Analysis of Aquifer System and Impact of Snowmelt Water on Groundwater Quality of Shallow and Deeper Aquifers: A Comparative Study in Upper Ganga Basin for Stretch between Muzaffarnagar to Rishikesh

Sadiqa Abbas[1], Gauhar Mahmood[2]

[1]Research Scholar, Department of Civil Engineering, Jamia Millia Islamia, New Delhi
[2]Professor, Department of Civil Engineering, Jamia Millia Islamia, New Delhi

Abstract- Ganga river originating from Gangotri in Himalayas has got very strategic location from water resource point of view. It receives water in three different seasons first from July to October called monsoon season, second from April to June called snow-melt season and third occurs occasionally in January, February, March where the scanty rainfall occurs due to western disturbances. It is occupied by number of watersheds which are generally active in monsoon season.

This study analyses hierarchy of micro-watersheds which are developed as microwatershed-1 from glacial melt to Gangtori, microwatershed 2 from Gangotri to Rishikesh and micro watershed-3 from Rishikesh to Muzaffarnagar with their correlation to shallow and deeper aquifers with their physical characteristics like pH, TDS, EC etc. Since the glacial melt has got lower pH, electrical conductivity, TDS and temperature and also global warming further reduces these values which has been reflected from the various groundwater structures such as handpumps, shallow and deep tubewells from the microwatershed-3 surveyed during the course of study Groundwater in the study area was found to be varying from alkaline to acidic due to inter-mixing of glacial melt water. The groundwater characteristics of acidic and alkaline found to be varying and mostly occupied by shallow and deeper aquifers, whereas the shallow aquifers are acidic at places and deeper aquifers are alkaline in nature.

I. Introduction

India is divided into three physiographic units these are extra Peninsular India i.e Himalayan region, Indo-gangetic plains and Peninsular India i.e. central and Southern parts. There are direct impacts of precipitation on activities of extra-peninsular India to the rivers in Indus and Ganges system. The Upper Ganga basin is one of the larger part of the extra peninsular India. The study area was selected in parts of Upper Ganga basin in a closed loop manner in sub-basin of upper Ganga region starting from Muzaffarnagar, Deoband, Roorkee, Haridwar and Rishikesh with its peak topography as Dehradoon, and from Dehradoon to Saharanpur, Shyamli to Muzaffarnagar via Bopa Road.

The Upper Ganga basin is occupied by a number of watersheds which are generally active in the monsoon season however major watersheds feed Ganag river and micro-watersheds feed groundwater.

The study area is a mixture of geomorphological and hydro-geo-morphological units such as plain topography covering hills and valleys from upland plain to plain land and low-land areas. Slight variations in soil type were found in the study area. The area in general has non-reactive lithological conditions owing to sandy formation where geo-chemistry is very much conducive to maintain water quality without any chemical reaction and as such no salinity on percolated water felt by geology of area.

The study area was chosen in such a way so as to form a close loop of watershed with varying morphometric condition in order to develop the mini-microshed of glacial melt water for analyzing the aquifer system and studying the impact of snowmelt water on groundwater quality of shallow and deep aquifers for a stretch between Muzaffarnagar to Rishikesh.

Since the lithological conditions are non-reactive in nature therefore it may be analyzed that the recharging through the glacial melt water is the only source on the change of groundwater quality. In order to verify this we have taken a long stretch of the investigation which is about 80 km in non-glacial melt water areas. In which we found that the groundwater is alkaline in nature which is found to be natural. In this way precisely we can say that the global warming has got its impact on shallow aquifers only due to recharging by snow-melt water as a result the shallow aquifers are acidic in nature at places and form unnatural character of groundwater, however deeper aquifers are unaffected and contain the natural groundwater with alkaline character.

It was found that there are drastic changes in the hydro-geochemical environment and the quality of groundwater varying from alkaline to acidic environment due to inter-mixing of glacial melt water which may further be acidified due to gradual increase in global warming. In this respect relationship have been developed among the key factors of hydro geochemical fecies and the impact assessment of groundwater quality in the lower part of Upper Ganga basin from Rishikesh to Muzaffarnagar.

II. OBJECTIVE & SCOPE

In order to make a comparison between shallow and deep aquifers taking four parameters i.e pH, TDS, EC and temperature into consideration qualitative mapping of area was done based on:

- Analysis of groundwater pH in study area

- Analysis of groundwater TDS in study area
- Analysis of Electrical Conductivity in study area
- Analysis of groundwater and atmospheric temperature in study area

Based on the comparison of above stated parameters in shallow and deep aquifers the impact of snow-melt water was ascertained with conformity to global warming.

