable

All over the survey and result of Dehradun ,it conform that Dehradun is upcoming smart city ,I want to tell one thing, water requirement in Dehradun based on total population and their daily use .

The total water requirement of Dehradun per annum is computed as follows:

Average daily water use of one person (lpd)× Total Dehradun population(as 2011 sense) ×365 days (for year)

$$= 125\times578{,}420\times365$$
$$=2.63904125\times10^{10}\ \text{l/year}$$

Annual storage water based on Average annual rainfall and Total Dehradun area

Rainfall (cm) ×DDN Area(km^2) × percentage of recharge

Take Average Annual Rainfall (cm) 218.7 and area is 300 km^2 and also assume 40% recharge

$$=2.187(\text{m})\times300(1000)^2\text{m}^2\times0.4$$
$$=262440000\ \text{m}^3$$
$$= 2.6244\text{x}10^{12}\ \text{cm}^3$$

Thus, the average annual available water that can be stored (excluding evaporation loses) or that can be recharged is 100 times more than the required water per year for Dehradun city. By constructing suitable surface or sub-surface structures major fraction of the run-off that gets passed through rivers can be can be saved and conserved for use in the non-monsoon periods.

CHAPTER4: CONCLUSION& SUMMARY

Dehradun is one of the famous place and capital city of Uttarakhand. According to 2011 census Dehradun has a population of 1,698,560. As of 2011 it is the 2nd most populous district of Uttarakhand(out of 13) after Haridwar. The annual rainfall is around 1300mm. It may reaches about 2000mm also. Many seasonal rivers are flowing throughout the year. More rainfall is seen during monsoon season but there is no proper use of it because it is a hilly region. Due to earth's gravity the rain water which falls on slope area or high altitude it flows through rivers and finally reaches the ocean.

As per my dissertation work, I visited the study area and surveyed. The main objective of my project is to save and conserve the rain water for drinking and cultivation purpose. The rivers Bindal rao and Rispana which are a seasonal source of water for most part of Dehradun. Activities say that things have gone from bad to worse in the past few years for both the rivers with not just slum colonies cropping upon the riverbanks and riverbeds but also cemented houses leading degradation of riverbeds that have become a dumping ground for waste.

The Rispana river of Raipur block was selected by me for the collection and analysis. It is a part of Ganga drainage system of valley. The impact of anthropogenic activities has been so extension that river has lost the self purification capacity to a large extent. The fresh water has become a scarce commodity due to over exploitation and pollution.

These rivers are having been converted to a dumping ground receptacle of garbage and sewage. These rivers are highly polluted and the solid waste consists of polythene bags that are dumped into it in large quantities. Obviously both are seasonal rivers and a life line of the city but if one reaches the river, one is forced to stand for a minute because of the foul smell that emanates from it. According to study, there are at least 10000 encroachments along the Rispana river, one can see the example of lawlessness when the river bed is used by some public. Conveyance operators as places for parking. Trucks that operate between Dehradun and other hip districts can be seen lined upon this river.

The management of water resources is an important issue for societal health and well being. As world population continuous to grow , a greater quantity and diversity of water needs will vex water resources managers.

Many traditional practices are being refined (ex. Rain water harvesting),while more recent advances (ex. Artificial recharge, desalination and water reuse) are being developed. To conserve the rain water one should have awareness about that.

Both Bindal rao and Rispana rivers flows from high altitude or slope are due to gravity. To conserve water from rain water sheds are constructed. The slope of this water shed is around 0.3-2.7%. this is the normal slop it is suitable for cultivation whereas other areas are very high % of slopes are undulated as I mentioned in the slope map.

Gabion check dams have found most effective in stabilization of gullies and arrest of silt. Most of the structures were silted up to this full capacity. The number and height of these structure is not possible to be increased hence the possible solution to reduce the soil loss by improving vegetation cover in the barren part of the catchment. As most of the barren land in the upper reaches of the watershed is having steep slope it may not be possible solution would be to check biotic interference for 3-4 years or till vegetation is established on its own

.

Among the stone masonry structure meant for water storage or silt detection. Most of them were suitable designed. In some cases they were over designed as far as structural design is concerned. Most of them were suitably located near lower reaches of watershed. Most of the water harvesting structure not only reduces soil erosion but also they are helpful in providing supplemental irrigation to farmers at downstream. There was improvement in ground water level which can be seen in the open wells of the area. Life saving irrigation from water harvesting structure has been helpful in enhancing crop production.

As a result of drainage live treatment, hydrological behavior of the sub-watersheds has improved. This resulted in increase in base flow of stream and spring, reduction in sediment load to reservoirs, raised groundwater level in the wells, crop yield improvement due to soil moisture enhancement. Vegetation cover improvement and increased availability of forage for livestock. Sediment yield reduced from 44%-78% in these sub-watershed. This shows the impact of soil and water conservation practices in the sample sub-watershed .

The results of monitoring programme represent the first analysis of its type undertaken on all Himalayan rivers system to access. the quality of water for drinking and irrigation purposes. All the water quality parameters showed significant seasonal variations and recorded higher value in PRM compared to POM which indicates the effective ionic leaching, due to dilution. The analyzed result showed that the parameters namely, turbidity, TDS, alkalinity, hardness calcium and magnesium exceed the desirable and permissible limits due to anthropogenic and neogenic activities. Higher contamination of total and faecal coliform in all the river water samples showed that river is under contamination from sewerage and also through runoffs from the places of open defecation on the bank's. The results highlighted that proper sanitary facilities should be provided in the are to control bacterial contamination in the rivers system, which is the most problematic issue. In addition to this, establishing the rain water harvesting and urban drainage systems in the area can minimize the diffusion of pollution from urban and agricultural runoff in river.

Wasting water has become a significant environmental problem both at consumer and industrial levels. Hence, it has become important for individual and business alike to find out was to reduce the wastage of water and conserve it. There are a lot of water that , we can conserve water at our home, industries and agricultural fields. Instead of waiting for somebody else to start conserving. Let us, an individual take the first step towards conserving water .

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