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Groundwater Zonation by using Landform Characteristics in Karha River Basin, Pune District, M. S.

Submitted By

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Certificate

This is to certify that Shri Virendra R. Nagarale (Professor and Head, Department of Geography, S.N.D.T. Women's University P.G.S.R. Pune) has successfully carried out the project work entitled "Groundwater zonation by using Landform Characteristics in Karha River Basin, Pune District, M.s." towards fulfilment of Major Research Project, funded by University Grants Commission. This work has been carried out at Department of Geography, SNDT Women's University P.G.S.R. Pune Campus, Pune.

This report contains the bonafied work carried out by him and the data supplemented from different sources is duly acknowledged.

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Prof. Virendra R. Nagarale

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CHAPTER – I

INTRODUCTION

1.1 INTRODUCTION:

Water is the main source for all forms of life and keeping the biosphere in a sustainable form. Life is not possible on this planet without water. Presence of water makes the earth a unique planet in the universe as its surface is covered abundantly by water, besides its occurrence within the crust and the atmosphere. Groundwater is a natural resource, fundamental to life, livelihood, food security and sustainable development. It is also a scarce resource. India has more than 17 percent of the world's population, but has only 4% of world's renewable water resources with 2.6% of world's land area. There are further limits on utilizable quantities of water owing to uneven distribution over time and space. In addition, there are inequitious distribution and lack of a unified perspective in planning, management and use of water resources (National Water Policy, 2012).

In geomorphological context, a landform may give a clue to surface and subsurface water conditions. Therefore, a complete terrain classification is often required to evaluate the hydrological conditions, its availability and for this, geomorphological surveying of landforms becomes essential. Integration of hydrological, geomorphological, geological data minimizes the area for the detailed survey by sophisticated method. Landforms are the configurations of the land surface taking distinctive forms and produced by natural processes of erosion, denudation and deposition (Strahler and Strahler, 1996). The study of landforms, in a drainage basin with reference to hydrology and geomorphology context has become increasingly important for understanding the surface and subsurface water conditions. In fact geomorphology is found to have very close links with both surface and subsurface water conditions (Verstappen, 1983). Geomorphological features of a terrain, generally controls the distribution of precipitation and amount of precipitation that is contributed as runoff as well as for groundwater recharge.

With this approach, the study, has been carried out to take an effort to prepare a groundwater potential zone map on the basis of landform characteristics of Upper Karha river basin of Pune district in Maharashtra. Study has been tried to focus out groundwater availability and fluctuations with respect to different seasons. It also focuses on groundwater quality for the domestic as well as agricultural purpose.

1.2 ORIGIN OF THE RESEARCH PROBLEM:

The Maharashtra state enjoys a tropical monsoon climate. But being densely populated, it is facing the problems like drying up of wells, water scarcity and groundwater pollution. The over exploitation of ground water and use of untreated waste creates pollution problems, so the water demand is increases day by day. Despite the incidence of high annual rainfall and a large number of rivers, the hilly tracts and elevated areas along the western part of the state experience drought of different order, during summer. This is due to the peculiarity of the terrain characteristics, which promotes high runoff and is therefore hydro-geomorphologically unfavourable for natural groundwater recharge. The recurring incidents of drying up of streams and rivers not only result in the non-availability of water resources but also create many environmental problems such as saline water intrusion in the coastal area and general ecological degradation and regional drought.

Modern remote sensing techniques facilitate demarcation of different landforms suitable for groundwater replenishment by taking into account the diversity of factors that influences groundwater recharge. Geology, geomorphology, structure and climatic condition are the controlling factors of ground water storage, occurrence and movement in hard rock terrain. These features cannot be observed on the surface by bare eyes but can be picked up through satellite remote sensing with reasonable accuracy. Better interpretation of hydrogeological data often requires that their spatial reference be incorporated to the analysis.

1.3 SIGNIFICANCE OF THE STUDY:

It becomes very difficult to quantify and explain the relation between geomorphic processes and hydrologic parameters of a river basin. Such kind of study of small river basin can be applicable to any other river basin having similar litho-climatic and geoenvironmental conditions for design and development of watershed. Planning and development activities in a river basin area can be efficiently formulated by following the criterions that will be evolved through this study. Such type of study has been provide a simple means to complete it with other basins to regionalize the experimental results.

1.4 REVIEW OF LITERATURE

Chow Ven Te (1964) 'Hand book of applied hydrology-A Compendium of Water resource Technology'. This book is deals with information about the water quality requirements for various beneficial uses and its importance in the evaluation of a water supply source. It also focus on each major type of water supply source has certain water quality characteristics which are valuable in the preliminary and formative phases of the development of a supply, and also to determining the quality of a natural water-supply source, the procedures used in sampling the supply are very important.

Scalf Marion R and et.al (1987) 'Manual of Ground-Water Sampling Procedures'. In this book some procedures are given which are currently utilized to sample groundwater and subsurface earth materials for microbial and inorganic and organic chemical parameters.

Kumar Ashok and Tomar Savita(1998) 'Groundwater assessment through hydrogeomorphological and geophysical survey- A case study in Godavari Sub-Watershed Giridih,Bihar' . Present paper was published in Photonirvachak-Journal of the Indian Society of Remote Sensing. This study emphasizes on correlation between different sub units of the same hydrogeomorphic units and top soil resistivity.

Saraf A.K. and Choudhury P.R. (1998) 'Integrated remote sensing and GIS for groundwater exploration and identification of artificial recharge sites', this paper was published in International Journal of Remote Sensing. The present paper attempts to select suitable sites for groundwater recharge in a hard rock area through recharge basins or reservoirs, using an integrated approach of remote sensing and GIS. The integrated study helps in designing a suitable groundwater management plan for a hard rock terrain.

Krishnamurthy Jagadish and Sambaraju Kasturba (2001) 'Project management and use of gis in danida-assessted rural drinking water supply and sanitation project in Karnataka', This paper was published in Workshop on remote sensing and GIS Applications in Water Resources engineering. This study emphasizes on groundwater monitoring, water quality studies and institutional set-up and Water supply planning and institutional set-up.

Natrajan P.M.(2001) 'Application of remote sensing technique to identify the groundwater potential geological and geomorphological settings of Tamil Nadu-india', This paper was presented and published in workshop on 'Remote sensing and GIS Applications in Water Resources Engineering' Lucknow. In this paper an attempt has been made to identify the favourable geological and Geomorphological settings of Tamil Nadu state for groundwater targeting by using the conventional and remote sensing techniques.

Murthy K.S.R and et.al (2003) 'Integration of Thematic Maps Through GIS for Identification of Groundwater Potential Zones', This paper was published in Photonirvachak-Journal of Indian Society of Remote Sensing. The paper focus on integrating the thematic Maps prepared from conventional and remote sensing techniques using GIS yields more and accurate results. The study also demonstrates that using remote sensing data and GIS techniques reconnaissance Mapping of Groundwater offers scope for improving the targeting of Field observations.

Chakraborty S. and Paul P.K (2004) 'Identification of Potential Groundwater Zones in the Baghmundi Block of Purulia District of West Bengal Using Remote Sensing and GIS' The present paper published in Journal Geological Society of India. In present paper Morphometric and Hydro-geomorphic analysis has been done to determine the potential water- bearing zone in the study area.

Nagarale.V.R (2007) 'Geomorphic Assessment of Groundwater Potential in Gunjawani Basin (Pune District)', a doctoral thesis submitted, emphases on relation between geomorphic landforms and groundwater potentials. In the further study author also studied the quality of groundwater for various purposes like agricultural and domestic purposes. In the last author has been success to show the groundwater potential with three zones of potentiality.

1.5 OBJECTIVES:

The main objective of the present study is to assess the Groundwater Resources of the Upper Karha River Basin area.

The supportive objectives are:

1. To study the Morphometric characteristics and correlate with Groundwater.
2. To study groundwater conditions in Karha River Basin with reference to Season.
3. To assess the quality of groundwater for the domestic and agricultural utilization
4. To study the correlation between soil characteristics and Groundwater potential.
5. To quantify the ground water availability in different potential zones like Low, Moderate and High Potential zones.

1.6 METHODOLOGY:

Geographic personality of an area is the result of the total effect of a particular combination of natural factors and human interventions. A broad procedure will involve the following steps

1.6.1 Preparatory Phase

- Base map preparation (on the basis of SOI toposheets.)
- Acquisition of satellite data
- Acquisition of secondary data

1.6.2 Analytical Phase

1.6.2.1 Cartographic analysis

- Analysis of basin Morphometry
- Classification of landforms on the basis of their origin (Denudational, structural and depositional)

1.6.2.2 Field analysis

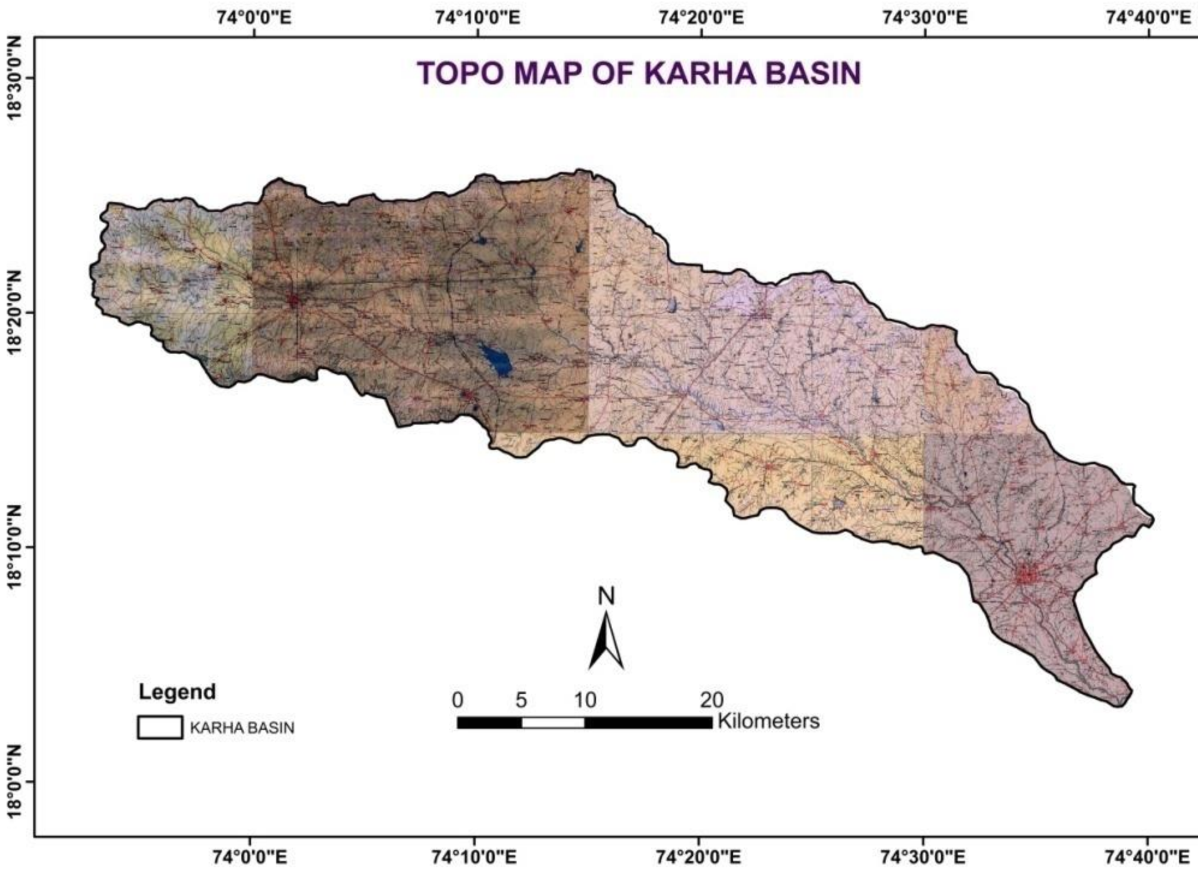
- Field surveys for verification (ground truthing) of morphometric characteristics
- Field visits for collection of water samples
- Measurement of Groundwater Depth (Pre-Monsoon and Post Monsoon) at various places

1.6.2.3 Laboratory analysis

- Analysis of groundwater samples for the Quality analysis.
- Generation of map layers
- Preparation of database in such a way that a groundwater zones will be displayed in basin map.

1.7 PROFILE OF THE STUDY AREA

Karha watershed is selected for the present study. Karha drainage basin is located in the southwestern part of Sahyadri mountain range in Pune District. The Karha river is one of the major tributary of the Nira river. Karha river flows from Askrwadi and confluence of Karha with Nira River at near Sonagaon. Malharsagar dam is built upstream on Karha river.



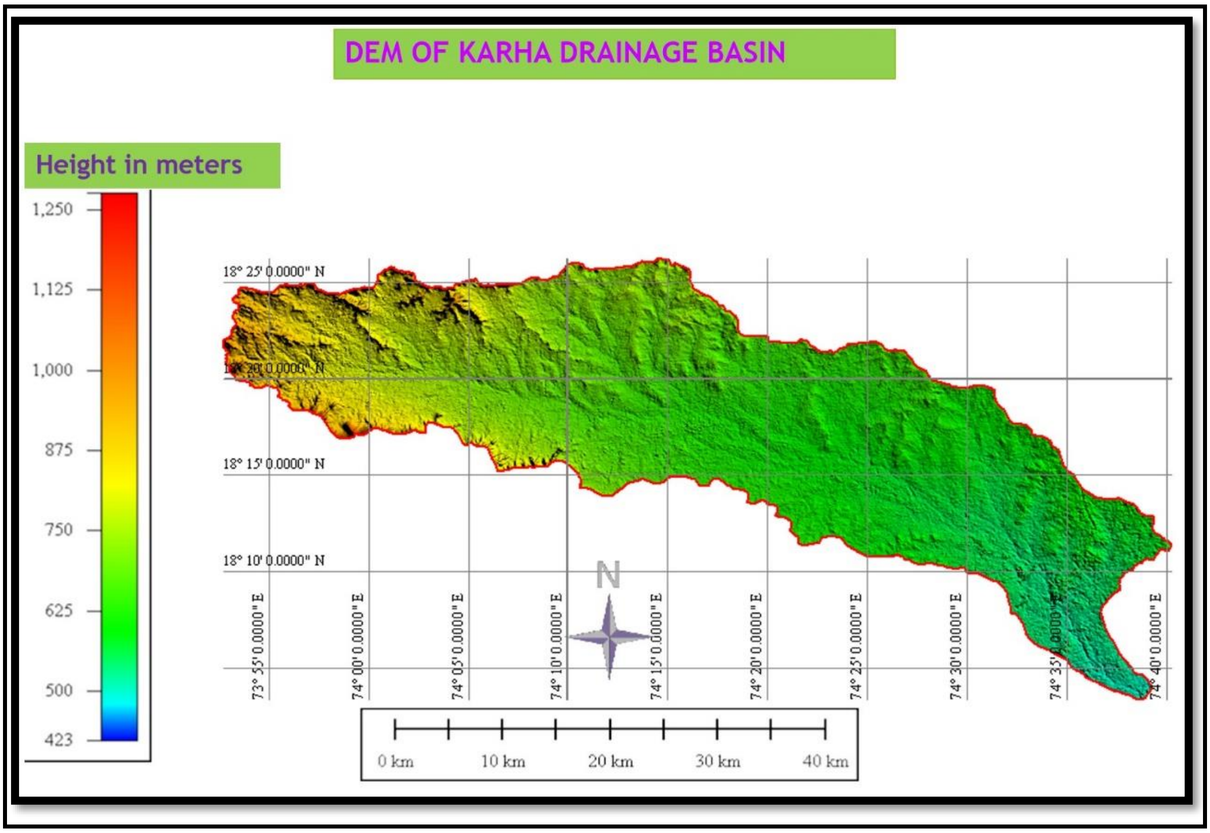
Map No. : 1.1

1.8 LOCATION AND EXTENT

Pune district located in central western Maharashtra. It ‘is triangular shape with Its base along Sahyadri Mountain that run from north to south along its western boundary and its apex it’s south eastern corner. Karha river basin is situated in the Purandar and Baramati block of Pune district in Maharashtra State and is located at $18^0$24’20’’North to 18^0 06’10’’ North latitude and $73^0$48’20’’ East to $74^0$40’10’’ East longitude. The Karha river basin covers an area of (1357.4 sqk.m.). The length of river Karha is 89 km. It is included in toposheet no. 47F/15, 47 J/3, 47J/4, 47J/7, 47J/8, 47J/11 and 47J/12 of Survey of India. The Karha River is one of the important sources of water of this region. Absolute relief of the study area is 1117 meters above sea level. The highest point of the area is 1403 m, situated on Torna fort. The lowest height is 400m situated on the western side of the basin.

1.9 PHYSIOGRAPHY:

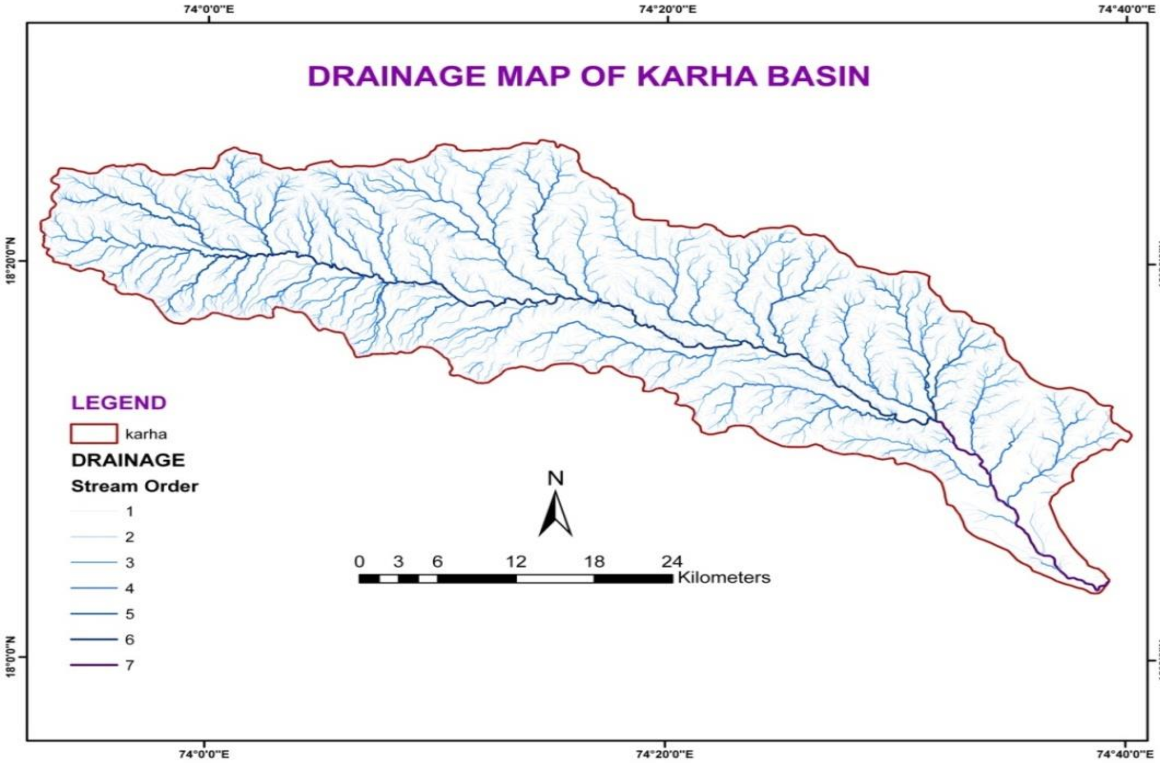
Structurally, the Karha basin lying in the western part of the Deccan Plateau is made up of basaltic rocks which are represented by horizontal lava flows. Western Ghats forms a real watershed between west flowing and east flowing rivers of Indian Peninsula. The present study area is part of eastern flanks of Sahyadri hills, therefore the area exhibits rugged topography and characterized by hilly terrain and shows varied natural relief generally low to moderate relief is observed in the study area. The hill range on which the river has its source locally known as "Purandar hill range" nearly 30 to 35 miles aways from crest line of Sahyadri Mountains.Ambala range is one of the range of sahyadri mountains extending to word east continuously to on distance of nearly 60 miles from sahyadri south of pune; if forms the watershed between the mutha river basin in the north of the river basin of Karha and Shivaganga in south. Karha forms Ambala range Purandar hill range runs toward south-east having maximum altitude of about 4545 feet above mean sea level. Karha flows over the plateau regions locally known as Saswad plateau having an average elevation of more than 2500ft above mean sea level bounded by steep scarps on all sides except the eastern side. Karha is seventh order non perennial stream in Nira river basin. The course of Karaha River from its source to its confluence with Nira is about 100 miles in length. It is joined by numerous small and large streams of various order, form to sixth order streams from both sides north as well as south. Karha is very smooth downstream but concave in upper course. Karha and Chambli this two rivers occupied most of the area of PuranderTahsil. Karhabasin occupied maximum area of Purandartahsil. Generally two types of different valley form are seen in the basin. The valley is bounded by dive ghat on the north and Purandar hill range on the south. The shape and size of valley vary from place to place. The narrow valley from of the uppermost pat in west with V shape and the shallow broad valley form of the lower part in east. Absolute relief of the study area is 1000 meters above sea level. The highest point of the area is 1117 meters above sea level the lowest point of the area is 506 meters.