III. DESCRIPTION OF SITE

The focus of present study is in parts of Upper Ganga Basin which receives water in three different seasons:

- January to March where scanty rainfall occurs due to western disturbances
- April to June called snow-melt season
- July to October called monsoon season

It is occupied by a number of watersheds which are generally active in monsoon. This upper Ganga basin in Gangotri glacier area can further be divided into three micro-watersheds:

- Micro-watershed 1 in upper regions of Gangotri
- Micro-watershed 2 from Gangotri to Rishikesh
- Micro-watershed 3 from Rishikesh to Muzaffarnagar.

Micro-watershed 3 from Rishikesh to Muzaffarnagar is taken as study area. The selected area has got three components which are very strategic from the hydro-geological point of view because there is a probability of change in hydro-geochemistry due to the leaching activity of rocks and also due to the melting of glaciers and recharging of groundwater.

The hydro-geochemistry has already been saturated because of the age of the rocks and groundwater quality there is only probability to change in physical parameters of shallow and deep aquifers due to enormous melting of glacial water in case of global warming. hence the following three components will have justification for comparison of shallow and deep aquifers especially from global warming point of view

- presence of acidic water in microshed and mini micro shed due to glacial melt water
  - The presence of inactive lithological units (i.e. granite, schist and gniess)
  - The alkaline formation of groundwater in downstream direction (i.e clay, silt and sandy formation)

A total of 51 locations were identified in the study area based on the survey conducted corresponding to their geography, hydro-meteorology and hydro-geology in a **closed loop manner,** starting from Modinagar with a common distance of 10 kms sampling was done. The distance was reduced to 5 km where there was a change in lithology. From location 1 to 17 sampling distance was 10 kms, location 18 to 24 the distance was 5 kms, location 25 to 27 distance was 10 kms, location 28 to 33 the distance was 5 kms and from location 34 to 51 it was again 10 kms.

IV. METHODS AND MATERIALS

The methodology adopted for accomplishing the above study comprised of identifying the sampling stations in the study area and collecting data pertaining to parameters of interest in such a way that data for four seasons of year is available. The depth of identified structures varied from 6-100 m. The hydraulic structures upto 25m depth were assumed to be part of shallow aquifers and those deeper than 25 m were considered to be part of deeper aquifers.

Primary data was collected from study area in such a way that data pertaining to rainy season, post-monsoon, snow-freezing, snow-melting, following rainy season, following post-monsoon etc is available.

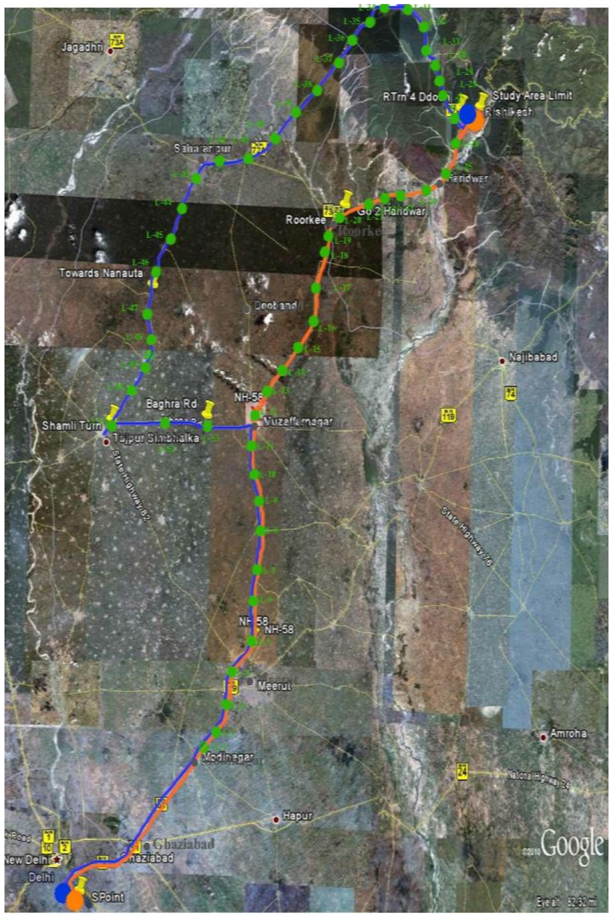

Fig.1, Location of Study Area in Upper Ganga Basin

V. INTERPRETATION OF RESULTS

Hydro-geomorphological study was carried out for the study area in order to understand the topography and physiography of the study area to work out the areas of recharge and discharge with hydro-geo-morphological undulations to establish the hydro-geological regime of the study area.

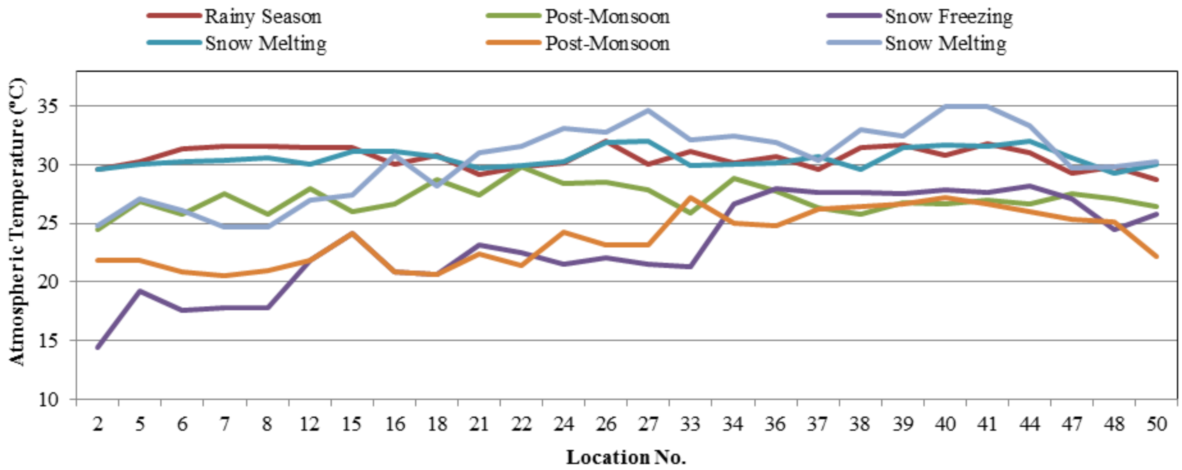

Fig.2: Atmospheric Temperature Variation in Shallow Aquifer

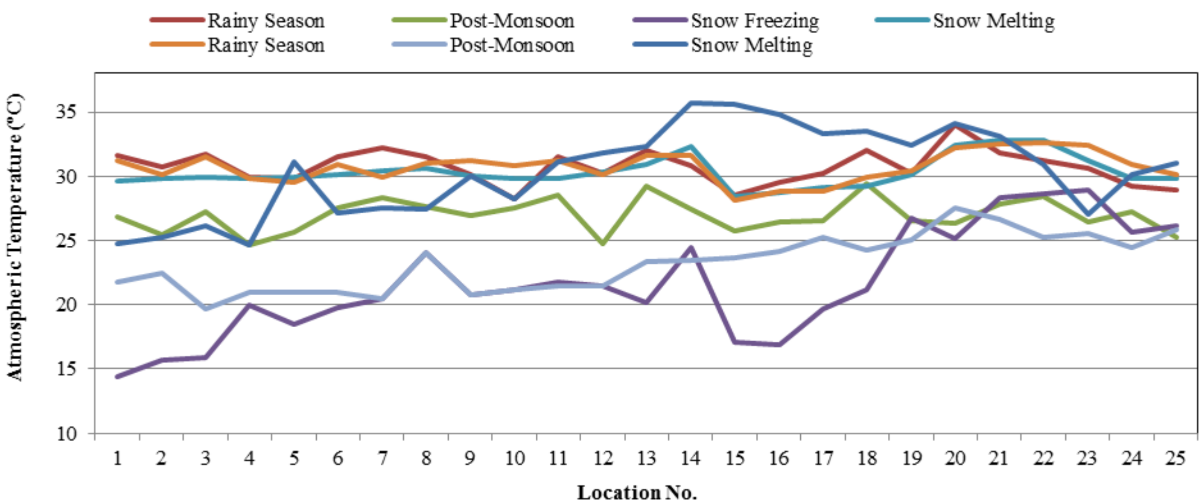

Fig. 3: Atmospheric Temperature Variation in Deeper Aquifer

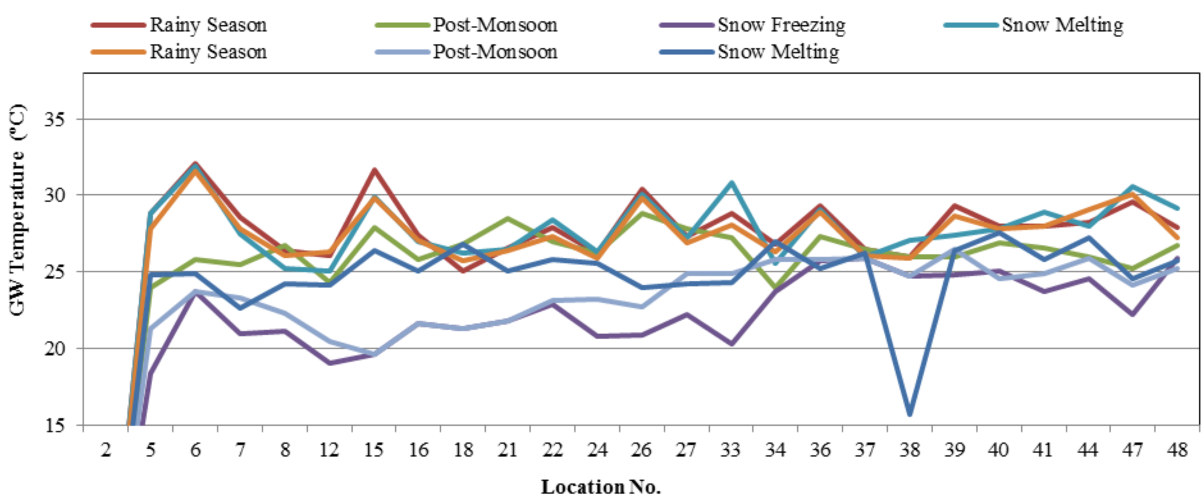

Fig.4: Groundwater Temperature Variation in Shallow Aquifer

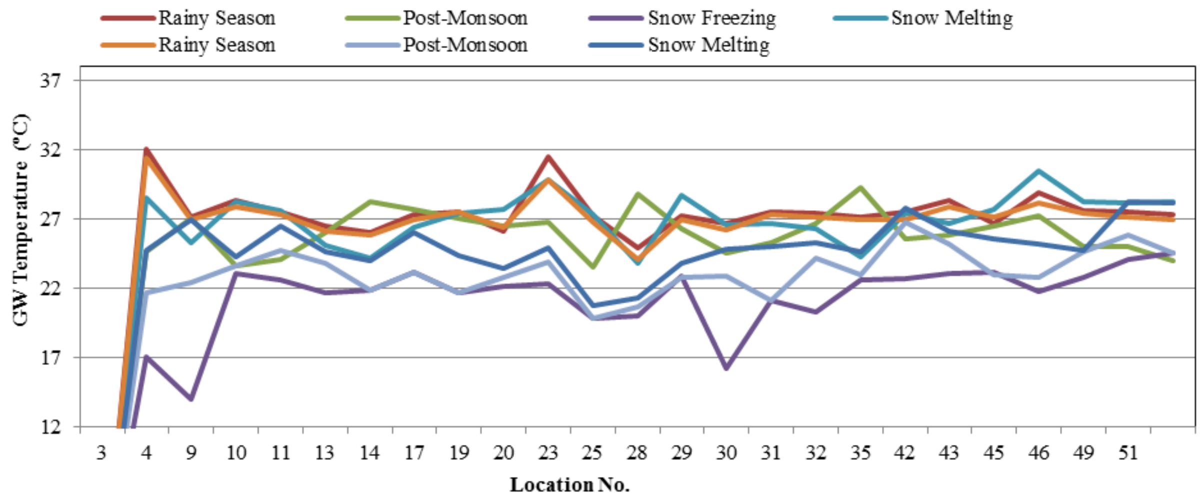

Fig.5: Groundwater Temperature Variation in Deeper Aquifer

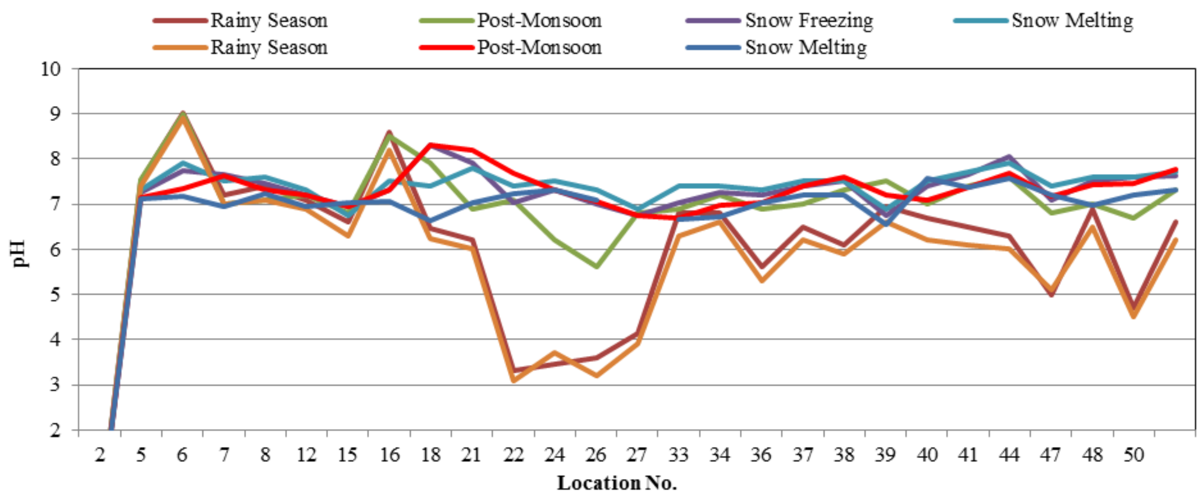

Fig.6: pH Variation in Shallow Aquifer

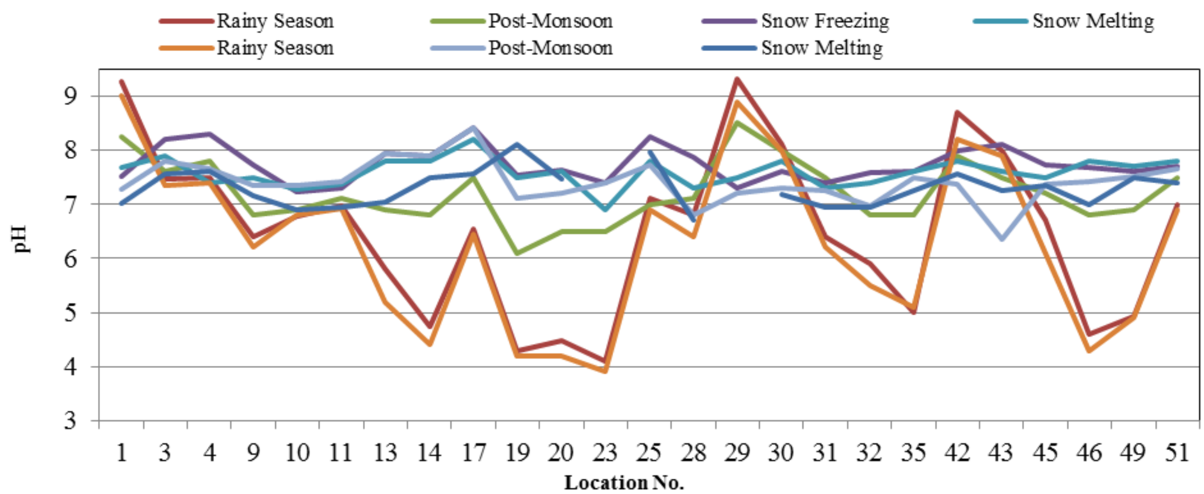

Fig. 7: pH Variation in Deeper Aquifer

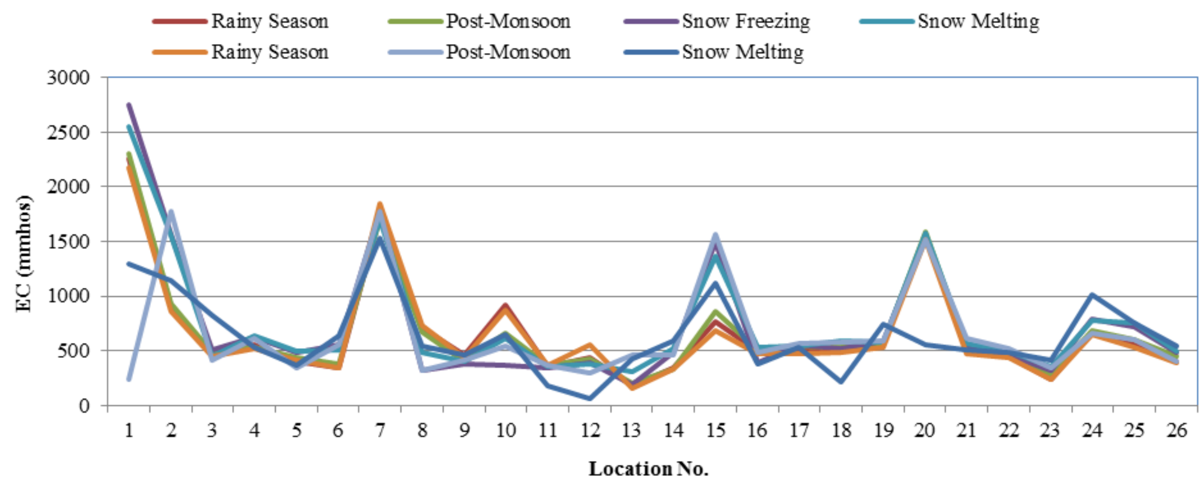

Fig.8: Electrical Conductivity Variation in Shallow Aquifer

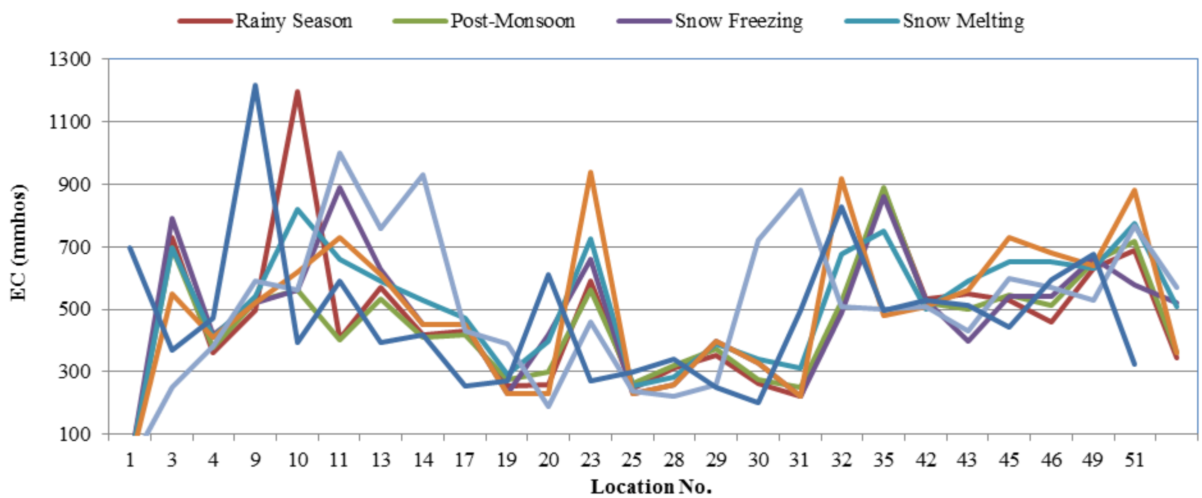

Fig.9: Electrical Conductivity Variation in Deeper Aquifer

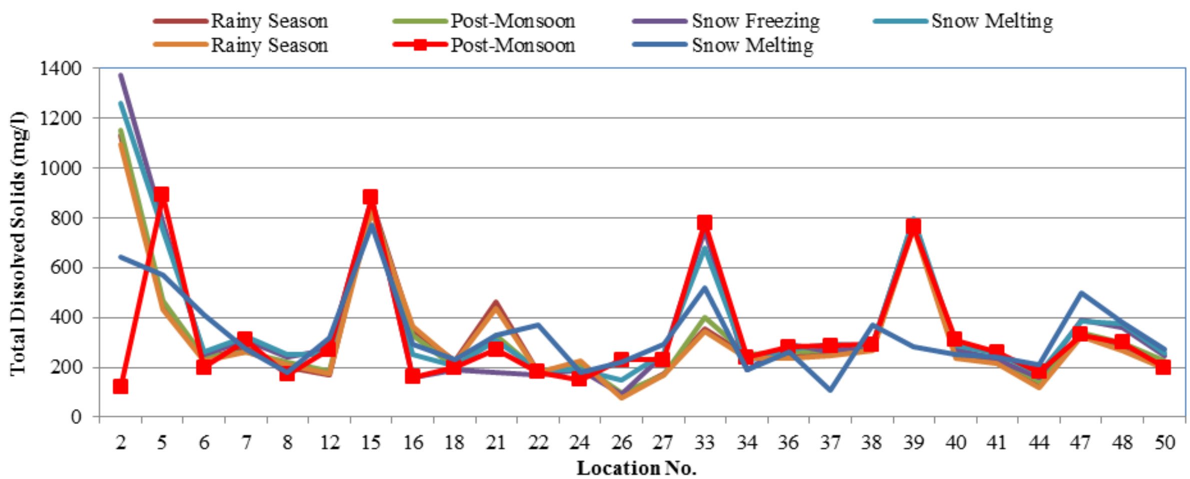

Fig.10: TDS Variation in Shallow Aquifer

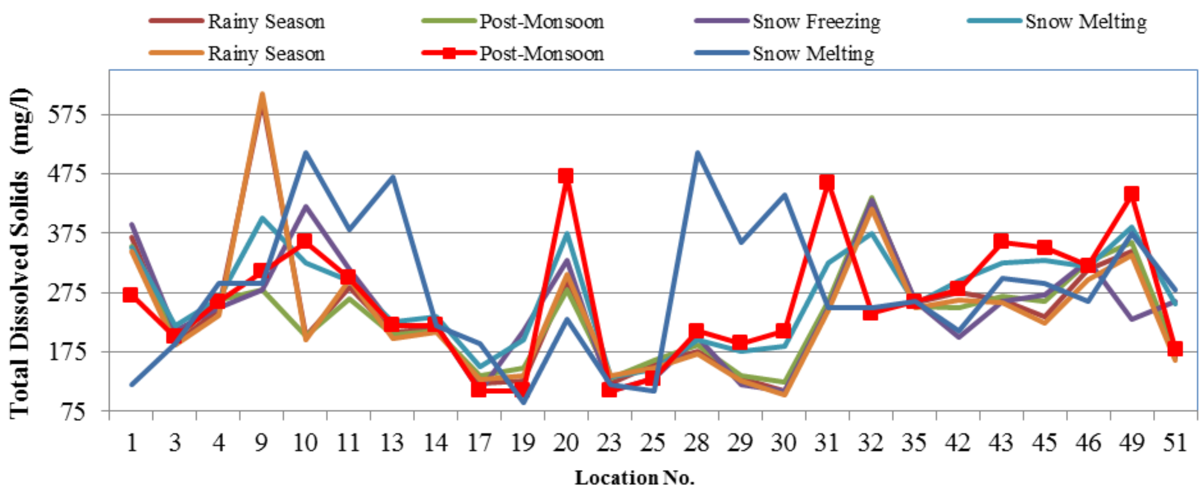

Fig. 11: TDS Variation in Deeper Aquifer

The study area comprises of upland hilly topography from Rishikesh to Dehradun, the geo-morphology indicates that the area has got unconfined shallow aquifers and confined deeper aquifers, and however at few locations in rocky areas perched aquifer system was also encountered. The groundwater in this zone is found to be alkaline, thus it is not found to be affected by glacial melt water.