Map No.1.2: DEM

1.10 DRAINAGE

The Karhariver is one of the major tributary of the Nira river. Its basin lies in parts of pune. The cities of Baramati and Saswad lies on the banks of this river. Malharsagar dam was built in the upstream area of karha River basin. karha river has confluence with Nira River at the Songaon. One of the holy temple of God Ganesha amongst the Ashtavinayaka Moreshwar of Mor gaon is situated on the bank of Karha River. The average annual rainfall of Karha drainage basin is about 200 cm. About 90 percent of the rain falls in the monsoon season in the months of June to September. The entire drainage basin is underlined by basalt rock which comprises of horizontally bedded lava flows commonly referred as 'Deccan Trap' formation. Slope sets limits on land use for annual crops, plantation and even on land reclamation depending on soil depth, stoniness, etc. Hence, the degree of slope and length of slope are important. The inclination of the terrain is the results of the several factors viz. relief, drainage, climate and geology.



Map No:1.3 Drainage Map of Karha River Basin

1.11 CLIMATE

Pune experiences three distinct seasons: Summer, monsoon and winter. The height above sea level and the leeward location with reference to the Western Ghats have made the city climate moderate and salubrious. Typical summer months are from March to May, with maximum temperatures ranging from 35 to 39°C (95 to 102°F). While May is the warmest month in most of the Deccan Plateau, the warmest month in Pune is April. Though the temperatures plunge in this month, the summer heat accompanied by high humidity can be occasionally quite oppressive. Nevertheless, the nights in Pune are significantly cooler compared to those in most other parts of this region owing to the city's high altitude. Pune receives moderate rainfall. Karha basin is located in the rain shadow zone of the Western Ghat. It receives heavy rainfall from southwest monsoon during June to September. karha basin has relatively dry climate Rainfall and temperature variation reflected on the growth of natural vegetation which is tropical semi evergreen to evergreen type. As a result of semi-arid climatic condition, the vegetation cover throughout the basin is very less. Pune experiences three distinct seasons: summer, monsoon and winter. The height above sea level and the leeward location with reference to the Western Ghats have made the city climate moderate and salubrious. Typical summer months are from March to May, with maximum temperatures ranging from 35 to 39°C (95 to 102°F). While May is the warmest month in most of the

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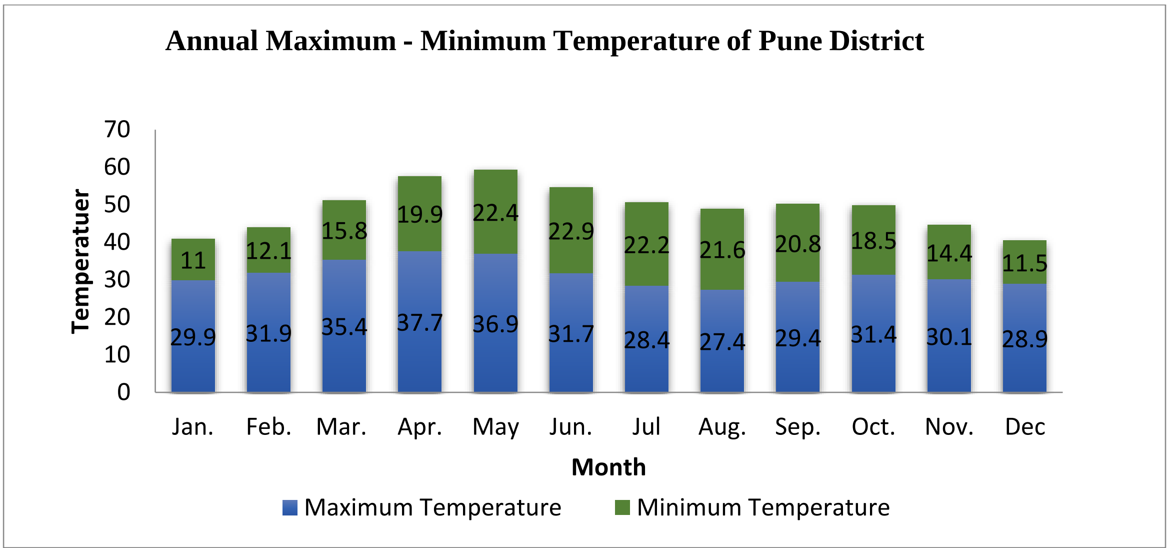


Fig. No. : 1.1

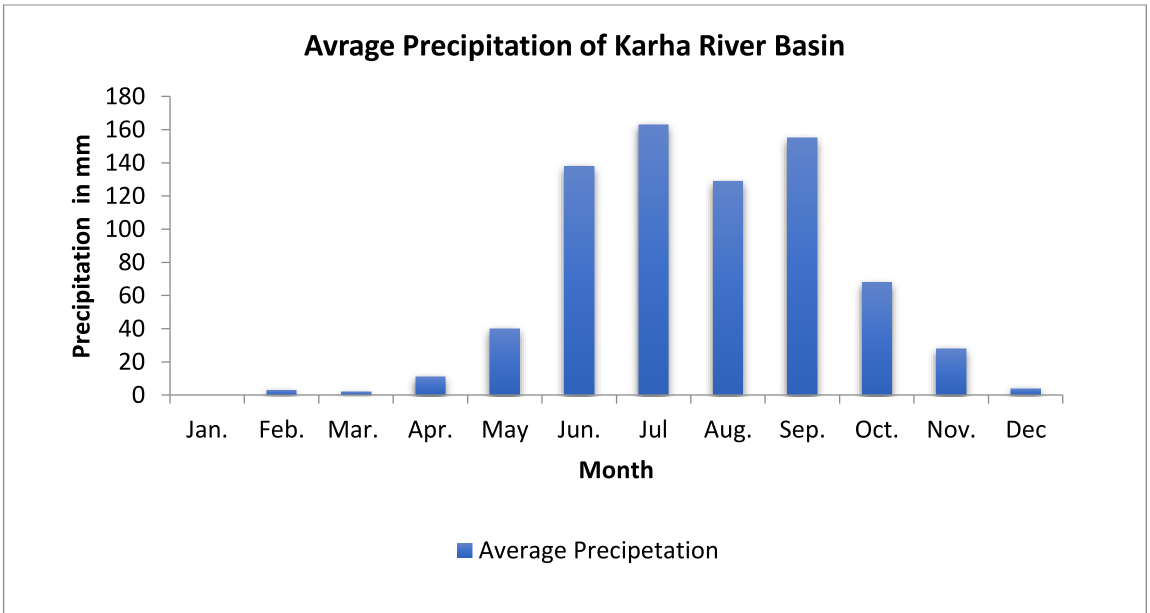
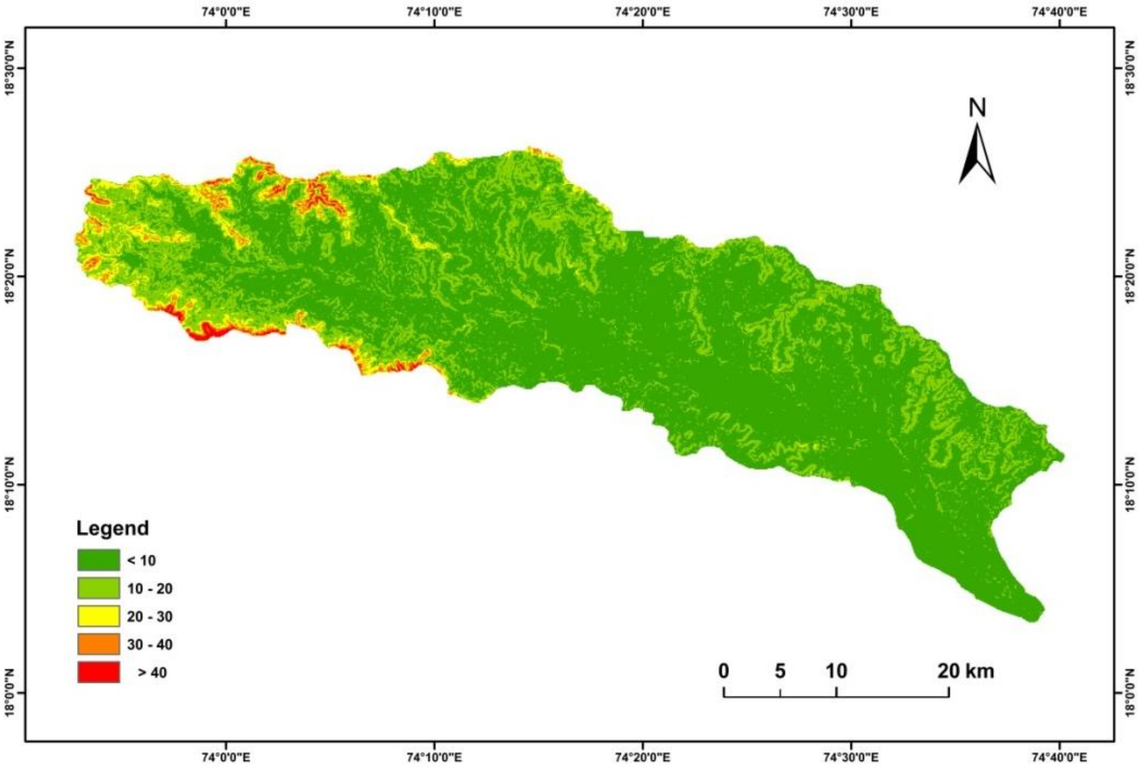


Fig. No. : 1.2

1.12 SLOPE

Slope analysis is an important parameter in geomorphic studies. Slope has major implication for land use. The slopes in watershed have major effect on peak discharge rate at downstream point. The speed and extent of runoff depend on slope of the land. A detailed understanding of slope distribution as the map helps in planning for various aspects like, settlement, agriculture, planning of engineering structure, etc. The greater the slope, the greater the velocity of flow of the runoff water. In the restricted sense, slope refers to the angle that any part of the earth's surface forms with the horizontal datum. The degree of the slope sets limits on land use for annual crops, plantation and even on land reclamation depending on soil depth, stoniness, etc. Therefore, the degree of slope and length of slope are important aspect in the study. The inclination of the terrain is the results of the several factors viz. relief, drainage, climate and geology.



Map No. : 1.4 Slope Map of Karha River Basin

In the present study, the slope analysis is carried out using the ASTER DEM data of 30 m resolution. The slope map of the study area shows that the catchment area of Karha basin is having maximum range of slope includes in 0 to 3.5 degree in slope and in study area 69 % of the area is under more suitable class which is classified as more suitable for agricultural. Minimum area of Karha drainage basin's shows higher degree of slope which includes in 35 -

77-degree range and it covers 0.57 % area. Higher slope is identified in western part of the Karha river basin where it originates. Higher slope degree results in rapid runoff and increased erosion rate (potential soil loss) with less ground water recharge potential.

1.13 SOIL

Soil is a valuable non-renewable resource and exists throughout the World in a broad diversity. Soil is a complex, living, changing and dynamic component of the agro ecosystem. The soil is the home of innumerable forms of plant, animal, and microbial life. A large numbers of processes are responsible for the formation of soils. Soil physical properties affect every use made of the soil. The Karha River Basin has various types of soils like clay loam, claye, gravelly sandy loam, gravelly sandy clay loam and sandy loam. Map No. 1.5 has shown the distribution of soil in Karha river Basin. According to this map it is clear that the clayey soil has captured maximum area of Karha River Basin. This soil suitable for cultivation of sugarcane, wheat, oilseeds and pulses. Sandy loam has captured minimum area of Karha River Basin. Sandy loam type soil is very poor in Humas and hence naturally it is less fertile with poor in moisture retention. In the uplands and slopes, the soils are stony gravelly and thin but in valley bottoms, soils are of moderate deep and rich. Fruits and mulberry are the other crops grow in this soil.

1.14 MORPHOMETRIC ANALYSIS OF BASIN

Morphometric analysis refers as the quantitative evaluation of form characteristics of the earth surface and any landform unit. This is the common technique in basin analysis, as morphometry form an ideal areal unit for interpretation and analysis of fluvially originated landforms where they demonstrations and example of open systems of operation. The composition of the stream system of a drainage basin in expressed quantitatively with stream order, drainage density, bifurcation ration and stream length ratio (Horton, 1945). It incorporates quantitative study of the various components such as stream segments, basin length, basin parameters, basin area, altitude, slope, volume, profiles of the land which shows the nature of development of the basin. It is a common belief among hydro geologists that the surface drainage characteristics of a region determine the sub-surface groundwater status like depth of water table in that region to a significant extent.

Geographical Information system (GIS) and Remote sensing techniques using satellite images are used as a convenient tool for morphometric analysis. Many researchers have carried out morphometric analysis using these new techniques. Digital Elevation Model (DEM) and Shuttle Radar Topography Mission (SRTM) are widely used in drainage basin analysis.

Landforms are basically defined as the ‘the function of the interaction between forces applied and the materials responding to these forces’. The variations in the intensity, magnitude and frequency of forces and levels of response of the material give to different landforms.

The study of landforms not only includes their morphometric characteristics and evolution but also refers to their accumulation and interrelationship as well as the individual landform spread over a given landscape.

Various properties of landforms are result of a variety of geomorphic processes and hence, the evolution of landscape needs to take into account all the quantifiable dimensions of the landforms. This becomes essential because the processes are too slow to observe in their entirety. Hence, the information about the processes as well as their role in shaping the landscape needs to be inferred through terrain analysis.

1.14.1 MORPHOMETRIC: Meaning and Definition

Fluvial Morphometry includes the consideration of linear, areal and relief aspect of a fluvially originated drainage basin. The linear aspect deals with the hierarchical order of streams number’s and lengths of stream segments and various relationship amounts them and related morphometric laws e.g. Laws stream numbers and stream lengths. The areal aspect includes the analysis of basin parameters, basin shape, basin area and related morphometric laws.

Morphometry means “measurement of the shape or geometry of any natural form-be it plant, animal or relief feature is termed Morphometry”. (Strahler A.N. 1979)

“Morphometry may be defined as the measurement and the mathematical analysis of the configuration of the earth surface and of the shape dimensions of its landforms” (Clarke, 1966). The term morphometry is used in several disciplines to mean the measurement and analysis of form characteristics. In geomorphology it is applied to numerical examination of land form, which may be referred to a geomorphometry (Gopalakrishnan,1997).

The drainage basin is the fundamental unit for the collection and distribution of water, solutes, and sediment in fluvial landscapes (Ritter et al., 1995).

Morphometry is the measurement and mathematical analysis of configuration of the earth surface and the shape and dimensions of its landforms (Thornbury, 1969).

1.14.2 MORPHOMETRIC ANALYSIS AND GIS

Morphometric analysis is referred as the quantitative evaluation of form characteristics of the earth surface and any landform unit. This is the most common technique in basin analysis, as morphometry form an ideal areal unit for interpretation and analysis of fluvially originated landforms where they exhibit and example of open systems of operation. GIS is an effective tool to analyze spatial and non-spatial data on drainage, geology, landforms parameters to understand their interrelationship. As a common conclusion they indicated that remote sensing and geographical information system as powerful tools for studying basin morphometry and continuous monitoring. The use of GIS technique in morphometric analysis has emerged as a powerful tool in recent years particularly for remote areas with limited access.

1.14.3 LINEAR ASPECTS

The drainage network transport water and the sediments of a basin through a single outlet, which is marked as the maximum order of the basin and conventionally the highest order stream available in the basin considered as the order of the basin. The size of rivers and basins varies greatly with the order of the basin. Ordering of streams is the first stage of basin analysis. Linear Aspects of Morphometric analysis are includes the Stream Order, Stream length, Stream number, Bifurcation Ratio. Linear aspects are helpful for to investigation the earth surface. Drainage network is most notable basin parameter which is susceptible to change in geomorphic environment. Geological structure and lithology influence the arrangement of the drainage line or network pattern. Resistance to the erosion of the rock differs with the type of the rock and forms various drainage patterns. When rock is homogeneous and surface is essentially flat without any directional control dendriatic pattern develops.

Linear morphometric relationships describe streams' hierarchical location in the drainage network, stream number and lengths of segments, and offer a measure of the basin's geometric homogeneity. Stream ordering schemes were first proposed by Horton (1945) then revised by Strahler (1952, 1957) and Shreve (1967).

1.14.4 STREAM ORDER (U)

The designation of stream order is the first step in morphometric analysis of a drainage basin, based on the hierarchic making of streams proposed by Strahler (1964). It is defined as a measure of the position of a stream in the hierarchical relationship between stream segments their connectivity and the discharge affecting from contribution affecting from contribution catchments. The Strahler's method has been followed in this study; according to his definition the smallest head water tributaries are called first order steams. Where two first order stream meet, a second order streams is created. Where two second order streams meet, third order stream is created and so on. It has been retrieved that the highest order in study area.

Horton (1945) laws of stream numbers states that the number of streams segments of each order forms an inverse geometric Sequence against plotted order. Most drainage networks show a liner relationship with small deviation from straight line. Plotting the logarithm of number of streams against stream's order shows a straight line which states the number of streams usually decreases as the stream order increase.

Table No.1.1: Morphometry (Stream Order) of Karha River Basin

Sr. No	Order of Stream	Number of Streams
1	1st Order	4232
2	2nd Order	1084
3	3rd Order	255
4	4th Order	93
5	5th Order	29
6	6th Order	4
7	7th Order	1

(Source – complied by Research)

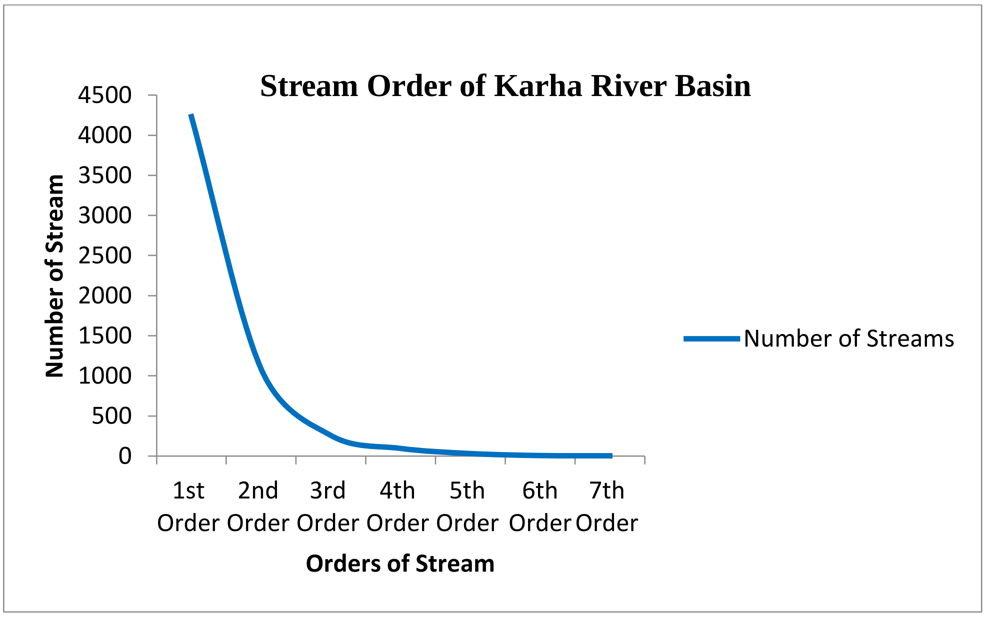
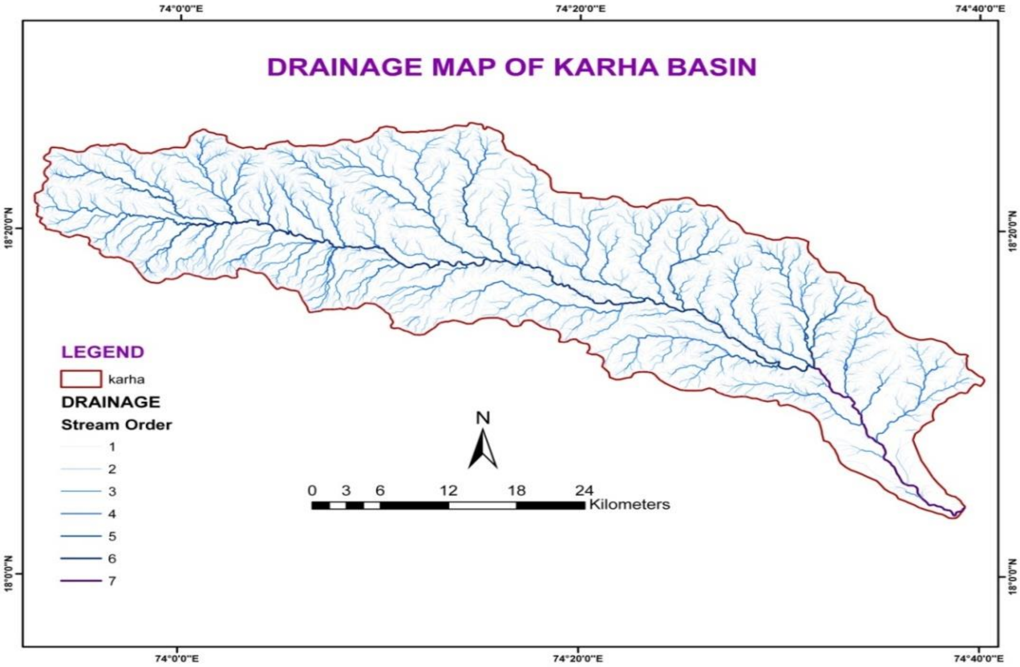


Fig. No:1.3 Stream Order of Karha River Basin

The total number of streams are 5698 out of which 4232 are first order 1084 are second orders 255 third order 93 fourth order, 29 fifth order ,4 sixth order,1 seventh order. As per law of stream number the number of streams decreases as the stream order increases. The streams have been formed in dendritic drainage pattern. The calculation number of streams in number of orders retrieved that number of stream segments are decrease as the stream order is increase.