This is followed by upland topography which starts from Haridwar extends 20 km from Dehradun to Saharanpur and runs parallel to uphill topography. The hydro-geomorphology indicates that the area has got perched aquifer system and the discharge and recharge capacity of this area is found to be very fluctuating in nature and it receives recharge from the hilly upland topography only, as surface and sub-surface runoff along with rainfall.

The plain land topography starts from Muzaffarnagar and extends upto Roorkee in the eastern direction and upto Saharanpur in the western direction. It is surrounded by the upland topographic units in the northern direction and low land topography in north-west and south-east direction. It comprises the largest area amongst various physiographic units of the study area. The hydro-geomorphology indicates that the area has got perched to unconfined aquifer system and the discharge and recharge capacity of this area is found to be unstable in nature and has got good response from the recharging parameters such as snowmelt water.

The low land was encountered at two places in between Roorkee and Haridwar at one end and from Shyamli to 32 kms towards Saharanpur. It is located in the north-western and south-western boundary of the study area. The typical feature of this area found as crescent shaped, being the low lying area it receives the surface and sub-surface run-off from the upper regimes and may be considered as typical recharge boundary for snowmelt water because of its groundwater quality.

The plain low land topography starts from Muzaffarnagar and extends upto Modinagar. This area is linear in character and was delineated for comparison of non-snowmelt recharge boundary to snowmelt recharge boundaries for the rest of the topographic units.

The direction of movement of groundwater is from hilly topography in Rishikesh, Haridwar and Dehradun towards plain areas of Saharanpur and Muzaffarnagar in general, however the groundwater movement is also affected by local topography at places. The flow of groundwater in an aquifer does not always mirror the flow of water on the surface. The groundwater flows from higher elevation to lower elevation in the direction