Map No 1.5: Drainage map of Karha River Basin

1.14.5 STREAM NUMBER

After assigning stream orders, the segments of each order are counted to get the number of segments of the given order. Individual counting of the streams in the river basin reveals the total number of the streams.

It is obvious that the total number of streams gradually decreases as the stream order increases with the application of GIS, the number of streams of each order and the total number of streams were computed

The total number of stream segments present in each order is the stream number. Nu is number of streams of order u. The total number of stream segments is found to decrease as the stream order increases in all the sub basins.

1.14.6 STREAM LENGTHS (LU)

The steam length is calculated on the basis of the law proposed by Horton (1945). The length of various order in drainage basin has been calculated using ArcGIS. The stream length has an important relationship with the surface flow discharge, longer the length slower the appearance of flood and larger the surface flow.

Horton observed that mean length of channel segments of a given order is smaller than that of higher order in a particular ratio called “length ratio”, which is defined as the ratio of mean channel length of an order to that of lower order (Lu+1). Mathematically the length ratio (RL) is given by the following formula:

$$RL = Lu / Lu + 1$$

The length ratio of the Karha basin is 2.10 and the values are presented in table 1.2

Table No 1.2: Morphometry (Linear Aspects) of Karha River Basin

Sr.No.	Stream Order ‘u’	Stream Number ‘Nu’	Bifurcation Ratio ‘Rb’	Mean Length of segment ‘Lu’ in km	Length Ratio ‘RL’
1	1	4232	3.9	0.56	1.2
2	2	1084	4.25	0.67	2.13
3	3	255	2.74	1.43	1.85
4	4	93	3.21	2.65	1.46
5	5	29	7.25	3.87	4.66
6	6	4	4	18.03	1.32
7	7	1	-	23.77	-
Mean					2.1

(Source – Field Investigation)

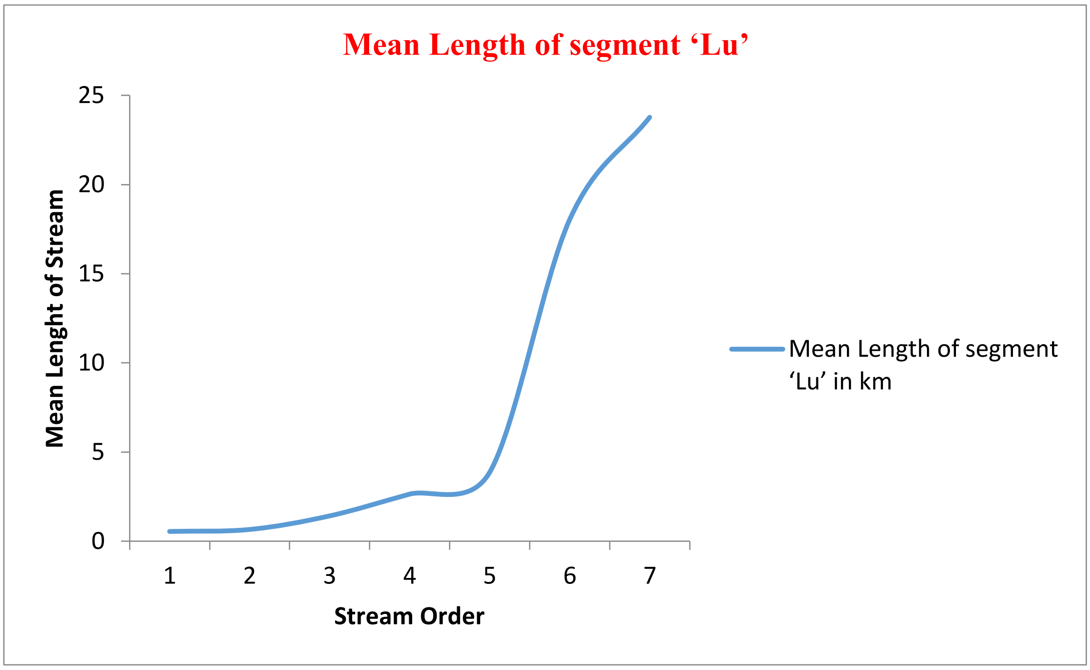


Fig. No. : 1.4 Mean Stream Length

1.14.7 MEAN STREAM LENGTH

The mean stream length is a dimensionless property, characterizing the size aspects of drainage network and its linked surface. It is obtained by dividing the total length of stream order by total number of segments in the order (Table 1.2). The present area mean stream length varies from 10.93 and 7.62 of Anjani and Jhiri river basin respectively. Mean stream length of any given order is greater than that of the lower order and less than of its next higher order, but present study 5th order stream of

1.14.7 STREAM LENGTH RATIO

It is the ratio between mean lengths of streams of any two successive orders. Horton's law of stream length states that mean length of stream segments of each of the successive orders of a basin tends to roughly a direct geometric series, with stream lengths increasing towards higher stream order. Study area shows variation in stream length ratio between streams of different order. Change of stream length ratio from one order to another order indicates their late youth stage of geomorphic development

The counts of stream channel in its order are known as stream number. The number of the stream segments decreases as the order increases, the higher amount streams order indicates lesser permeability and infiltration. The number of streams had high influence, on slope character of that region. The total number of streams are 1991, in that 1st order streams are 1553, 2nd order streams are 331, 3rd order streams are 81, 4th order streams are 20, 5th order streams are 5 and one is indicating 6th order stream. (Table 1.2)

1.14.8 BIFURCATION RATIO (RB)

Bifurcation ratio related to the branching pattern of the drainage network is defined as a ratio of the number of streams of a given order to the number of streams of the next higher order. Bifurcation ratio is supposed to be controlled by drainage density, stream entrance angles, lithological characteristics, basin shape, basin area etc. (Singh 1998) Bifurcation values are ranging from 3 to 7. The higher values of 2 and 3 order streams indicate well developed stream network. The bifurcation values in the 6th and 7th order are low compared to the overall bifurcation ratio of the basin. Bifurcation values ranging from 3 to 7 suggest that it is a natural river system where uniformity is seen with respect to climate, rock type and stage of development. The purpose of stream ordering is not only to index size and scale but also to afford an approximate index of the amount of stream flow which can be produced by particular network. It is the ratio of number of streams of any given order to the number of streams in the next lower order (Horton, 1945).

In the Karha river basin bifurcation ratio ranges from 2.74.to 7.25 to The mean bifurcation ratio for Karha river basin is 4.23. This means that on an average, there are 4.23 times as many channel segments to any given order as of the next higher order. The average bifurcation ratio of the basin reveals that there appears to be strong geological control in the development of the drainage.

$Rb = N\mu / N\mu + 1$

Where,
Rb=Bifurcation Ratio
Nµ = number of segments of a given order
Nµ +1= number of segments of the next higher order

Table No-1.3: Bifurcation Ratio Analysis of Karha River Basin

Sr. No	Stream Order	Total Stream Length (km)	Total Streams	Ratio
1	1st	2390.43	4232	3.9
2	2nd	727.32	1084	4.25
3	3rd	364.12	255	2.74
4	4th	246.63	93	3.21
5	5th	112.32	29	7.25
6	6th	72.13	4	4
7	7th	23.77	1	--
TOTAL		**3936.72**	**5698**	**25.35**
Mean Bifurcation Ratio				**4.23**

(Source – Field Investigation)

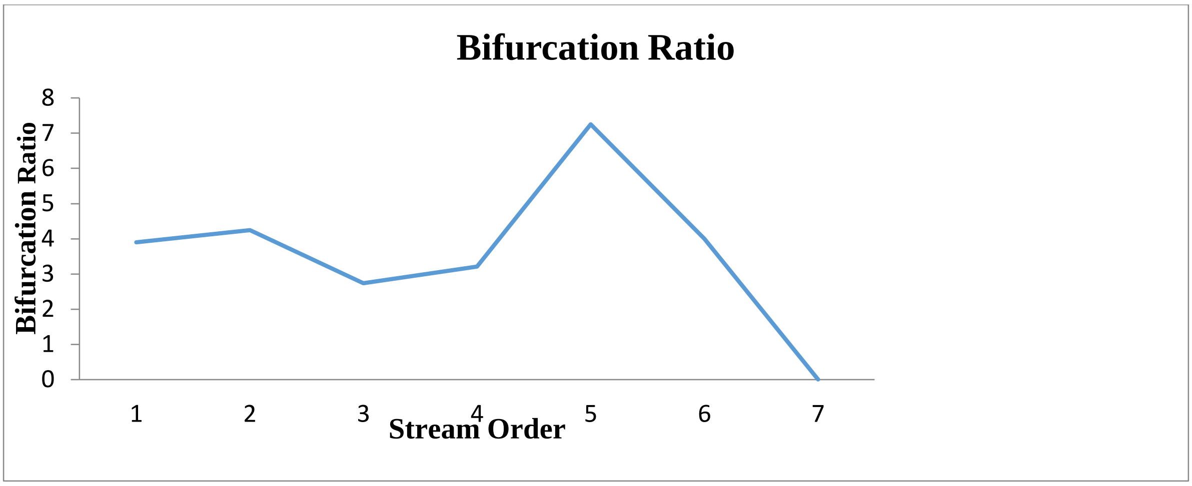


Fig. No. 1.5 Bifurcation Ratio Analysis

1.15 AREAL ASPECTS

The areal aspect is the two dimensional properties of a basin. It is possible to delineate the area of the basin which contributes water to each stream segment. The watershed can be traced from where the stream has its confluence with the higher order stream along hillcrests to pass upslope of the source and return to the junction. This line separates slopes which feed water towards the streams from those which drain in to other streams. The information of hydrologic importance on fluvial Morphometry is derived by the relationship of stream discharge to the area of watershed. The plan metric parameters directly affect the size of the storm hydrograph and magnitudes of peck and mean runoff is the basin area.

Area of a basin (A) and perimeter (P) are important parameters in quantitative geomorphology. The area of the basin is defined as the total area projected upon a horizontal plane. Perimeter is the length of the boundary of the basin. It is measured along the divide between watersheds and may be used as an indicator of watershed size and shape. Aerial aspects include different morphometric parameters, like drainage density, texture ratio, stream frequency, form factor, circulatory ratio, elongation ratio and length of the overland flow. Basin area is a very important factor in the study of Morphometry and it is related to various factors such as drainage density, stream frequency, drainage texture, and slope. As the first order stream starts to flow in its own way it takes its source from head ward erosion. It increases the stream length and basin area. Where the area is homogeneous this law works but varies if relief characteristics limit the functioning of basin development. (Singh et al. 1982)

1.15.1 DRAINAGE AREA (A)

Drainage area is most important basin parameter, it is mainly responsible to change in geomorphic environment. The drainage pattern of an area refers the design of the stream courses and their tributaries. It is influenced by the slope of the land lithology and structure. The distribution and attitude of the rock systems and their arrangement also control the drainage pattern. A study of drainage pattern and drainage texture is helpful in the interpretation of geomorphic features and understanding land form evolution. Geological structure and lithology influence the arrangement of the drainage line or network pattern. Resistance to the erosion of the rock differs with the type of the rock and forms various drainage patterns. When rock is homogeneous and surface is basically flat without any directional control dendriatic pattern develop. The study area of River Karha shows the above characteristics which result into dendriatic pattern. The drainage network development in the Karha river basin is very typical which is seen everywhere in the hilly basaltic area. The network development in Karha river is mainly controlled by structure. The area of Karha river basin is about 1357.4 sq. km. The drainage area (A) is possibly the single most important watershed characteristic for hydrologic design. It reflects the volume of water that can be generated from rainfall. The basin area of Karha river is homogeneous in respect of lithology, geological structure, climate and vegetation cover.

1.15.2 DRAINAGE TEXTURE (RT)

Drainage texture is the product of drainage density and drainage frequency Horton (1945) defined drainage texture on the basis of stream frequency (number of stream per unit area.). It is related to the degree of looseness of drainage.

An essential geomorphic concept is drainage texture by which we means the relative spacing of drainage lines Horton (1945) has pointed out that what we commonly refer to as drainage texture assuredly includes both drainage density and stream frequency The drainage texture depends upon a number of natural factors such as climate, rainfall, vegetation, rock and soil type, infiltration capacity, relief and stage of development (Smith, 1950). by vegetation produce a fine texture, whereas massive and resistant rocks cause coarse texture. Sparse vegetation of arid climate causes finer textures than those developed on similar rocks in a humid climate. Fine drainage texture of dendritic pattern indicated that the rock formation are impervious and the permeability is low. Soils formed in such area are deep, heavy and slowly permeable.

Drainage texture is defined as the total number of stream segments of all orders per perimeter of the area (Horton). Smith (1950) classified drainage into five classes i.e., very coarse (<2), coarse (2-4), moderate (4-6), fine (6-8) and very fine (>8). Horton (1945) recognized infiltration capacity as the single important factor which influences drainage texture and considered drainage texture which includes drainage density and stream frequency.

1.15.3 DRAINAGE DENSITY (D):

Drainage density acts as an important parameters for analysis of a drainage basin

Drainage density is a significant factor affecting the flow, infiltration capacity etc. It is defined as the ratio of the total length of channels of all orders in a basin to the area of the basin. It has been observed that low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture. It is an average length of channel per unit area of the drainage basin. According to Horton, drainage density is the length of streams per unit of the drainage area. Here it is derived by using the formula i.e.

$$D = \sum Lu / Au$$

Where,

D = Drainage Density,

$\sum Lu$ = total length cumulated for each stream order within a given basin area Au.

$$D = 3936.72/1353.4$$

Drainage Density = 2.90 km /sq. km

The drainage density of Karha basin is 2.90. The density is high due to the regions of weak or impermeable surface materials and sparse vegetation.

Table No-1.4: Morphometry of Karha River Basin

Basin	Stream Frequency	Circularity Ratio	Form Factor	Elongation Ratio	Elipticity Index	Ruggednes Number	Relief Ratio
Karha	4.2	0.3	0.17	0.76	4.59	2.4	9.29

(Source – Field Investigation)

1.15.4 STREAM FREQUENCY: (FS)

The stream frequency is defined as the total number of stream segment of all order per unit area. A large basin may contain as many sufficient tributaries per unit of area as a small drainage basin, and in addition, it usually contains a larger stream or streams (Horton 1945).

Stream frequency is defined as the number of streams per unit area in a drainage basin. It is also computed by the formula i.e.

$$F = \sum Nu / Au$$

The stream frequency of Karha basin is 4.20, so the texture of the drainage net is of good quality.

1.15.5 CIRCULARITY RATIO (RC)

Circularity ratio is the ratio of the area of the basin to the area of a circle having the same circumference as the perimeter of the basin (Miller, 1953). It is influenced by the length and frequency of streams, geological structures, land use/ land cover, climate, relief and slope of the watershed. The circularity ratio and form factor are the measurements to analyze the outline form of the basin. The circularity ratio is the ratio of the basin area of a circle having the same perimeter as the basin. The value of these ratio approaches 1 as the shape of the basin approaches a circle. It is calculated from the following relationship:

RC = Area of basin / Area of Circle = $4\pi A / P2$

The circularity ratio of Karha basin is 0.30. Therefore it is not circular shaped basin because value is close to 0.

1.15.6 FORM FACTOR: (RF)

Form factor is the numerical index (Horton, 1932) normally used to represent different basin shapes. Smaller the value of form factor, more elongated will be the basin. The basins with high form factors have high peak flows of shorter duration, whereas, elongated sub-watershed with low form factors have lower peak flow of longer duration. Form factor is defined as the ratio of basin area to the square of the basin length

Horton (1932) suggested the 'form factor' which can be expressed as:

$$F = A / L2$$

If the 'F' value is higher, then the basin shape is more circular. The 'F' value of Karha basin is 0.17 which is much less so it is not circular shaped basin.

1.15.7 ELONGATION RATIO (RE)

Elongation ratio is defined as the ratio between the diameter of a circle with the same area as that of the basin and the maximum length of the basin. The shape of the any basin is conveyed by an elongation ratio (Re), it is the ratio between the diameter of the circle of the same area as the drainage basin. A circle basin is more capable for discharge of run-off than an elongation basin. These values can be grouped into 4 categories namely a circle > 0.9, b Oval 0.9 to 0.8, c Less elongated <0.7, the elongation ratio of sub-watershed of the study area varies from 0.423 Anjani to 0.84 Jhiri indicates less elongated basin. Elongation ratio is defined as the ratio between the diameter of a circle of the same area as the basin and the maximum basin length (Schuman 1956). It is very significant index in the analysis of basin shape to give an idea about the hydrological character of the drainage basin. Values of Re generally vary from 0.6 to 1.0 over a wide variety of climatic and geologic types. Re values close to in the range 0.6 to 0.8 are usually associated with high relief and steep ground slope (Strahler, 1964). These values can be grouped in to three categories namely; Circular, Oval and Elongated. Elongation ration is another parameter introduced to analyze the basin shape. This is defined as the ratio of diameter of circle having area equal to the basin area to the basin length. The elongation ratio of the study area is 0.184 it indicates the Hemavathi watershed region is rotundity and low degree of integration within a basin.

1.16 RELIEF ASPECTS

Relief aspects of drainage basin relate to the three dimensional features of the basin involving area, volume and altitude of vertical dimension of landforms wherein different morphometric methods are used to analyze terrain characteristics. Relief is the elevation difference between the heights and lowest point on the valley floor of the region. The relief measurements like relief ratio, basin length and total relief have been carried out. The parameters converging the relief aspect of the basin and channel network are as follows

1.16.1 BASIN RELIEF (H):

Relief of a basin is the maximum vertical distance from the stream mouth to the highest point on the divide. The total relief (H) of Karha basin is 828 meter.

1.16.2 RELIEF RATIO (RH):

The relief ratio is the ratio of maximum relief to horizontal distance along the longest dimension of the basin parallel to the principal drainage line is termed as relief ratio (Schumm, 1956). The Rh normally decreases with the increasing area and size of sub-basin of a given drainage basin relief ratio is the ratio between total basin relief (i.e., difference in elevation of basin mouth and summit) and basin length, It is calculated by using formula as:

$Rh = H/ Lb$

The relief ratio of Karha basin is 9.29.

1.16.3 RUGGEDNESS NUMBER (RN)

It is the product of maximum basin relief (H) and drainage density (D), where both parameters are in the same unit. An extreme high value of ruggedness number occurs when both variables are large and slope is not only steep but long as well (Strahler, 1956).

This dimensionless measure combines slope and length characteristics into one expression:

$$Rn = HD.$$

So, the ruggedness number of Karha basin is 2.40.

1.16.4 CHANNEL GRADIENT

Channel Gradient ratio is an indication of channel slope from which the runoff volume could be evaluated. The basin has a gradient ratio of 0.015, while those of the 5 sub-basins as shown in Table 5, varies from low to moderate.

1.16.5 SLOPE

The slope angle of a basin is a morphometrical factor of hydrological relevance. Steep slopes generally have high surface run-off values and low infiltration rates. Sediment production thus tends to be high except when largely barren slopes are concerned (Verstappen.H 1983).

1.16.6 BASIN SHAPE

The shape of the basin mainly governs the rate at which the water is supplied to the main channel. The main indices used to analysis basin shape and relief are the elongation and relief ratios. The elongation ratio is calculated by dividing the diameter of a circle of the same area as the drainage basin by the maximum length of the basin, measured from its outlet to its boundary. Three parameters viz. Elongation Ratio (Re), Circulatory Ratio (Rc) and Form Factor (Rf) are used for characterizing drainage basin shape, which is an important parameter from hydrological point of view.

CHAPTER II

GROUNDWATER QUALITY ASSESSMENT

2.1. INTRODUCTION

The source of water supply to the area is through bore wells and dug wells. Irrigated agriculture is depending on adequate water supply of suitable quality. Water quality concern has been plentiful and readily available. For irrigation, the quality of water determines if optimum returns of from the soil can be obtained as the quality affects the soil, crop and water management. Nearly all water contains dissolve salts and trace elements, many of which results from the natural weathering of the earth's surface (Sultana Nahid and et.al 2009). In most irrigation situations, the primary water quality concern is salinity levels, since salts can affect both the soil structure and crop yields. The elaboration and implementation of sustainable water use strategies based on the detailed data on the seasonal variation of the water quality that is strongly related to dilution processes taking place during high flow periods especially in post-monsoon seasons, and to the loads of soluble compounds carried by the return waters utilized for drinking and irrigation (Crosa, et al., 2006). The results reveal that except some of the sample's parameters like, EC, TDS. All other quality parameters are safe for irrigation and drinking purpose. Groundwater in study area is utilized for both agricultural and drinking purposes hence the hydrochemistry is discussed to understand water rock interaction process and to investigate the concentration of the total dissolved constituent present in groundwater with respect to the standards of safe potable water.

2.2 GEOLOGY AND HYDROGEOLOGY

Geologists use a wide variety of methods to understand the Groundwater potentiality and occurrence of groundwater underneath the rock structure like as field work, rock description, geophysical techniques, chemical analysis, physical experiments, and numerical modelling. In practical terms, geology is important for mineral and exploitation, evaluating water resources, understanding of natural hazards, the remediation of environmental problems, and providing insights into past climate change. Geology, a major academic discipline, also plays a role Groundwater studies.

The area consists of Deccan Trap encompassing different types of basaltic flows, separated by red bole. The basaltic lava flows belonging to Deccan volcanic province that flooded during upper Cretaceous to Eocene age.

Table No.2.1 The Stratigraphic sequence and lithology as indicated given below.

Formation	Age	Lithology
Deccan Trap	Upper Cretaceous to Eocene	Vesicular and Amygdaloidal Zeolitic Basalt inter bedded with red bole.

2.3HYDROGEOLOGY

The area consists of Deccan Trap, encompassing different types of basaltic flows, separated by red bole. The occurrence of groundwater is found in shallow and deep aquifers. The Deccan Trap consists of four types of rocks like compact, amygdaloidal, vesicular, and tachylitic basalt. The groundwater is found in compact basalt due to the presence of secondary porosity, i.e. Fracture and joints in the rocks. Depth of the dug wells. The chemical composition of groundwater of the study area is shown in table no.2.2 The chemical composition of the groundwater is controlled by nature of geochemical reaction, velocity and volume of groundwater flow, lithology, precipitation and role of human activity (Matthes and Harvey,1982; Reddy, Subba Rao and Reddy 1991, Bhatt and Sakalani, 1996.).

2.4 HYDROCHEMISTRY

The chemical constituents of groundwater are result of geochemical processes occurring due to the reaction of water and geologic materials (Appelo et al. 1996). The hydrochemistry of the groundwater assesses based on EC, TDS, Ca, Mg, TH, Na, K, NO_3, SO4 etc. (Table-2.). During post-monsoon (October 2014). It is observed that the average concentration of EC, TDS, Cl, Ca, Mg, TH, TA, are within the permissible limit. The pre-monsoon seasons. The concentration of these elements increases in post-monsoon seasons may be due to the effects of leaching during rainy season (K. Srinivasamurthy, et. al 2009). The concentration of sodium (Na) was more in pre-monsoon and potassium (K) have remain constant values in both the seasons, it is indicating that lower geochemical mobility. Nitrate (NO_3) and sulphate (SO_4) shows more concentration indicate infiltration of surface water into groundwater during rainy season. Nitrogen in groundwater is mainly derived from fertilizer or nitrogen fixing bacteria leaching of animal's dung in agriculture field, sewage and septic tank from city area or industrial influent.

2.5 MATERIAL AND METHODS

The current study was designed to investigate the condition of groundwater contamination in the study area. The chemical investigations of groundwater are results of chemical process occurring due to the reaction of water and geochemical materials (Appelo et.al.,1996). The hydrochemistry of the groundwater assessed on the basis EC, TDS, Ca, Mg, TH, Na, K, NO_3, SO_4 etc. Water quality parameters such as pH, EC, Temperature were analyzed immediately. Other parameters were later analyzed in the Laboratory. TDS were computed by the multiplying the electrical conductivity (EC) by the factor (0.64) .Total Hardness (TH) as $CaCO_3$ and Calcium (Ca) were analysed titrimetrically, using standard EDTA. Magnessium (Mg) was calculated by taking the differential value between Total Hardness (TH) and calcium concentration chloride (Cl) was determined by titrimetrically by standard $AgNO_3$ titration. The content of the Sodium (Na) and Potassium (K) in ground water was estimated flame photo metrically, employing Elico-flame photometer. Sulphate (SO_4) and Nitrate (NO_3) detected by U.V. Spectrophotometer. All parameters are expressed in (mg/l). Except pH units and electrical conductivity is expressed in micromoh/cm.

2.6 RESULTS AND DISCUSSION

The quality standards for drinking water have been specified by the World Health Organization (WHO) in 2004.The behavior of major ions (Ca, Mg, Na, K, HCO_3, SO_4, Cl) and important physico-chemical parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), and total hardness (TH) and the suitability of groundwater in the study area are discussed below.

Table No.2.2 Physico-chemical parameters of groundwater and its comparison with standards

Parameters	WHO (1996)	Highest Desirable Limit	ISI (1995)	Post-monsoon 2016/2017		
	MPL		MPL	Min.	Max.	Ave.
pH	8.5	6.5-8.5	6.5-9.2	8.00	9.1	8.52
EC	1400	………	………	516.00	2930	1123
TDS	1500	500	1500	336.00	1885	719.60
Cl	1000	250	1000	28.00	568.00	179.66
Ca	500	75	200	14.00	192.00	62.92
Mg	100	50	100	5.00	48.00	24.00
CO_3	……	300	600	Nil	90.00	30.00
HCO_3	……	…….	…….	214.00	732.00	446.60
Na	22.00	…..	……..	14.00	40.30	22.44
K	…..	…….	…….	0.40	3.20	1.46
SO4	400	200	400	24.00	68.00	42.40
NO_3	45.00	…….	45.00	35.20	44.50	40.53
TA	…	300	600	214.00	792.00	465.10
TH	…….	…….	…..	82.00	600	298.40

(Source – WHO, ISI and Field work)

2.7 DRINKING SUITABILITY

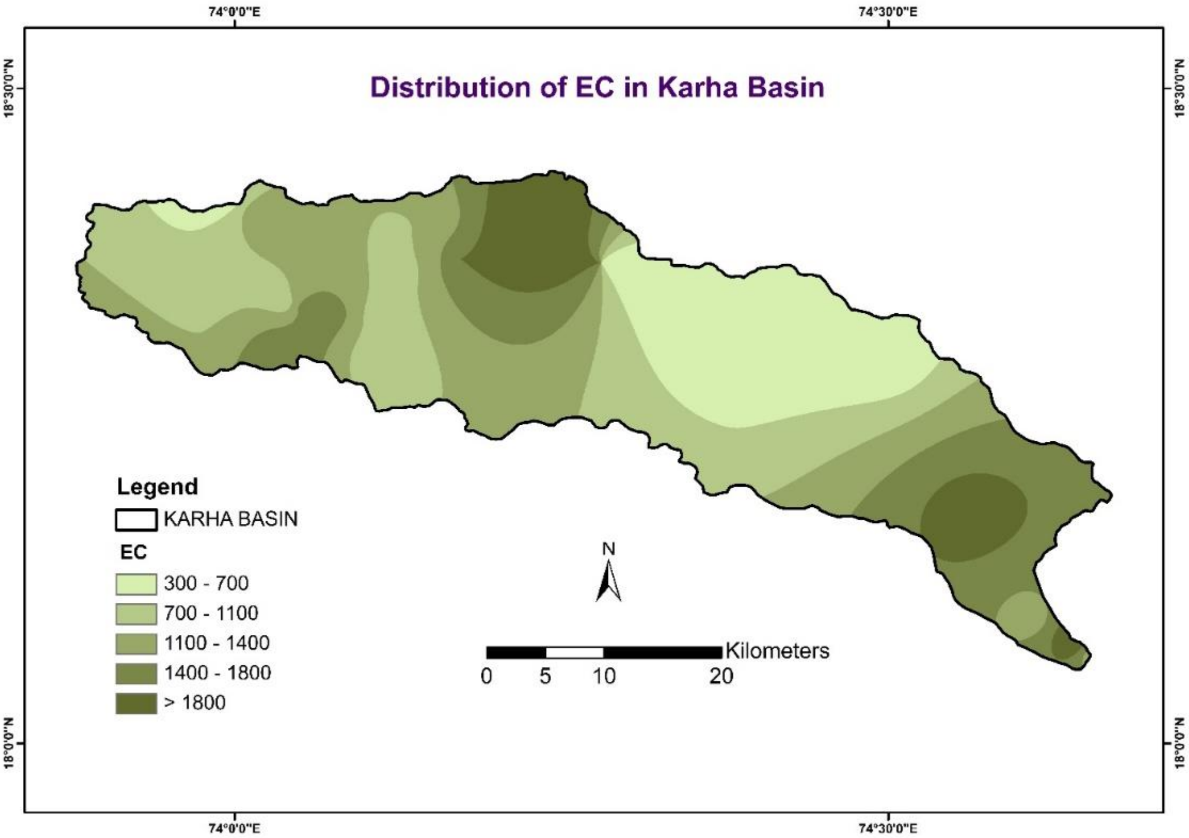
The analytical results have been evaluated to ascertain the suitability of groundwater in the study area for drinking and agricultural uses. The analytical results for all the parameters for the groundwater samples in the study area from post monsoon are presented in the Table 2.2.

2.7.1 pH

pH is a measure of the balance between the concentration of hydrogen ions and hydroxyl ions in water. The pH of water provides vital information in many types of geochemical equilibrium or solubility calculations (Hem1985). The limit of pH value for drinking water is specified as 6.5–8.5 (WHO 2004, 1996; ISI1993, 1995). The pH value of most of the groundwater samples in the study area varies from 8.00-9.00 and average is 8.52.

2.7.2 ELECTRICAL CONDUCTIVITY (EC)

Electrical conductivity is a measure of water capacity to convey electric current (Sarath Prasanth.et.al. 2012.). It is used to estimate the amount of dissolved solids. It increases as the amount of dissolved mineral (ions) increases. In the study area, the value of conductivity ranged between 816.00 to 2930 and average is 1123 S/Cm. The maximum concentration of electrical conductivity (EC) in the study is 2930 S/Cm (0.25 ds/m) which is above WHO (1996). This could be related total slightly acidic condition (Obiefuna and Sheriff ,2011).

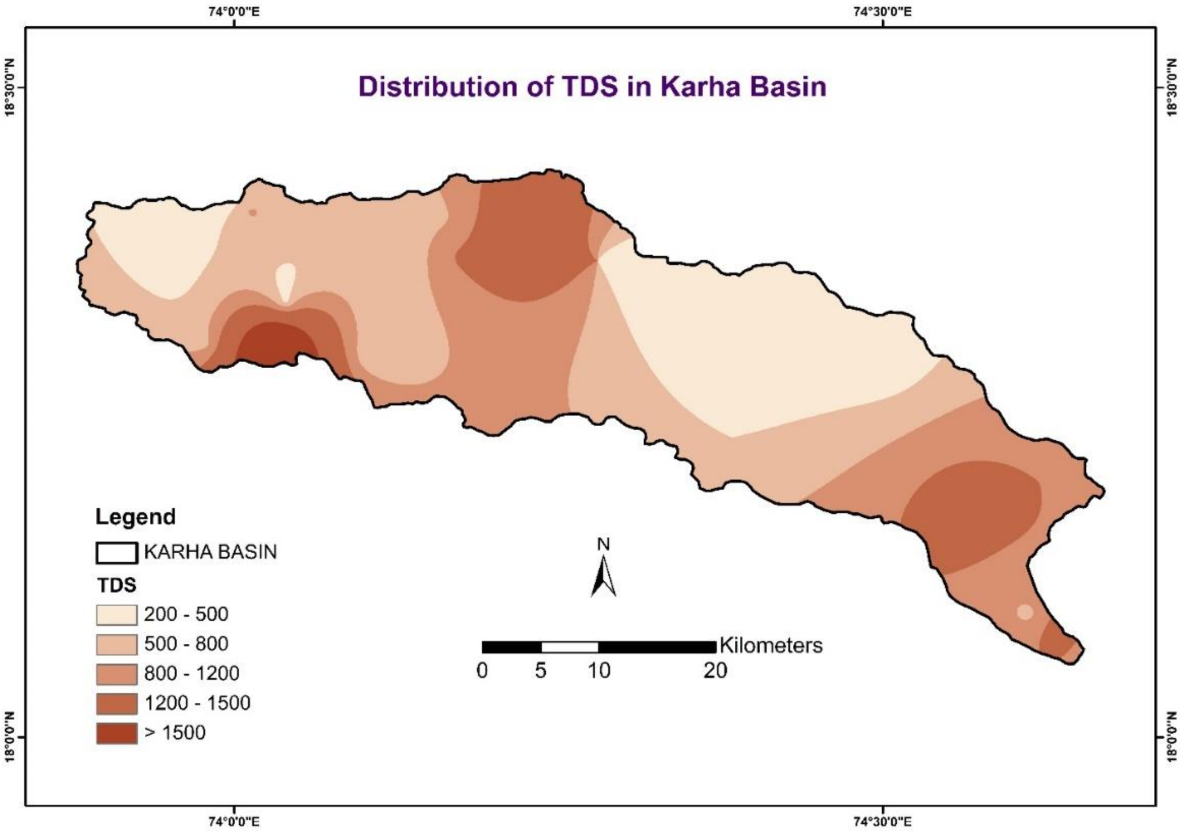


Map No 2.1: Distribution of EC

2.7.3TOTAL DISSOLVED SOLID (TDS)

Total Dissolved Solid (TDS) generally reflects the amount of minerals content that dissolved in the water, and this controls its suitability for use. High concentration of total dissolved solid may cause adverse taste effects. Highly mineralized water may also deteriorate domestic plumbing and appliances (Obiefuna and Sheriff, 2011). In the study area, the concentration value of TD ranged between 336.00 to 1885 mg/L with the average value is 719.60 in post-monsoon season and the average concentration of TDS is within the permissible limit.

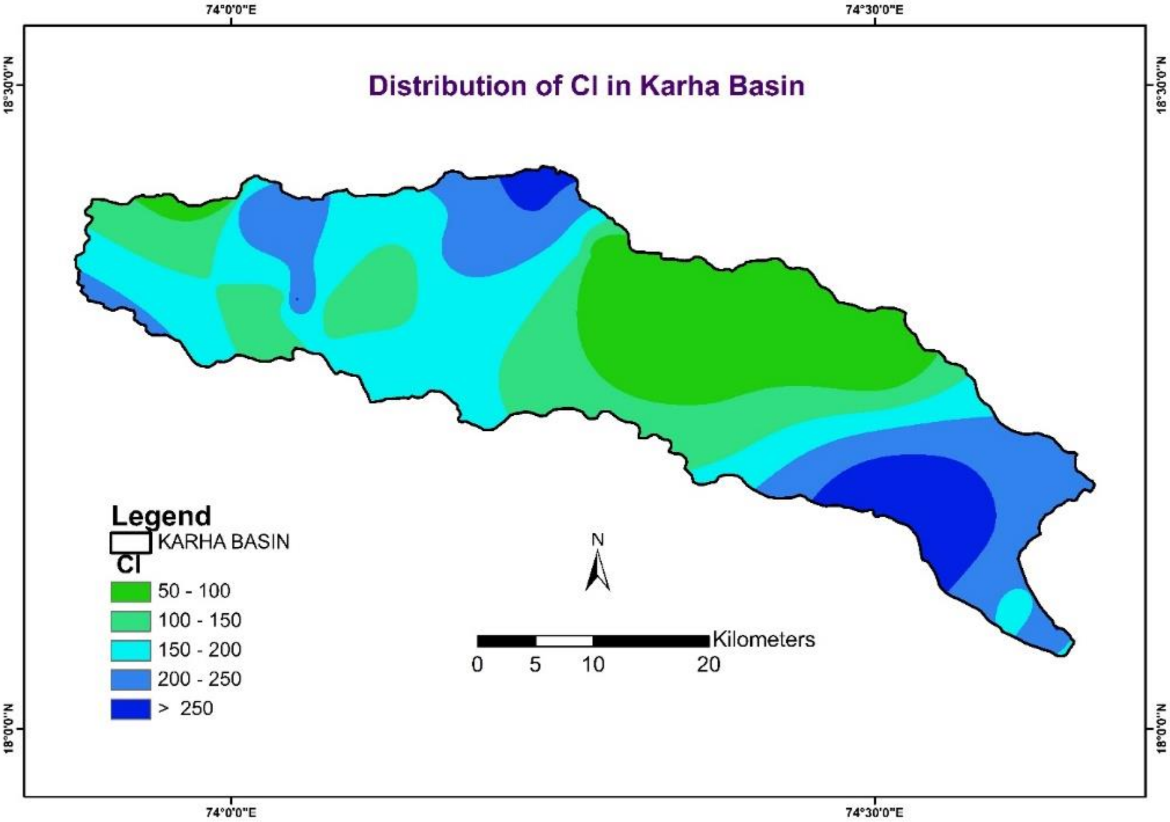
It must be said that the water is thus good for human consumption (domestic) and agricultural purposes.



Map No 2.2: Distribution of TDS

2.7.4 CHLORIDE (CL^-)

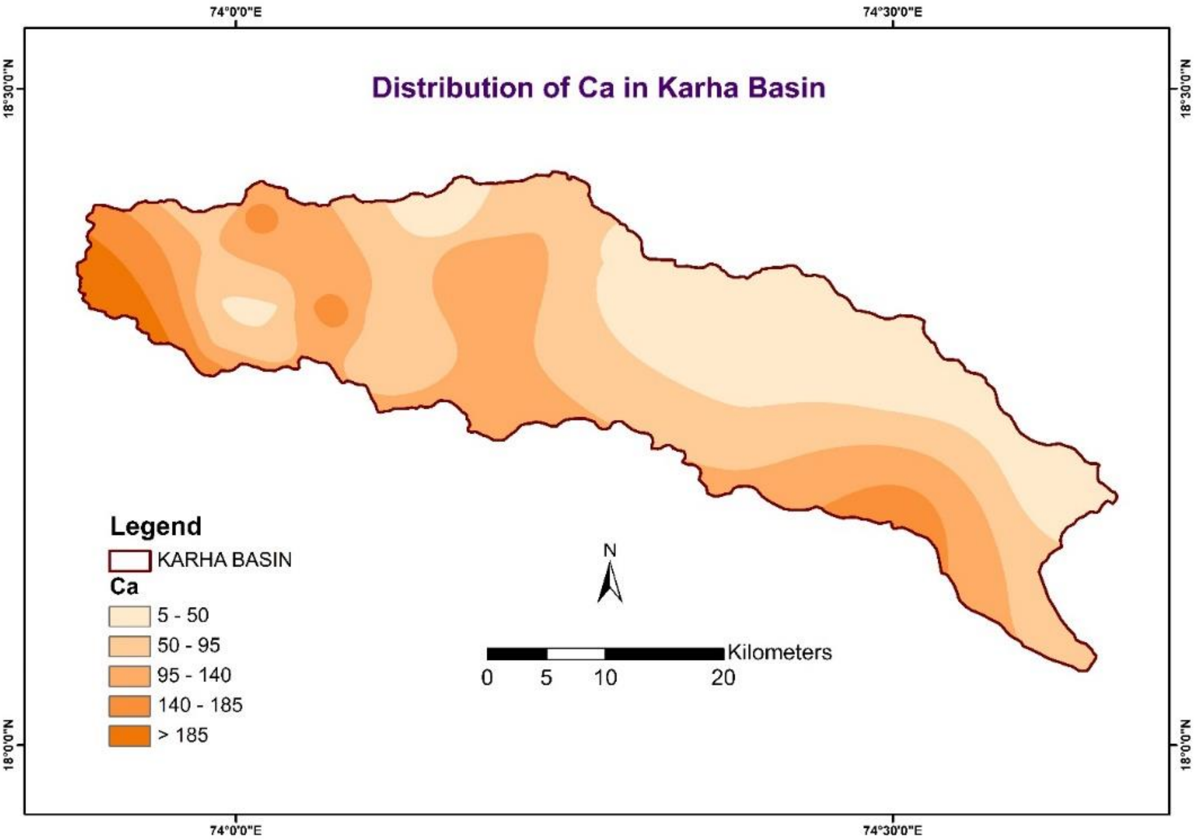
A major ion that may be associated with Individual Septic Disposal System (ISDSS) is chloride (Canter and Knox, 1985). Chloride is present in all-natural waters, usually in relatively small amounts; however, chloride also can be derived from human sources. Chloride is not effectively removed by the septic systems and therefore, remains in their effluent high concentration of chloride in water is known to cause no health hazard, hence, its readily available in almost all potable water. In the study area, the concentration of chloride is range between 28.00 to 568 mg/L, and average is 179.66 in post- monsoon season. The average value of the Chloride is within the permissible limit.