of maximum change in elevation. Fractured rocks, weathered rocks and alluvial strata are the main water bearing formation in the study area from hilly region to plain topography. The aquifers are separated with thick clay with considerable thickness, which acts as confining layers in alluvial areas whereas the aquifers acting as perched and unconfined aquifer system in hilly formations. Water level data suggests presence of multi-layer aquifer system. The first one is unconfined and others are semi-confined to confined.

The data pertaining to pH, TDS, EC, groundwater temperature and atmospheric temperature collected from all the 51 locations is presented for shallow and deeper aquifer locations of study area from figure 2 to 11.

The geochemical analysis of the study area was done on the basis of physiography and lithological interpretation and their overall impact on the pH of the study area to determine the alkalinity vs acidic environment in shallow and deeper aquifers.

The pH in upland hilly topography varies from 7.5-9.0 which is a high alkaline zone owing to topography and lithology of the area. The pH range clearly indicates that this area is not affected by snowmelt water and contains natural groundwater in confined aquifers.

The pH in upland hilly topography varies from 6.0-6.5 which is medium alkalinity zone owing to topography and lithology of the area. The pH range clearly indicates that this area has been recharged by snowmelt water since the pH is reducing.

The pH in plain land topography area varies from 5.5-6.0 which is low alkalinity zone found to be reactive with snowmelt water and the snowmelt water has been absorbed by this area. Being the largest area within the study area which further dilutes the natural groundwater to acidic water and mostly occupied by shallow aquifers.

The pH in low land topography area varies from 4.0-5.5 which is very low alkalinity zone, this area represents the recharge boundary of the entire study area and receives maximum snowmelt water. Since the area is small therefore the snowmelt water reaction is very fast. Further the crescentric shape on both the sides clearly indicates the possibility of further zooming of the area in due course of time which may be monitored further to claim the Assessment of Impact of Global Warming on Groundwater Resources in Parts of Upper Ganga basin.