Map No 2.3: Distribution of Cl

2.7.5 CALCIUM Ca^{2+}mg/L

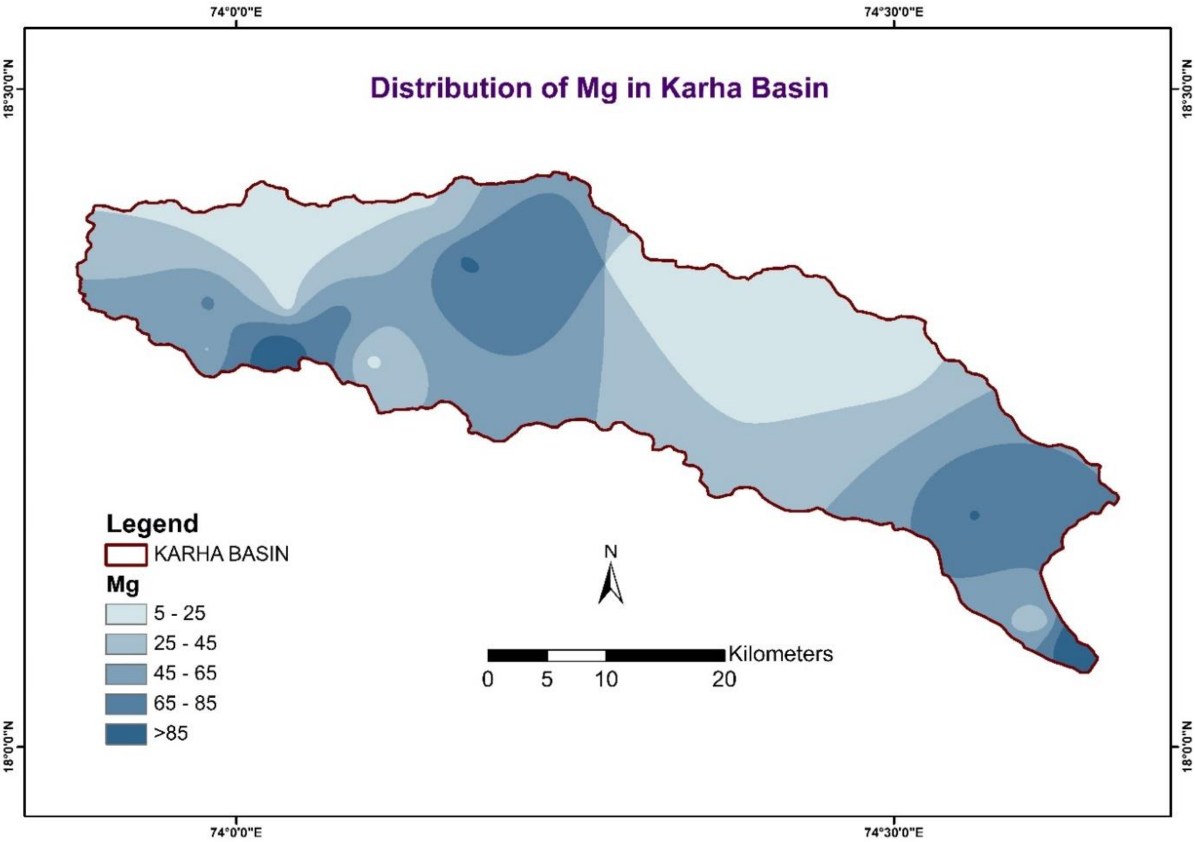
Calcium contributes to the hardness of water and it is the fifth most common element found in most natural waters. The sources of calcium in ground water especially in sedimentary rocks are calcite, aragonite, gypsum and anhydride (Obiefuna and Sheriff, 2011). The calcium concentration in the sampled well in the study area is 14.00 to 192.00 and average is 62.92 in post monsoon season. All the values of Ca are within the permissible limit of (WHO 1996). The possible source of this calcium is limestone or gypsum.



Map No 2.4 : Distribution of Ca

2.7.6 MAGNESIUM (Mg^{2+})

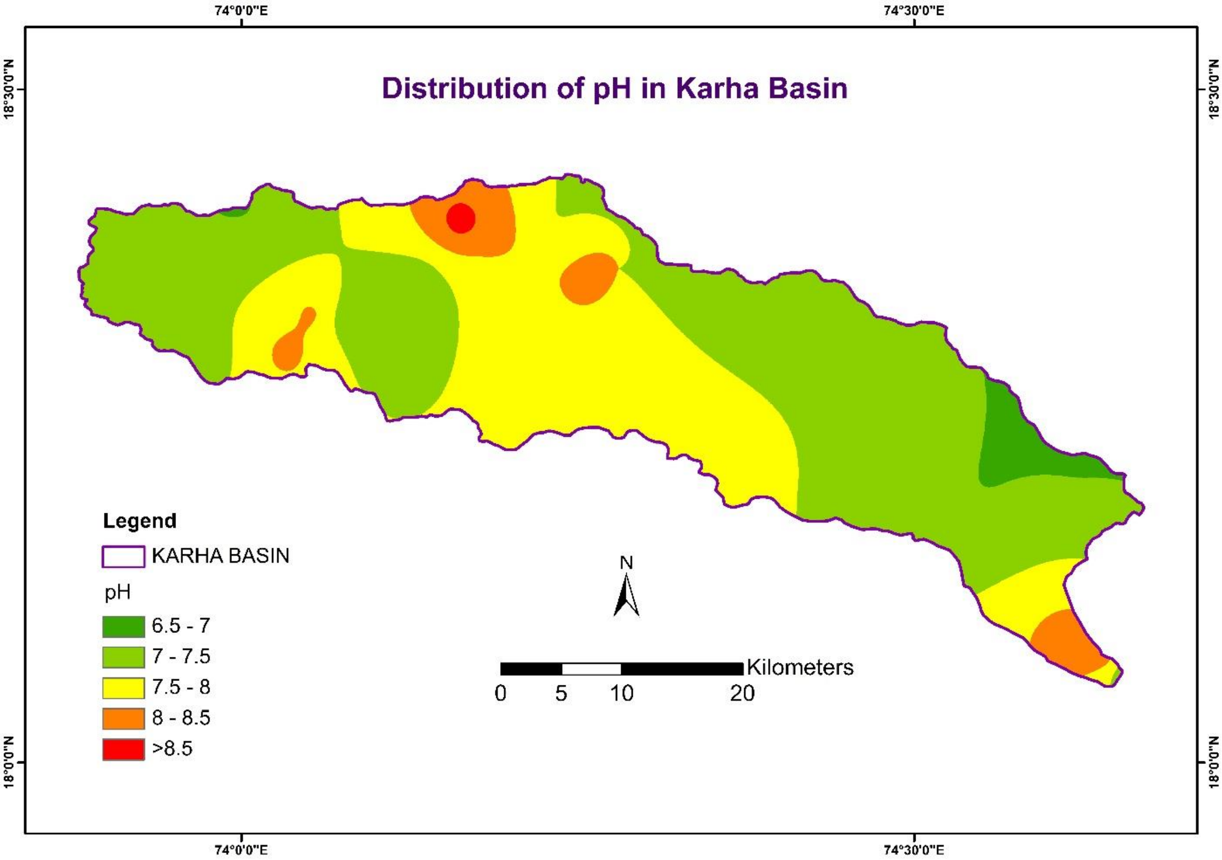
Magnesium is one of the most common elements in the earth's crust. It is present in all-natural waters. It is an important contributor to water hardness. The sources of magnesium in natural water are dolomites and mafic minerals (amphibole) in rocks. The solubility of dolomite in water depends on the composition. The concentration of Mg in study area are ranges from 5.00 to 48.00 and average is 24.75. All the values of Mg in study area are within the permissible limit and the water quality is good for the health.



Map No 2.5: Distribution of Mg

2.7.7 TOTAL ALKALINITY

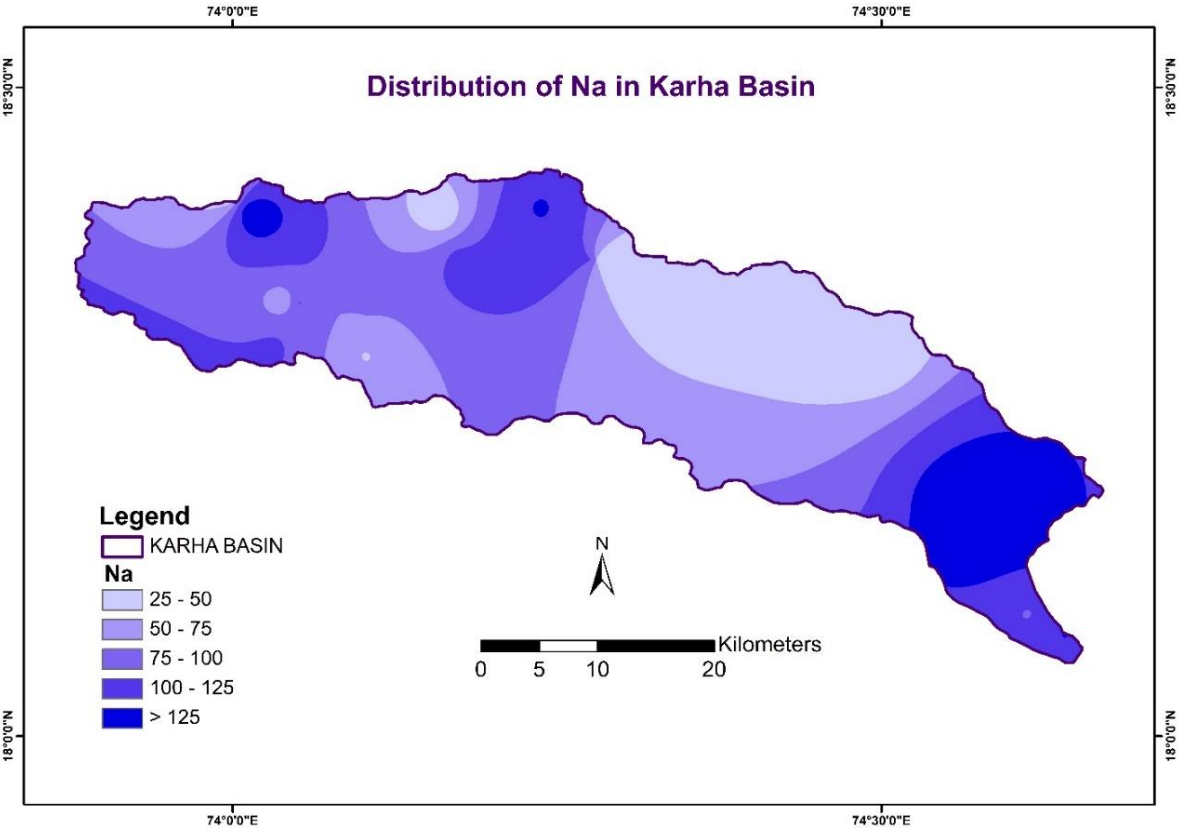
Total alkalinity is a measure of the capacity of water or any solution to neutralize or "buffer" acids. This measure of acid-neutralizing capacity is important in figuring out how "buffered" the water is against sudden changes in pH. Alkalinity should not be confused with pH. pH is a measure of the hydrogen ion (H^+) concentration, and the pH scale shows the intensity of the acidic or basic character of a solution at a given temperature. The reason alkalinity is sometime confused with pH is because the term alkaline is used to describe pH conditions greater than 7 (basic). The most important compounds in water that determine alkalinity include the carbonate (CO_3^{2-}) and bicarbonate (HCO^{3-}) ions. Carbonate ions can react with and neutralize 2 hydrogen ions (H^+) and the bicarbonate ions are able to neutralize H^+ or hydroxide ions (OH^-) present in water. The ability to resist changes in pH by neutralizing acids or bases is called buffering. One source of alkalinity is calcium carbonate ($CaCO_3$), which is dissolved in water flowing through geology that has limestone and/ or marble. The concentration of total alkalinity is ranges from 214 to 792 and average is 465.10.



Map No 2.6: Distribution of pH

2.7.8 SODIUM (Na)

Sodium is an important constituent for determining the quality of irrigation water. Sodium bearing minerals like albite and other members of plagioclase feldspars, nepheline and sodalite weather to release the primary soluble sodium products (Pradhan Biswajeet, et. al.2011). Most sodium salts are readily soluble in water, but take no active part in chemical reactions. Sodium has wide variations in its concentration in ground water. The sodium content of the samples was determined by a flame photometer. Sodium content in the water samples varies between 14.00 to 40.30 and average is 23.44 in post monsoon season.



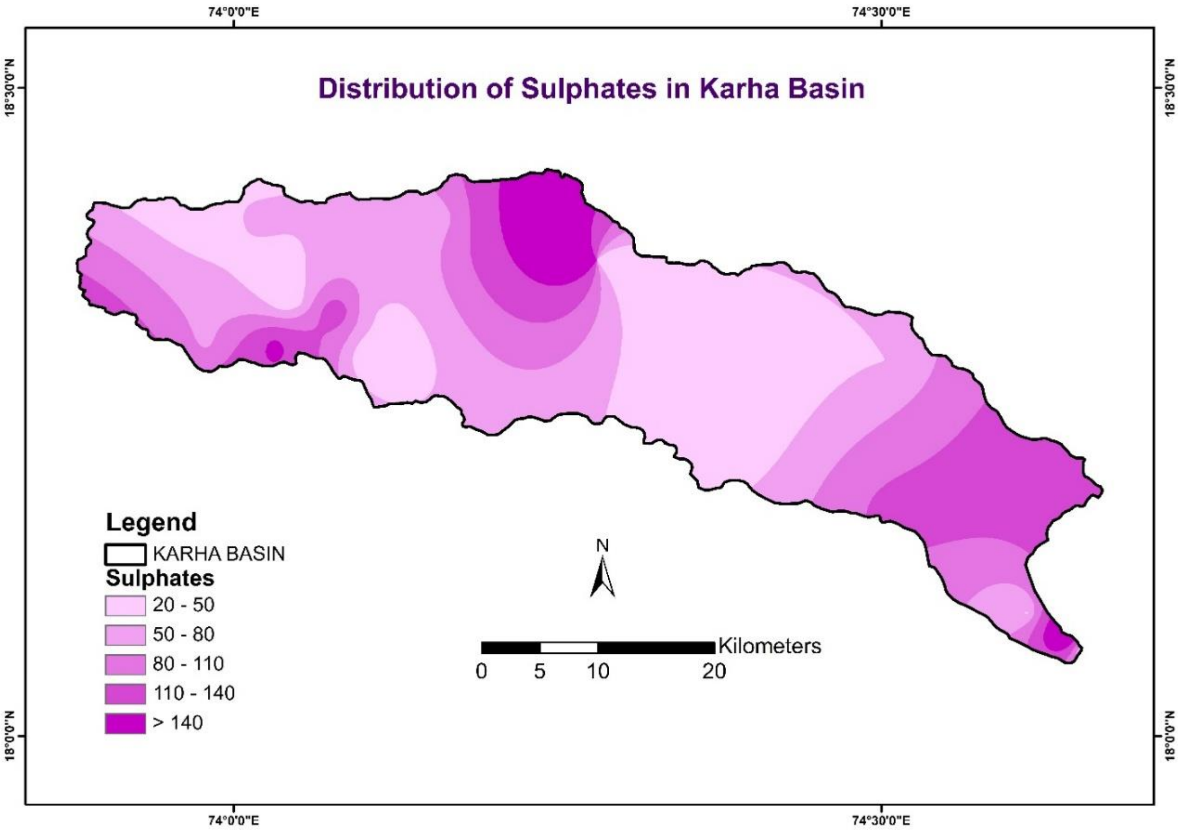
Map No 2.7: Distribution of pH

2.7.9 POTASSIUM

Although potassium is nearly as abundant as sodium in igneous rocks, its concentration in ground water is comparatively very less as compared to sodium nearly one-tenth or one-hundred that of sodium (Pradhan Biswajit and et, al.2011). This is due to the fact that the potassium minerals are resistant to decomposition by weathering. The potassium concentration in the water was deter-mined with the help of Flame photometer. The concentration of Potassium in study area in post monsoon varies from 0.40 to 3.20 and average is 1.46.

2.7.10 Sulphate (SO_4^{2-}) mg/L

Sulphate occurs in water as the inorganic sulphate salts as well as dissolved gas (H_2S). Sulphate is not a noxious substance although high sulphate in water may have a laxative effect. The concentration of sulphate (SO_4^{2-}) in study area is between 24.00 to 68.00 with the average value of 42.40011mg/L in post-monsoon season. The highest permissible limit of SO_4 is 300 all the values are below this limit. The high concentration of sulphate in the other settlements is likely due to the dissolution of gypsum.



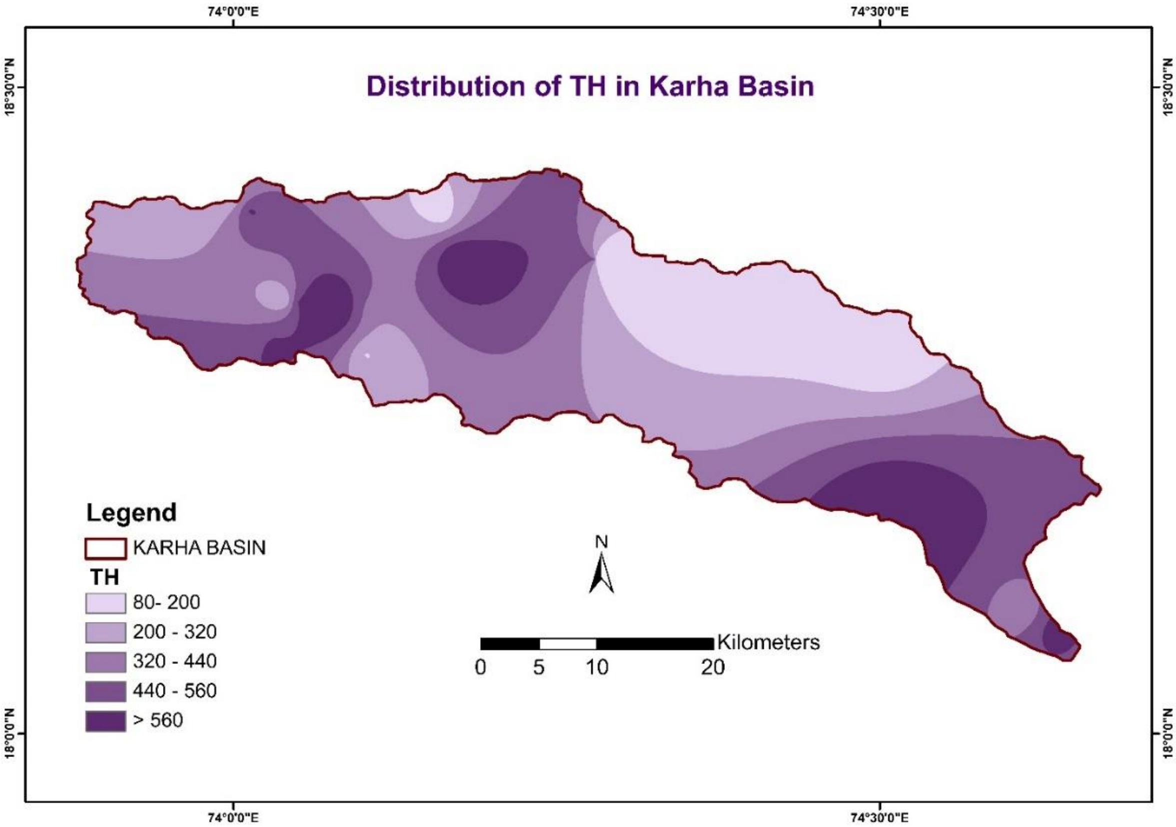
Map No 2.8: Distribution of Sulphates

2.7.11 NITRATE (NO3):

Sources of nitrate in water include human activity such as application of fertilizer in farming practices, human and animal waste (which relate population). The concentration of NO_3 is ranges from 35.20 to 44.50 and average is 40.53 in post-monsoon season. The possible cause may be the highly populated and the human waste management system is poor (shallow pit toilets and open defecation in thebushes) and the use of nitrogenous fertilizer and animal dung in farming is a likely source of input into the ground water of this chemical (Obiefuna and Sheriff, 2011).

2.7.12 TOTAL HARDNESS (TH)

The total hardness is varying from 82.00 to 600.00 and average is 298.40 in post-monsoon season. Groundwater of the entire study area lies within the maximum permissible limit prescribed by ISI. Sawyer and Mc Carty (1967) classified groundwater, based on TH, as ground water with TH\75, 75–150, 150–300 and [300 mg/l, designated as soft, moderately hard, hard and very hard, respectively. Very few samples in the study area are falling under the category of very hard.



Map No 2.9: Distribution of TH

2.8 ASSESSMENT OF GROUND WATER QUALITY FOR IRRIGATION PURPOSES

Assessment of the groundwater quality of the study area was done to determine its suitability for domestic and agricultural purposes water for each of these purposes is require meeting certain safety standard that have been set by either World Health Organization or agencies (Obiefuna and Sheriff, 2011).

2.8.1 PIPER DIAGRAM

The Piper- tri-linear diagram (1953) is used to infer hydro-geochemical facies. These plots include two triangles, one for plotting cations and the other for plotting anions (figure 2). The cations and anion fields are combined to show a single point in a diamond-shaped field, from which inference is drawn based on hydro-geochemical facies concept. These tri-linear diagrams are useful in bringing out chemical relationships among groundwater samples in more definite terms rather than with other possible plotting methods. Chemical data of representative samples from the study area is presented by plotting them on a Piper-tri-linear diagram for post-monsoon season of study area. These diagrams reveal the analogies, dissimilarities and different types of waters in the study area. The concept of hydro-chemical facies was developed to understand and identify the water composition in different classes. Facies are recognizable parts of different characters belonging to any genetically related system. Hadrochemical facies are distinct zones that possess action and anion concentration categories. To define composition class, Back and co-workers (1965) suggested subdivisions of the tri-linear diagram (figure 2).

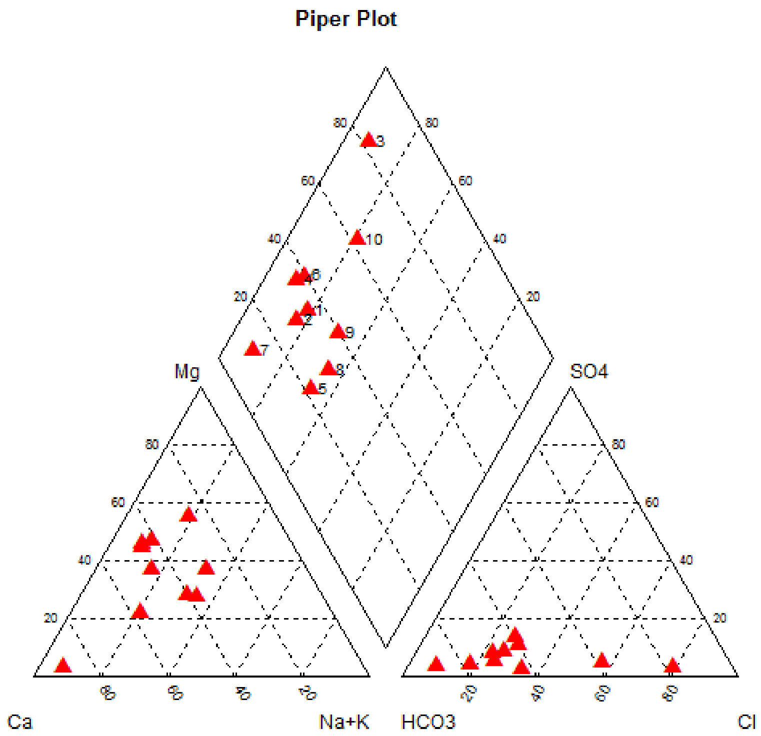


Figure 2.1: Classification diagram for anion and cation facies in the form of major-ion percentages (Piper, 1953; Back and Hanshaw, 1965; Sadashivaiah et al., 2008)

Piper diagrams are an example of water quality diagrams which are probably the most frequently used today. The subdivisions of the trilinear or piper diagram depict that Na-Ca-HCO3, NaCa HCO3, Mg-HCO3, and HCO3 type of water was dominated during post-monsoon in study area (Fig.2.1). The appreciable change in the hydro-chemical facies was noticed during the study period (post-monsoon), which was might be due to the leaching of alkali salts through precipitation (Tomar Vikas et.al 2012). Hydro chemical evaluation of groundwater indicates that Na-Ca-HCO3 type water dominates during pre-monsoon and Mg-HCO3 during post monsoon seasons of the year and $NaHCO_3$ waters shows high sodacity with high soluble sodium percentage and residual sodium carbonate.

2.8.2 SALINITY HAZARD AND ALKALI HAZARD

Based on EC values, Richards classified total concentration of soluble salts in irrigation water into four groups. High-salinity problems are encountered where irrigation activity is in poor drainage agricultural soils and where water logging allows the water table to rise close to the root zone of plants, causing accumulation of sodium salts in the soil solution through capillary rise following surface evaporation. The sodium or alkali hazard in the use of water for irrigation is determined by the absolute and relative concentration of cations. The relative activity of sodium ion in the exchange reaction with soil is expressed in terms of SAR. If high sodium content and low calcium content are present in waters used for irrigation purpose, the base-exchange complex may become saturated with sodium. This can destroy the soil structure due to the de-flocculation (dispersion of clay particles) process. The U.S. salinity Laboratory's Diagram uses electrical conductivity, and SAR classifies groundwater. The groundwater quality of study area according to U.S. Salinity Diagram is classified into four classes (Table 2.2). This classification is mainly based on the concentration electrical conductance ranging from excellent to unsuitable. Only 10% of the groundwater samples are falling in unsuitable field (Table 2.2)

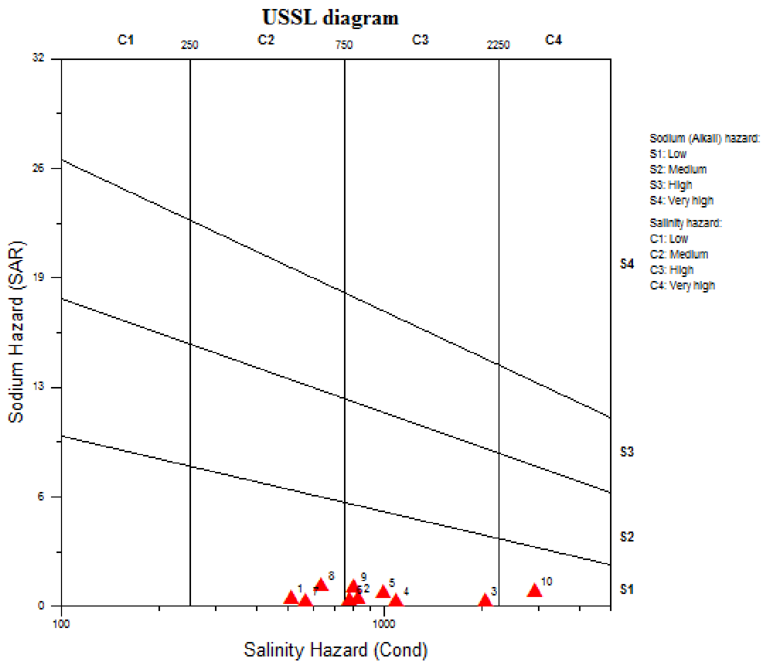


Figure 2.2 U.S. Salinity Diagram

Table. 2.3 Classification of Groundwater on U.S. Salinity

Salinity hazard class	EC in (micromohs/cm)	Remark on quality	Percentage of Samples
C_1	100-250	Excellent	Nil
C_2	250-750	Good	30
C_3	750-2,250	Doubtful	60
C4 & C5	>2,250	Unsuitable	10

(Source - U.S. salinity Laboratory)

CHAPTER III

GROUNDWATER POTENTIAL

3.1 INTRODUCTION

Groundwater is the fully saturated sub-surface water mainly received from atmospheric precipitation deposited in water bearing sedimentary rocks, cracks and crevices in crystalline rocks and subsequent penetration and cooling joints. When rain falls, some of the water runs off, some evaporates and the remainder soaks into the ground. Therefore, the water soaks into the ground is the primary source of groundwater. Water below the ground surface occurs in four zones viz; soil moisture zone, intermediate zone, capillary zone and saturation zone. The zone in which this water is held is known as the zone of aeration or unsaturated zone, which is characterized by partially water filled and partially air-filled voids and pores. At the base of the intermediate zone, is the capillary fringe a thin layer (ranging from few cm to 3m) in which water has been drawn upward by capillary force. Below the zone of aeration, lies the zone of saturation. This is also known as phreatic zone or groundwater zone or water table. There is a vadose zone, lies in between the top soil water zone and lower capillary zone, in which water percolates down to the water table.

The present chapter incorporates the principle source of ground water. Beside the prime sources, factors determining the occurrence of groundwater sources also discussed here. The occurrence of groundwater mainly depends upon climatic conditions, soil characteristics, vegetation cover, land use and lithology of rock in the area. Though the precipitation is prime source of groundwater recharge, out of total precipitation received, major part is lost through evapotranspiration, from soil and plants. Some part flows as runoff and only small amount of rainwater infiltrates through the soil to underlying strata or aquifers (Babar 2005).

3.2 SOURCES OF GROUNDWATER

Groundwater includes all sub-surface water in a solid liquid or gaseous state other than that which is chemically combined with any mineral present (Siddharth K, 2000).

There are four sources a ground water.

I. Connate water
II. Juvenile water

III. Meteoric water
IV. Condensational water

(I) Connate water: - Connate water is the water trapped in the interstices of sedimentary rocks at the time of their depositions. It is usually highly mineralized and is not involved in active groundwater circulation, although connate waters may be expelled from their original location by compaction pressure and migrate, accumulating in more permeable formations.

(II) Juvenile water : The water that originates from the interior of the earth from condensation of steam of uncertain origin and has not previously existed as water in any state. Juvenile water is that water which is considered to have been generated in the interior of the earth and have reached the upper level of the earth surface for the first time. It is also called magmatic water. The term was coined by Meinzer (1923) who contrasted juvenile with meteoric water.

(III) Meteoric water : Meteoric water is derived by precipitation in any form from the atmosphere. It falls as precipitation and became groundwater by infiltration. Meteoric water constitutes the bulk of groundwater and this is evident in the fluctuation of water level in winter and summer seasons. The term originally defined by (Meinzer 1923 and K. Siddhartha 2000) in contrast to Juvenile water.

(IV) Condensational water : In the deserts of arid or semi arid regions, particularly in summer the land is always warmer than air in the soil. In such situation, the water is the results in a difference of pressure between the water vapor in the atmosphere and the water vapor in the soil. The water vapor from the atmosphere penetrates into the rocks and is converted into water as the temperature of the water vapor drops below. This water is the basic source of replenishment in arid and semi-arid areas.

3.3 FACTORS DETERMINING THE OCCURRENCE OF GROUNDWATER SOURCES

The occurrence of ground water sources in any region are not evenly distributed but controlled or determined by various factors. Its occurrence is determined by climate (occurs at greater depths in deserts and shallow depths in humid regions) and topography (higher at high altitude and lower near the valley flats/ water sources). Type of materials i.e. underground rock structures determining porosity and permeability that plays important role in water infiltrations.

3.3.1 Topography : The Karha river basin is confined by high hill ranges comprising of Deccan Trap Basaltic lava flows. The height of the all hill ranges varies from 1000 to 1250 m comprising 15%of the basin area. Piedmont/rolling topography with average height of 700 to 1000 m comprising 25% of the basin area. Valley plains below 700 m comprises 60% basin area. These three zones categorized namely. Runoff zone, recharge zone and storage zone are the topographic expressions.

3.3.2 Type of material / Underground rock structure : Karha river basins covers hard and massive basalt. Laterite is developed as capping on basaltic flow and occurs at various altitudes, mainly it founds near Narayanpur and Garade. Average depth of sammital sediment/kaolinitic clay deposits varies between 2 to 5 m. Porosity (texture) and permeability are two most important properties, which determines the storage and movement of groundwater. Porosity (Texture) and permeability of the soils in the Karha Basin are comparatively permeable however water-holding capacity is medium. Still it bears an aquiclude properties. Weathered basaltic terrain bears water, which is percolated through the faults joints and weaker zones and carried by same type of zones. Water percolated and seeped through these faults and weaker zones. Veins like calcite and other vesicles have good storage capacity.

3.4 PRIME GROUNDWATER SOURCES IN THE BASIN

Groundwater refers to water in a zone of Saturation consists of geologic stratum usually referred as aquifer. Aquifer is a self-defining term as it split into aqua + fer, where aqua means water and fer refers to bearing. Groundwater hydrology is defined as the science of the occurrence, distribution and movement of water below the surface of the earth. Geohydrology has an identical connotation, and hydrogeology plays an important role in determining the water bearing, storing and transmitting capacity of rocks. Three major geological features - (a) lithology (b) geomorphology and (c) structure, controls the flow and occurrence of the groundwater in nature. Rainfall is a prime source to recharge to the groundwater. Rainfall, aquifer characteristics and infiltration in the Karha Basin have been discussed below, which contributes as a main source of groundwater.

3.4.1 Infiltration: - Infiltration is the vertical movement of water through the soil surface into the soil. Under specified conditions, the actual rate at which the water is absorbed by soil is known as infiltration rate and the maximum rate at which the water can penetrate the soil under a given set of conditions is defined as the infiltration capacity (Horton, 1933). The rate of infiltration is determined by the soils initial moisture content, surface permeability, physical and chemical characteristics, temperature, duration and intensity of rainfall. Infiltration occurs mainly by diffusion, suction and gravitation. Rainwater infiltrates into land surface both vertically as well as horizontally. The horizontal movement is due to transmission of moisture by soil matrix. A portion of the infiltrated rainwater finally reaches the groundwater storage or aquifer which develops the quantity and quality of groundwater. In Karha Basin hilly area i.e. moderate to steep slope (upto 30^0) are characterized by coarser soil texture. Hence in the hilly region, with dense vegetation cover and high rainfall (1200 mm) zone of the Karha Basin shows high rate of infiltration capacity. Soil profile on the gentle slope (0^0 to 2^0) topography shows soil with loamy texture indicates low infiltration capacity. In the Karha Basin silt and clay content of the soil increases with decreasing gradient of the ground.

3.4.2 Other Sources: - Surface water is a common term usually describing any water body of running or standing on the surface in the form of streams, rivers, lakes, ponds and reservoirs. Surplus precipitation that escapes evapo-transpiration or infiltration, become surface runoff and directly contributes to the streamflow. The rainwater may either in the form of overland and seep from the soil may reach the river as subsurface throughflow.

3.5 OPEN WELL INVENTORY

Well inventory data in any region helps to understand the relationship between physiographic and movement of groundwater in that particular region. In order to understand the groundwater regime of the Karha Basin, well inventory of open wells has been worked out. Well inventory data also provides useful information about lithologs, characteristics of aquifers, depth of wells, water table fluctuations etc.

3.5.1 Open well lithologs: - The details of the well lithologs for 30 wells in the Karha Basin have been accurately observed. These observed (field survey) litholog units were also compared with the litholog constructed by GSDA, Pune. The variation in the thickness of the lithological units with their material composition was also considered during the well inventory. From this data detail open well lithologs of 30 wells were prepared. Depending upon the well location, two or more lithological units recorded to get further information. Wells situated in or along the channel or foothill zones shows alluvium, colluvium, gravel and sand, jointed basalt with massive basalt at the base. Study of lithologs indicates that some of the sections can independently act as an aquifer for that well.

3.6 POTENTIAL

Study of groundwater potential requires proper understanding of its origin, occurrence and movement, which are directly or indirectly controlled by landform characteristics. There is need of study of Groundwater potentials because of its importance. There has been increasing awareness among the geographer, geomorphologist, geologists, planners and water resources scientist, to study the potentiality, availability, development of management of groundwater resources in the last four decades.

Groundwater generally escapes direct observation, except where it emerges in spring or is tapped by wells, bore wells. There is no direct method (way/approach) for the evaluation of groundwater. In geomorphological context, landforms may give clue to subsurface water conditions. Various landforms of structural, denudational and depositional origin, play an important role in the groundwater potentials. On the basis of landforms and their characteristics identified in the Karha Basin, the groundwater potential zones can be classified as High, Moderate, Medium and Low zone, Very low zone and no groundwater zone. In the present chapter occurrence of groundwater and relationship between landforms and groundwater potentials have been discusse. As the main aim of the present investigation is Assessment of groundwater potentials, landforms present in the Karha Basin and their groundwater potentiality has been described in detail in this chapter. The last section attempts different maps showing various groundwater potential zones, on the basis of landform assemblage and their groundwater potentiality.

3.7 GROUNDWATER OCCURRENCE

The Karha Basin is underlained by basaltic rock. The storage capacity and transmissivity are the two cardinal parameters as regard groundwater bearing properties of the Deccan Traps. In Deccan Trap country, the primary porosity is due to the presence of interconnected vesicles, which is not filled with secondary minerals where the secondary porosity depends on due to weathering, and formation of joints and fractures in the rock. The groundwater potentiality depends on the extent of interconnection within the different sets of fractures, joints and weak planes and in case of vesicular basaltic unit's groundwater potentiality increases rapidly when the vesicles are interconnected.

The occurrence of groundwater aquifer zones (within 15.5 m BGL) have been studied in detail by inventorying a total of 30 open wells. The total depth of open wells ranges from 3.3m to 15.1m BGL with an average of 8.01m BGL. The well diameter ranges from 2.3m to 12.2m with an average of 7.27m. Water table fluctuation ranges from 3.3m to 15.1m BGL in post monsoon.

3.8 GEOMORPHOLOGY AND GROUNDWATER

Geomorphologists found to have very close links with both surface and subsurface water conditions. Geomorphological features of a terrain control the distribution of precipitation and amount of precipitation that contributes to the runoff and groundwater recharge. A specific asset of geomorphology is that it aids to describe and evaluate the environment in which the water circulates, thus providing hydrologists working in areas where essential data are lacking with information enabling him to understand the situation and to make the proper decisions. Schumm (1964) emphasized this role of geomorphology and mentioned that a general relationship exists between hydrological and geomorphological variables. Infiltration, moisture content of soil, angle of slope and relief are the important geomorphological factors determine the groundwater (subsurface water) flow. For the infiltration, fracture and permeability of rock, soil cover, steepness of the slope and vegetative cover effectively works together. Thus infiltration estimation or measurements plays an important role in the study of groundwater condition. Soil characteristics its structure, organic matter, moisture content, $_{p}$H are important. Infiltration in dry soil is maximum and in moist soil it is minimum. The degree to slope also plays an important role in the infiltration. Slopes with convex elements in plan tend to spread the overland flow and thus favour infiltration, whereas concave slopes in plan promote concentration of flow and linear runoff.

The geomorphological situation can also give clue to the hydro-geomorphologists in the other environment e.g. springs may occur in the areas where a capping of resistant and pervious rocks (such as limestone beds and ferricretes). Comparatively shallow groundwater may occur where alluvial and/or colluvial deposits cover the bedrock. Generally speaking, one can justify that geomorphology contributes to the location of recharge or intake areas of groundwater and the prediction of recharge of various groundwater zones (Knisel, 1972, cf. Verstappen, 1983). On the basis of geomorphological study the features such as dykes and faults observed in the particular region become barrier for the horizontal movement of groundwater. Drainage density also has a bearing on the permeability of the rocks, the amount of geological control on the drainage pattern and the integration and homogeneity of the patterns (Schumm, 1964). The assessment of the groundwater recharge potential is facilitated by a study of the texture and permeability of the superficial materials and deposits in the riverbed.

3.9 LANDFORMS AND GROUNDWATER POTENTIAL

Considering the role of geomorphology in groundwater potentials discussed earlier, study of groundwater potential requires proper understanding of its origin, occurrence and movement, which are directly or indirectly influenced by the landform characteristics. Various landforms specially structural, denudational and depositional landforms play vital role in the groundwater potentials. Some of the important fluvial landforms, their characteristics and groundwater potential in the Karha Basin are discussed below.

3.9.1 STRUCTURAL LANDFORMS

The landforms which owes its existence to a resistant rock layer. Many features are formed due to the tectonic readjustments that take place within the crust of the earth (Nath et al., 2000). The tectonic readjustment plays an important role in the formation and evolution of landscape and landforms. The most important features of this category found in the study area are structural hills and lineaments.