The pH in plain low land topography area varies from 6.5-7.5 which is alkaline zone owing to the topography and lithology of the area. The pH range indicates that this area is not affected by snow-melt water and primarily contains natural groundwater.

The variation of Electrical Conductivity in an area depends on the geology of the area, geo-chemistry of the area and hydro-geo-morphological conditions of the area. Likewise TDS, EC also represents the saline and fresh water conditions, lower the electrical conductivity, softer the groundwater and higher the electrical conductivity, higher the salinity. Through empirical relation the TDS is almost 60% of the electrical conductivity. The electrical conductivity reciprocates the electrical resistivity of the soil and water, and thus without any destructive tests like drilling etc EC becomes decisive factor indirectly to achieve the interphase between saline water and fresh water vertically as well as laterally.

VI. CONCLUSION & RECOMMENDATIONS

The shallow aquifers are effected by recharging thourgh snow-melt water in the upper region at present, however the deeper aquifers are found to be unaffected by the snow-melt water, in this way it maybe concluded that at present the change of pH towards acidity confined to shallow aquifers for a short period which does not have any direct or visible impact, however probably the deeper aquifers shall also be effected by snow-melt recharge factor and then the impact on the crops, human health and complete eco-system will be felt, if the rate of global warming goes at this pace, however there is no precise prediction of climate change, hence it is difficult to predict the bio-diversity factors for futuristic ecological systems.

It is therefore recommended that a continuous data monitoring system with installation of peizometric system with telemetric configuration maybe adopted in order to predict the impact of climate change on aquifer system.

REFERENCES

[1] Draft Report on Environmental and Social Management Framework of Ganga Basin by National Ganga River Basin Authority, Ministry of Environment and Forests, Government of India, January 2011.

[2] Hydrological Inventory of River Basins in Eastern Uttar Pradesh, National Institute of Hydrology, Roorkee, Uttar Pradesh, 1998-99.

[3] Groundwater Brochure of District Dehradun, Uttarakhand, June 2011, Central Groundwater Board, Ministry of Water Resources, Govt. of India.

[4] Groundwater Brochure of Ghaziabad District, Uttrar Pradesh, 2008-09, Central Groundwater Board, Ministry of Water Resources, Govt. of India.

[5] Groundwater Brochure of Hardwar District, Uttarakhand, April 2009, Central Groundwater Board, Ministry of Water Resources, Govt. of India.

[6] Groundwater Brochure of Muzaffarnagar District, U.P, April 2009, Central Groundwater Board, Ministry of Water Resources, Govt. of India.

[7] Barnett et al., 2005 "Witnessing Change: Glaciers in the Indian Himalyas"chapter 2, page-8

[8] Cruz et. Al., 2007 "Witnessing Change: Glaciers in the Indian Himalyas"chapter 2, page-8

[9] Jianchu et. Al, 2007 "Witnessing Change: Glaciers in the Indian Himalyas"chapter 2, page-8

[10] R.K.Mall, Akhilesh Guota, Ranjeet Singh and L.S.Rathore, 25 June 2006 "Water resources and climate change: An Indian perspective", Current Science, Volume. 90, No. 12,

[11] Assessment of Impact of Global Warming on Groundwater Resources in parts of Upper Ganga Basin-India, International Conference for Water Resources & Environment, Geneva, November, 2011.

AUTHORS

First Author – Ms.Sadiqa Abbas has acquired her M.Tech in Environmental Science & Engineering from the Department of Civil Engineering, Jamia Millia Islamia in the year 2008. She is currently pursuing Ph.D from the same department under supervision of Prof.Gauhar Mahmood. She has 5+ years of industrial experience in the area of environmental engineering and 6+ years of teaching and research experience. She has worked as Research Scientist in the Department of Civil Engineering, Jamia Millia Islamia, New Delhi.
E-mail: sadiqaabbas@hotmail.com.

Second Author – Prof. Gauhar Mahmood is a doctorate in Qualitative and Quantitative Resource Evaluation of Kali-Ganga basin Aquifer System from Aligarh Muslim University, India. He has 20+ years of research experience in the field of groundwater, surface water especially in rainwater harvesting system and artificial recharging, development of water resources etc. He has guided more than 10 scholars in Ph.D and more than 10 M.Tech students. He has organized and presented more than 30 papers in various national and international conferences. He is currently working as Professor in the Department of Civil Engineering, Jamia Millia Islamia, New Delhi, India.
E-mail: symposiumjamia@yahoo.com.

Correspondence Author – Ms. Sadiqa Abbas
Email:sadiqaabbas@hotmail.com