3.9.1.1 Structural Hills (SHL) are massive linear or arcuate hills exhibiting definite trend lines dominated by hard unweathered basalt rock (Vittala, et al., 2005). These hills are structurally controlled with complex folding faulting criss-crossed by number of joints and fractures, which facilitates infiltration and acts as runoff zone. In the Karha Basin, structural hills are observed prominently in the peripheral area (divide) of basin.

Structural hills found in the Karha Basin are devoid of water bearing aquifers however gloomy aquifer available due to highly jointed and fractured basalt with thin soil cover at the hill top and on the slopes. Generally, the groundwater potential is very poor in structural hills owing to their poor permeability where surface runoff is greater.

3.9.1.2 Lineaments (LNMT)

A lineament is defined as a large-scale linear fracture, which express itself in terms of topography, which in itself, an expression of the underlying structural features. In simple words lineaments are linear fractures commonly associated with dislocation and deformation.

Lineaments are important in the rocks where secondary permeability and porosity dominate and inter-granular characteristics combine in secondary openings influencing weathering, soil water and groundwater movements. Lineaments provide the pathways for groundwater movement and are hydro-geologically very important (Sankar et.al 1996). The lineament intersection areas are considered as groundwater potential zones. Lineaments joints, fractures etc. developing generally due to tectonic stress and tension, provide important clue on surface features and are responsible for infiltration surface runoff into subsurface and also for development and storage of groundwater (Subba Rao et. al 2001)

Lineaments (LNMT) have been observed in the Karha Basin, in the southeastern and northern part. Two most prominent lineaments having NE-SW trend are running between the village saswad, Morgaon, and baramati. These lineament are running almost parallel to main stream of Karha River. These lineaments had given an advantage of groundwater convergence from western and eastern part of the basin.

The lineament observed as the manifestation of straight stream course near Jejuri region. Along this lineament, high moisture zone and dense vegetation is noted during field check.

3.9.1.3 Dyke (DYK) A sheet like intrusion of igneous rock, usually oriented vertically which cut across the structural planes. The wall or trough formed by differential weathering of such an intrusion when exposed as the land surface. Dykes have moderate to good groundwater potentials. During field work set of two dykes approximately trend in NE-SW, discontinuously observed from Saswad to Karkhel.

3.9.1.4 Messa/Butt (MSBT)s These are the erosional features, which are structurally controlled made up essentially of horizontally layered rocks, having a cap of hard and resistant rock that has escaped erosion. These features with steep sided slope at the top has poor groundwater potential Forts presents in and along the Karha Basin i.e. Purandar represented by Messa and Butts.

3.9.1.5 Denudational Hills (DNHL) These hills are marked by sharp to blunt crestline's with rugged tops indicating that the surface runoff at the upper reaches of the hill has caused rill erosion. Groundwater potential is moderate to poor in this region. These hills are observed near, Garade, Songaon, Kapurhol, Jejuri, Morgaon region of Karha Basin.

3.10.1 Denudational Landforms

The surface of the earth is constantly being acted upon by different kinds of exogenetic forces like wind, water and ice. These forces tend to bring physical and chemical weathering of bed rock and also transport and deposit the weathered debris in certain locations on the earth (Nath et al., 2000). This complete phenomenon is referred to as a denudational process and this gives rise to many denudational landforms such as pediment, pedeplain, insulbergs, tors etc.

among these, pediment and pedeplain observed in the study area are discussed with reference to their groundwater potentiality. Surface geometry, the chemical constituents of rocks, tectonic setting and climate are the main factors determine the denudational processes.

3.10.1.1 Pediment (PDMT) is a gently sloping landform with erosional bedrock situated between hills and plains consisting of veneer of detritus and undulating rock floor (Gopinath and Seralathan, 2004). The groundwater condition in pediment zone is expected to vary depending upon the type of underlying folds, fractures and the degree of weathering. Generally pediments do not favour much infiltration and therefore, these areas are not favorable for groundwater explorations. In the present Karha Basin, Pediment is observed along the down slopes of structural hills and foothill zones. Foothill zone found all along the periphery of the Karha and its tributaries. From the groundwater point of view this unit falls in poor to moderate groundwater potential zone. In this zone most of irrigation depends on dug wells.

3.10.1.2 Pedeplain (PDPL) This geomorphic unit is developed as a result of continuous process of pediplaination. Pedeplain are found to be good for groundwater potentiality. Groundwater exploration can be done mainly through dug wells. Pedeplain is the gently

Sloping undulating plain of large areal extent. These are formed as a result of continuous process of pedimentation with intensive weathering under semiarid climatic conditions (Spark, 1960).

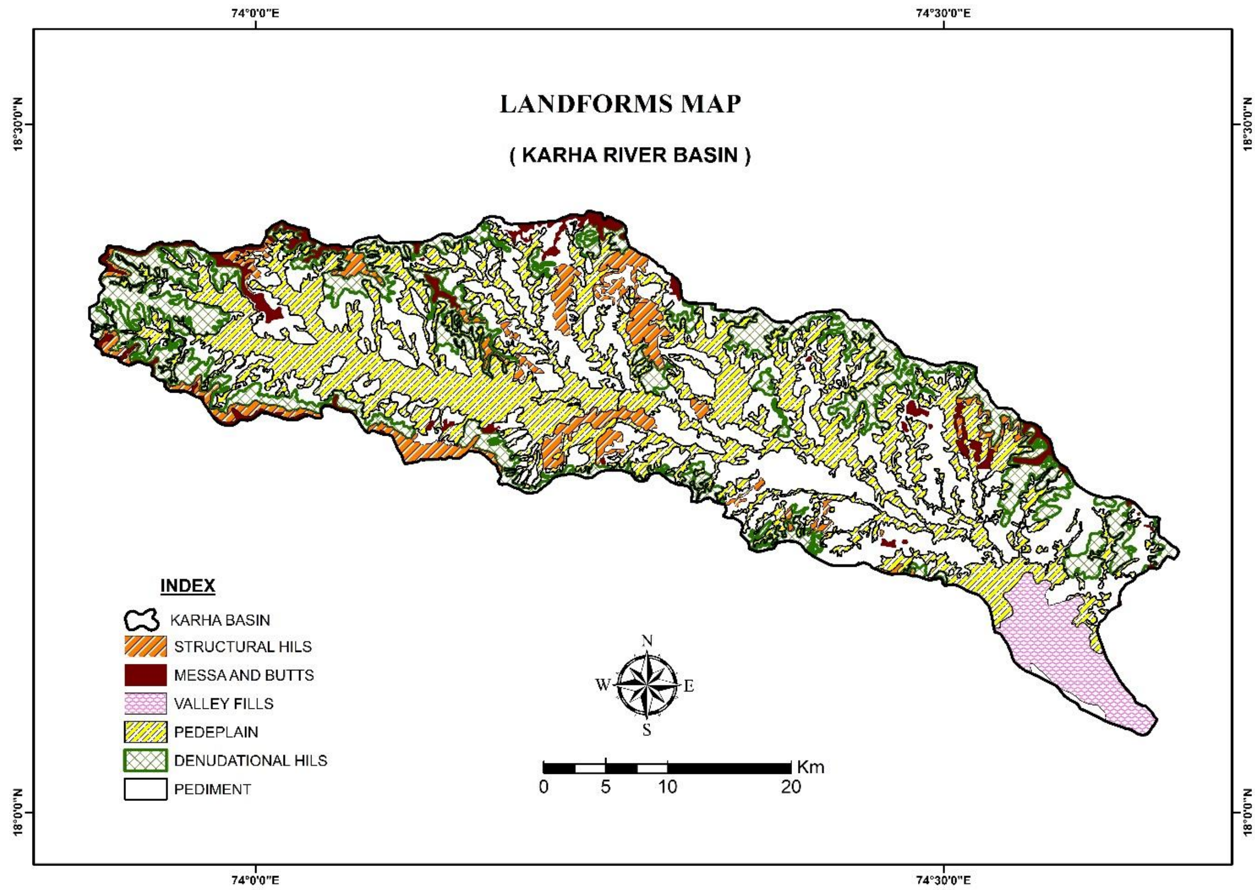
Pedeplain, are located between pediment and alluvial plains in the Karha Basin. And another part of the basin, they are observed between pediments and valley fills. Pedeplain have fairly weathered thick mantle underlain by weathered and fractured basalt locally known as murum, indicates high porosity and permeability. In the Karha Basin pedeplain unit has an average elevation of 550 to 750m ASL. Pedeplain have moderate to good groundwater potential.

3.11.1 Depositional Landforms (Fluvial)

These types of landforms occur in old stage of river, where the lack of erosion and transportation work. Fragments of soil, regolilth, and bed rock that are removed from the parent rock mass transported by fluvial agent and deposited elsewhere to make an entirely different set of surface features–the depositional landforms. Alluvial plain, valley fills are two hydrogeomorphic units that have come in to existence due to fluvial depositional processes in the Karha Basin. These features occupy the valley part and are composed of loose deposits of permeable material like sand, silt, clay. Near about approximately 30% of the basin occupied by these landforms.

3.11.1.1 Alluvial Plain (APLN) Alluvial plains are level to gently sloping plains with undulating topography composed of unconsolidated sediments or partly consolidated sediments such as sand, slit and clay (Nagarale et al., 2007). These fluvial depositional plains are developed on either sides of the river and their tributaries. From the river banks it extends from few hundred meters to 1-2 km laterally. It is highly permeable zone helping in partial bank recharge and subsurface flow. Groundwater in alluvial plain occurs under semi confined to perched water table conditions with shallow water levels. Groundwater prospects in alluvial plain is invariably found to be good and it is a promising zone for the same through which groundwater has been tapped by digging numerous wells and tube wells, giving high yield of water.

3.11.1.2 Valley Fills (VF) The unconsolidated materials partly filling the river valley are termed valley fills, which are formed by depositional processes at the youthful stage of river. Valley fills consisting of loose sediment deposits of boulders, cobbles, pebbles, gravel, sand and silt brought in by the stream. They show a high range of grain size and less compaction, which gives high permeability resulting high infiltration. They are confined to narrow linear depressions. Lithologically valley fills comprises weathered and erosional products of surrounding rock consists of cobbles, pebbles, sand, silt, clay and gravels (Magar et al., 2007). Valley fills are observed in the Karha Basin along Baramati and Dorlevadi region This hydrogeomorphic unit is characterized by high porosity and high permeability resulting in high infiltration rate. Most of the wells have been dugged in this zone to get the high yield of water. Groundwater potential in this zone is fairly good. In the Karha Basin valley fills zone is mostly occupied by cultivation. Owing to large amount of recharge from both valley side slopes, they are most favorable groundwater zones.



Map No 3.1: Landforms along Karha River Basin

Table 3.1: Landform Units in the Karha Basin

Landforms	Geomorphic Unit for Groundwater Prospect	Surface Material, Lithology,
Structural Landforms	Structural Hills (SHL)	Thin soil, bare rock surface, sparse grass cover
	Lineaments (LNMT)	Expressed in terms of topography
	Dykes (DYK)	Expressed in terms of topography
	Messa Buttes (MSBT)	Flat gentle slope surface with bare rock, thin soil layer
Denudational Landforms	Denudational Hills (DNHL)	These are marked by rugged tops with sparse grass cover
	Pediment (PDMT)	Medium soil thickness, Veneer of detritus, sparse shrubs & Grass cover
	Pedeplain (PDPL)	Thick soil, fractured and weathered basalt, thick vegetation
Depositional Landforms (Fluvial)	Alluvial Plain (ALPN)	Alluvial soil, Agri. Crops
	Valley Fills (VF)	Alluvial & colluvial deposits, Crop plantation

(Source - Field Investigations and SOI Toposheets)

3.12 GROUNDWATER FLUCTUATION STUDIES

Groundwater fluctuation studies are very much important to understand Potential and availability of the groundwater, sub surface groundwater movement, general characteristics of rocks having high water holding capacity known as aquifer. Water bearing sub surface rock responds to hydraulic stresses due to change in levels of groundwater with reference to seasonal variation. Recharge and discharge are two important parameters responsible for Hydraulic stresses. When groundwater discharge is less than groundwater recharge the then the water bearing rock maintained the gap in storage and therefore there is rise in water table. But when the discharge is more than recharge the situation get reversed and because of this there is fall in groundwater level. To maintain the equilibrium for long time there should be balance in between recharge and discharge. It doesn’t mean that the water holding rock is always in equilibrium. Equilibrium is basically depends on some factors namely type of aquifer and pattern of rainfall during that time span. In the season of monsoon basically storage of groundwater is takes place because recharge is higher than discharge and the reason for that is continuous rainfall in the season of monsoon. Storage is increasing slowly and due to this there is rise in water levels. In non-monsoon seasons the rate of discharge is more than the recharge. So to respond this situation the groundwater levels goes down slowly. If the yearly recharge is approximately equal to yearly discharge then there is no notable change observed in the storage of ground water and hence no big difference observed in water levels. However there is no rain fall then the annual discharge always exceed the annual recharge it results in lowering the groundwater table.

Karha river basin enjoys wet season during whole monsoon and then monsoon season is followed by long dry season, so there is more discharge than that of recharge and it results in over exploitation of groundwater resources along the study area. In study area groundwater is used through bore wells and dug wells for domestic as well as agricultural and industrial purpose. To analyse the groundwater potential through groundwater fluctuation or groundwater level researcher has to be fix the location of observations wells. Total 23 observation wells have been selected to monitor and analyse underneath groundwater potential. All sample observations wells are randomly selected from the field. While making observations Pre-Monsoon, Post-Monsoon and one odd season Groundwater levels from the desire wells have been take in to consideration. Depth to the groundwater from surface is measured in meters along the all observation wells as observed Groundwater level. Total depth and diameter of the well also measured during field work by the researcher.

TABLE 3.2 – INFORMATION RELATED TO GROUND WATER LEVELS

SPATIAL INFORMATION						Jan-14		May-14		Oct-14	
LAT	LONG	ALTITUDE	WELL LOCATION	DIAMETER	TOTAL DEPTH	MEASURED	OBSERVED	MEASURED	OBSERVED	MEASURED	OBSERVED
18 24 15.3	74 00 46.9	826	ZENDEWADI	12.2	13.2	2.5	10.7	5.6	7.6	3.5	9.7
18 19 55.8	74 03 46.2	759	TATHEWADI	11.8	21.2	11.9	9.9	14.2	7	12.2	9
18 19 38.7	74 04 42.9	739	KHALAD	6.9	16.15	13.25	2.9	14.85	1.3	12.75	3.4
18 19 43.2	74 06 17.6	729	KHANAVDI	6.9	16.15	13.25	2.9	14.75	1.4	7.9	8.25
18 21 38.8	74 07 59.4	744	PARGAON	7.02	10.2	8.3	1.9	9.9	0.3	2.7	7.5
18 22 11.1	74 10 22.5	712	BABA WADI	10.5	9.8	4.5	5.3	6.2	3.6	4.5	5.3
18 24 00	74 09 42.4	740	AMBALE	7.09	9.4	8	1.4	9.1	0.3	8.1	1.3
18 24 30	74 14 13.4	727	TEKAWDI	11	14.8	10.25	4.55	6.1	8.7	5.9	8.9
18 22 057	74 16 50.2	705	RAJURI	6.2	8.4	6.2	2.2	6.9	1.5	6.4	2
18 17 17.3	74 30 12.2	597	KARKHEL	8.2	13.4	4.55	8.85	6.45	6.95	4.2	9.2
18 10 32 7	74 33 37.7	599	PARAWADI	7.5	4.4	3.1	1.3	3.3	1.1	2.8	1.6
18 11 53.7	74 37 21	574	WANJARWADI	5.3	7.65	6.6	1.05	7	0.65	3.5	4.15
18 05 41.1	74 36 46.8	532	DORLEWADI	7.5	4.9	3.5	1.4	4	0.9	2.9	2
18 10 18.1	74 30 25.1	573	KARHA WAGHAJ	8.4	13.2	6.3	6.9	8.5	4.7	1.8	11.4
18 13 50.8	74 23 0.67	607	LONI BHAPKAR	4.4	6.39	2.27	4.12	3.8	2.59	1.1	5.29
18 16 31.5	74 17 20.2	639	MORGAON	8	15.95	13.7	2.25	15.1	0.85	8.2	7.75
18 17 13.7	74 08 03.1	737	SAKIRDE	7	5.8	3.5	2.3	4.7	1.1	3.7	2.1
18 18 0.75	74 01 53.3	821	PIMPLE	10.7	11.4	10.45	0.95	DRY WELL	DRY WELL	2.4	9
18 18 08	73 58 42.3	857	NARAYANPUR	8.5	12	10.1	1.9	DRY WELL	DRY WELL	3.7	8.3
18 20 18.7	73 58 43.3	807	KODIT BK	6.5	10.3	4.9	5.4	8.25	2.05	3.1	7.2
18 20 56.5	73 55 49.1	871	GARADE	6.1	15	11.8	3.2	13.28	1.72	4.8	10.2
18 23 26	73 55 47.2	895	BHIVRI	8.5	9.4	5	4.4	8	1.4	0.9	8.5
18 22 16.5	73 58 22.1	841	CHAMBHALI	2.3	17.4	10.9	6.5	14.35	3.05	10.6	6.8

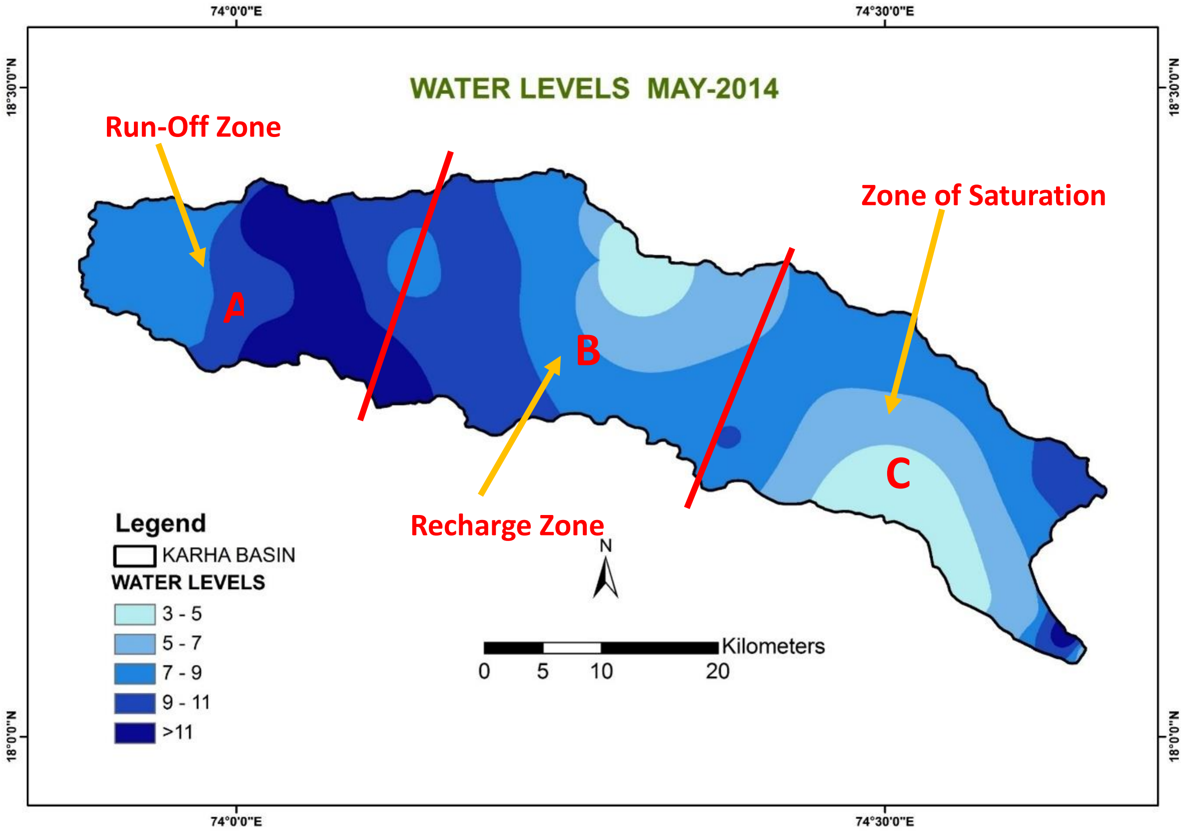
3.12.1 PRE-MONSOON

In the pre monsoon season ground water levels have been measured in the month of May, 2014. For carrying out present study 23 wells has been demarcated as observation wells. Out of 23 wells 6 wells have less than 5 m gbl (Meters below ground level), 10 wells have below than 10 m gbl and remaining 7 wells ware have greater than 10 m gbl ground water level. The average groundwater level during pre-monsoon season in the study area is about 8.013 m gbl. The runoff area has the highest depth of groundwater level and it is about 14.75. The lowest depth is observed in the zone of saturation and it is about 3.3 m gbl.

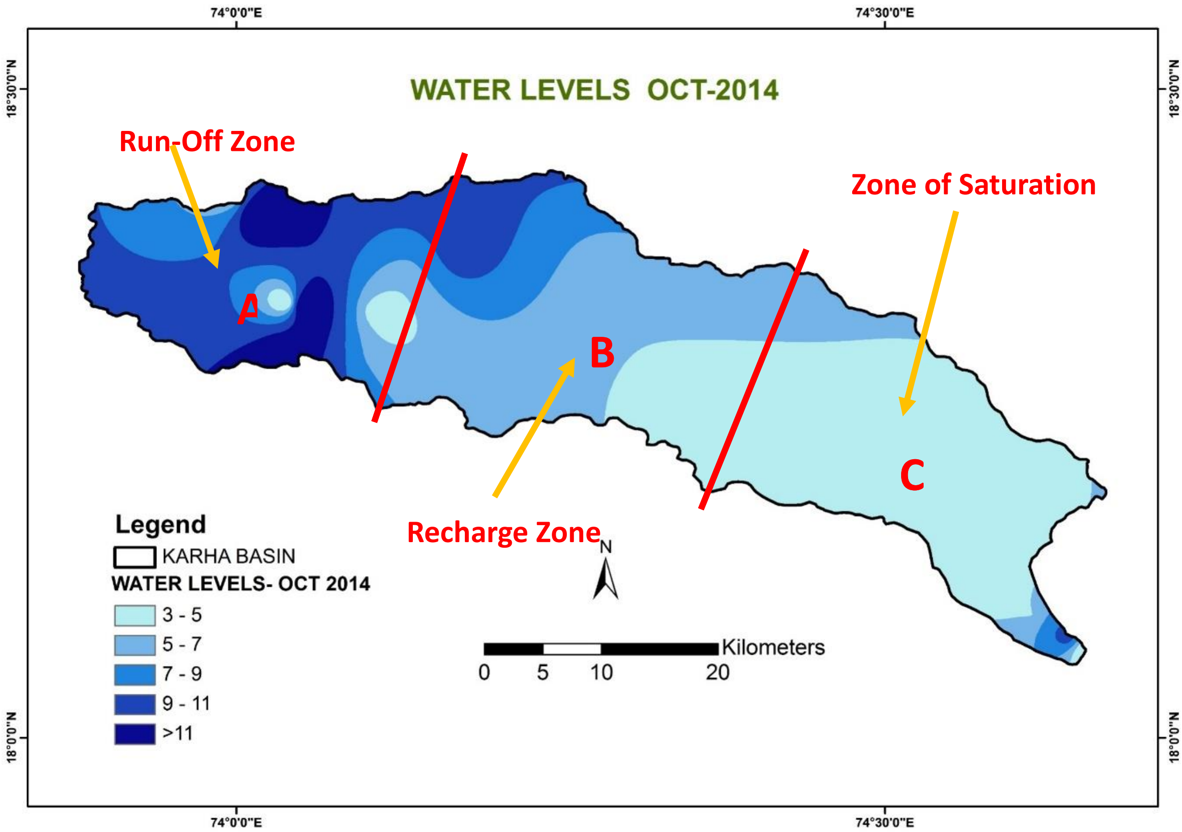
3.12.2 POST-MONSOON

In the post monsoon season ground water levels have been measured in the month of October, 2014. Out of 23 wells 15 wells have less than 5 m gbl (Meters below ground level), 5 wells have below than 10 m gbl and remaining 3 wells ware have greater than 10 m gbl ground water level. The average groundwater level during post monsoon season in the study area is about 5.115 m gbl. It means there is increase in water table during session of monsoon and thats why such huge fluctuation is observed in groundwater levels along the study region. Therefore groundwater fluctuation studies are important to understand Groundwater occurrence below the surface and its potential also

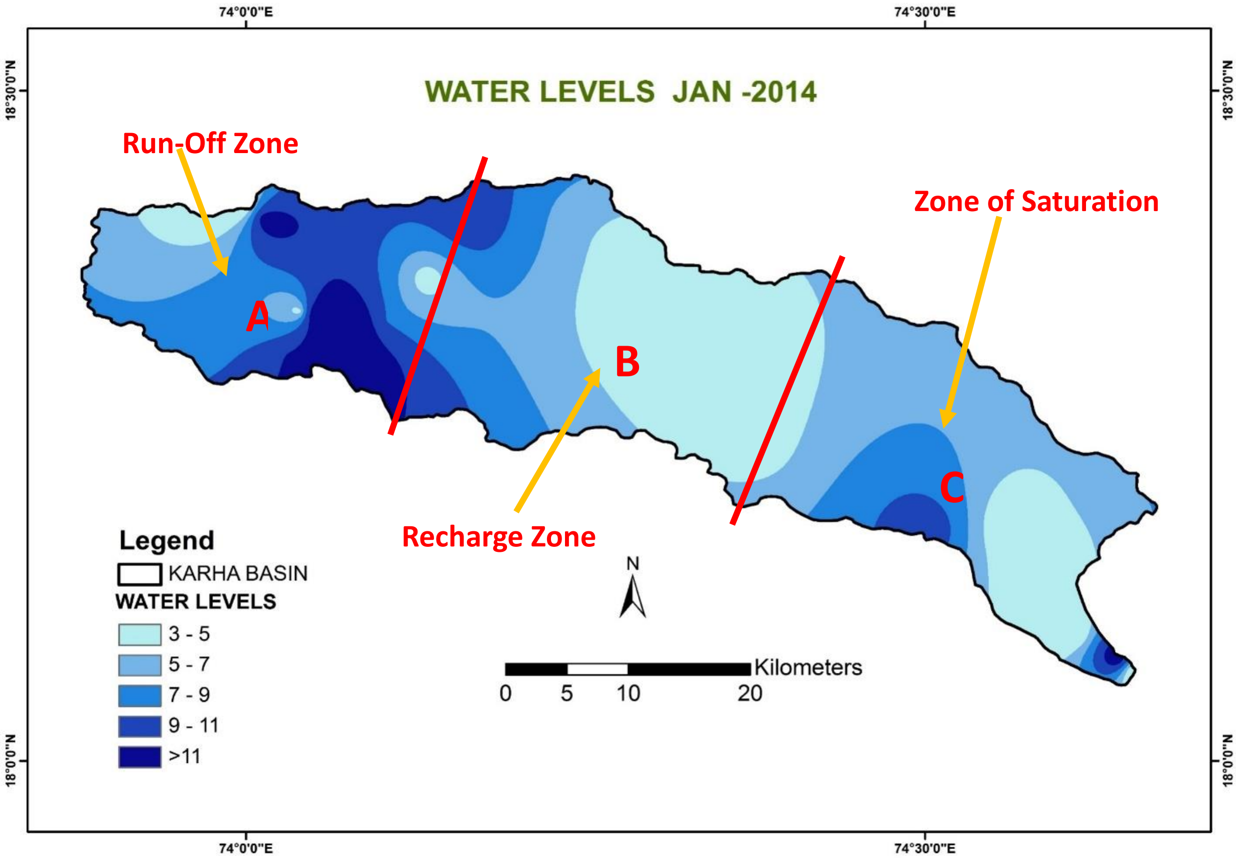
MAP 3.2 PRE - MONSOON GROUNDWATER LEVELS



MAP 3.3 POST – MONSOON GROUNDWATER LEVELS.



MAP 3.4 ODD SEASON OBSERVATION OF GROUNDWATER LEVELS



3.12.3 ODD SEASON OBSERVATIONS OF GROUNDWATER LEVELS

Instead of taking only two readings in terms of pre monsoon and post monsoon season researcher had took odd season observation during pilot field work in the month of January 2014. The odd season ground water levels have been measured in the month of January, 2014. Out of 23 wells 7 wells have less than 5 m gbl (Meters below ground level), 5 wells have below than 10 m gbl and remaining 11 wells ware have greater than 10 m gbl ground water level. The average groundwater level during odd season in the study area is about 6.7 m gbl.

3.13 GROUNDWATER FLUCTUATIONS IN THE STUDY AREA

To study the fluctuation of groundwater in the study region researcher has split study area in three parts like as run off zone recharge zone and saturation zone. It is observed that there is quick storage in the recharge zone during monsoon period. In the Saturation zone the rate of enrichment of groundwater is high and in the run-off zone there is no big change observed, it may be because of this is the origin of the river and the topography is undulating.

From the above study we comes to know that in the run-off zone there is scarcity of ground water for non-monsoonal period and depth to the groundwater during monsoon season is near by 10 m gbl, so the groundwater table is very low in this area. During field work in the non-monsoonal season some observation wells are totally dry, so it gives idea of groundwater scarcity problem in the study region.

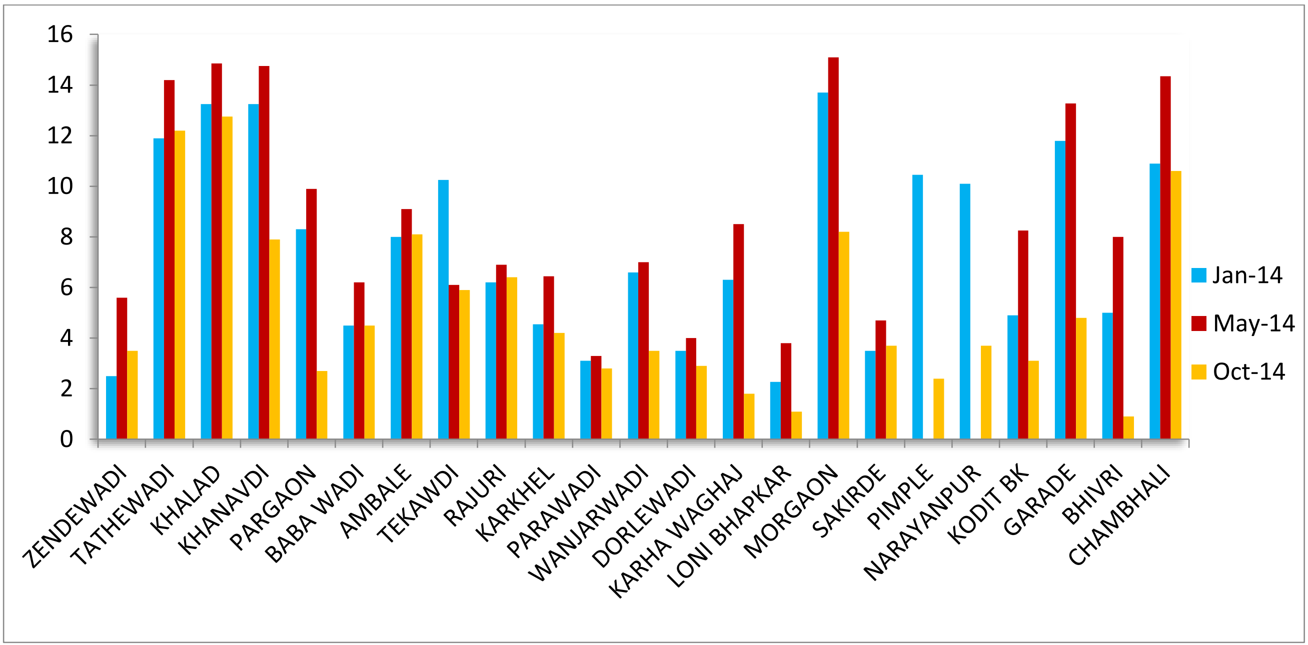


Fig 3.1-Well Depth in Meters on Y axis and Name of villages on X axis.

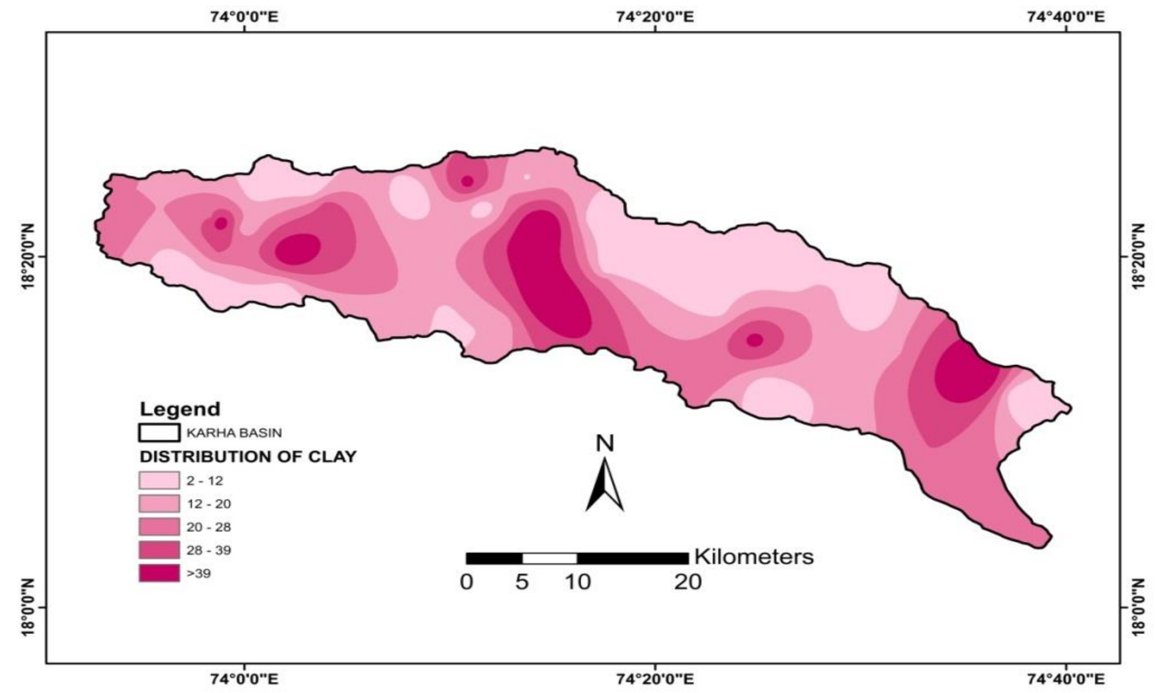
From the above graph it indicates the fluctuation of groundwater during pre-monsoon post monsoon and odd season. It helps to understand groundwater potential, groundwater movement and availability of groundwater. During the month of May groundwater table is very low at the Khalad and Morgaon it is more than 14 m gbl and Parawadi, Dorlewadi has high groundwater table, it is near by 2 m gbl. In the month of October lowest groundwater table is observed at Khalad, Tathewadi and Chambhli. Bhivri and loni Bhapkar have very high groundwater table it is near by 1 m gbl. Additional reading has been taken by the researcher during pilot fieldwork an during this period the lowest water table is observed at Morgaon, Khalad and Tathewadi. Paravdi and Zendewadi are showing the highest watertable during this period. Near bhivri groundwater table is near surface and it lies in run-off zone. Loni bhapkar also have the same situation like Bhivri.

3.14 PHYSICAL CHARACTERISTICS OF SOIL OF KARHA BASIN

The soil is important resource for man. The process of formation of soil is very slow. Soil in its natural state rarely provides the most favorable physical conditions for crop growth. The physical properties of soil texture, structure, density, porosity, water content, consistency, temperature and color- are dominant factors affecting the use of a soil. These properties determine the availability of oxygen in soil, mobility of water into or through soils, and the ease of root penetration. Texture is an important soil characteristic because it affected the water holding capacity and workability of soil. The amount of aeration vital to root growth and will influence soil fertility. Physical properties are some of important soil attributes affected by erosion so again a call is recognize for quantifying the relationship between soil physical conditions and plant growth. In considering soil physical properties which are important in crop production, it is essential to separate factors which directly affect plant growth.

3.14.1 CLAY

Clay is probably the most important type of mineral particle found in a soil. Clay is a fine-grained soil that combines one or more clay minerals with traces of metal oxides and organic matter. Clay is involved in almost every reaction in soils which affects plant growth. Both chemical and physical properties of soils are controlled to a very large degree by properties of clay. Clay is an important reservoir of plant food. Nutrients such as calcium, potassium, magnesium, zinc and iron from a loose chemical bond with the clay particles; the process is called "adsorption" which is very important from the point of soil fertility. This large surface is highly reactive and has the ability to attract and hold positively charged nutrient ions. These nutrients are available to plant roots for nutrition. Clay particles are also somewhat flexible and plastic because of their lattice-like design. This feature allows clay particles to absorb water and other substances into their structure. A clay soil is more likely to be difficult to work, sticky and plastic when wet and prone to drainage problems, but hard when dry. Clay is a fine-grained soil that combines one or more clay minerals with traces of metal oxides and organic matter. Soil texture indicates much about the possible limitations to crop production in a given soil. Soils which are low in clay, such as sands and silts, exhibit a rather narrow range over which physical properties can change and may be unfavorable for plants, being droughty and lacking in fertility. Higher amount of clay content has significant influence on water holding capacity and it reduced nutrient leaching.

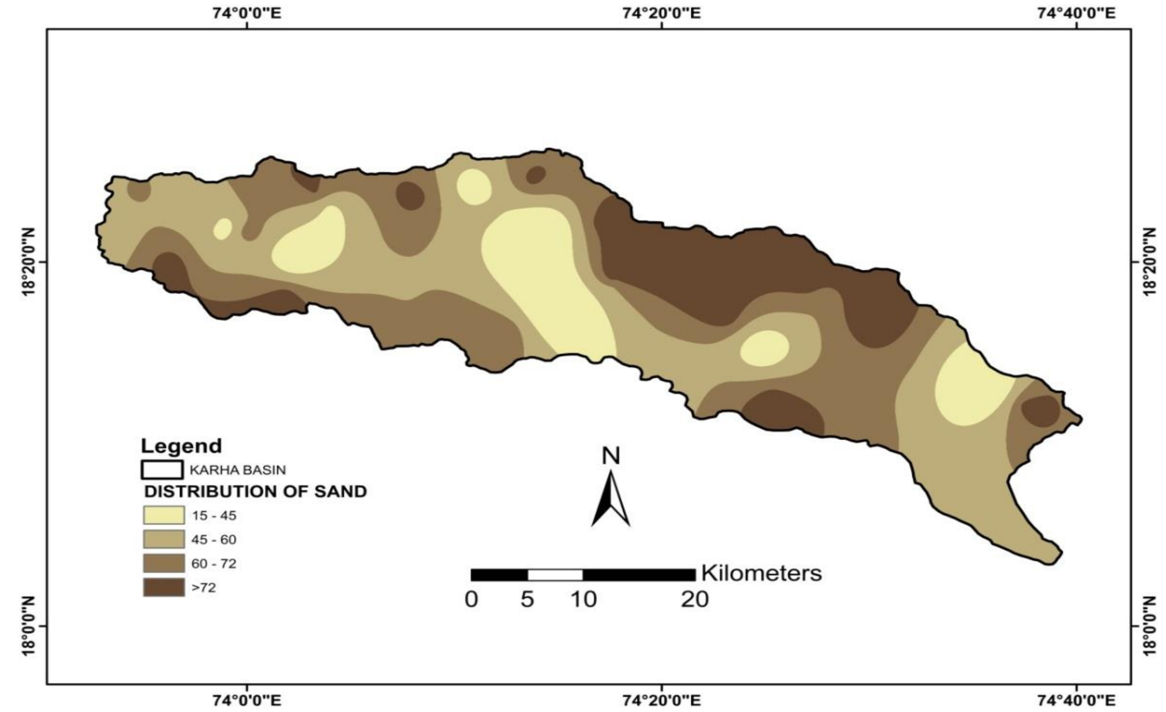


Map No. 3.5: Clay Distribution of Soil in Karha Basin

Map No. 3.5 indicates Clay distribution of soil in Karha Basin. Clay particles have a very large surface area relative to their volume. Middle part of Karha basin shows high concentration of clay soil, also near confluence part of basin having more percentage of clay soil. Nazare Narayanpur, Sawantwadi, Saswad, Mouli Supe, Chambli, Malewadi these village of Karha basin observed Maximum percentage i.e.36 % of clay in soil and less clay observed Amble,Pimple, Supe, babhurdi, Karkhel minimum i.e. 3.4 % in soil. Irrigation facility high clay percentage in soil therefore in Karha basin high agricultural production observed also sugarcane is dominant crop in these area.

3.14.2 SAND

Sand is the 2.0 to 0.05 millimeter fraction and, according to the United States Department of Agriculture (USDA) system, the sand fraction is subdivided into very fine, fine, medium, coarse, and very coarse sand separates. Sand soils are often dry, nutrient deficient and fast-draining. They have little ability to transport water from deeper layers through capillary transport. Therefore, tillage of sandy soils in the spring should be kept to a minimum in order to retain moisture in the seedbed. The nutrient- and water-holding capacity of sand soils can be improved through adding material. Because they drain faster than other soil textures, they are subject to nutrient losses through leaching, and they also warm faster in the spring. Sandy soils tend to have a low pH and very little buffering capacity; hence, are often acidic.

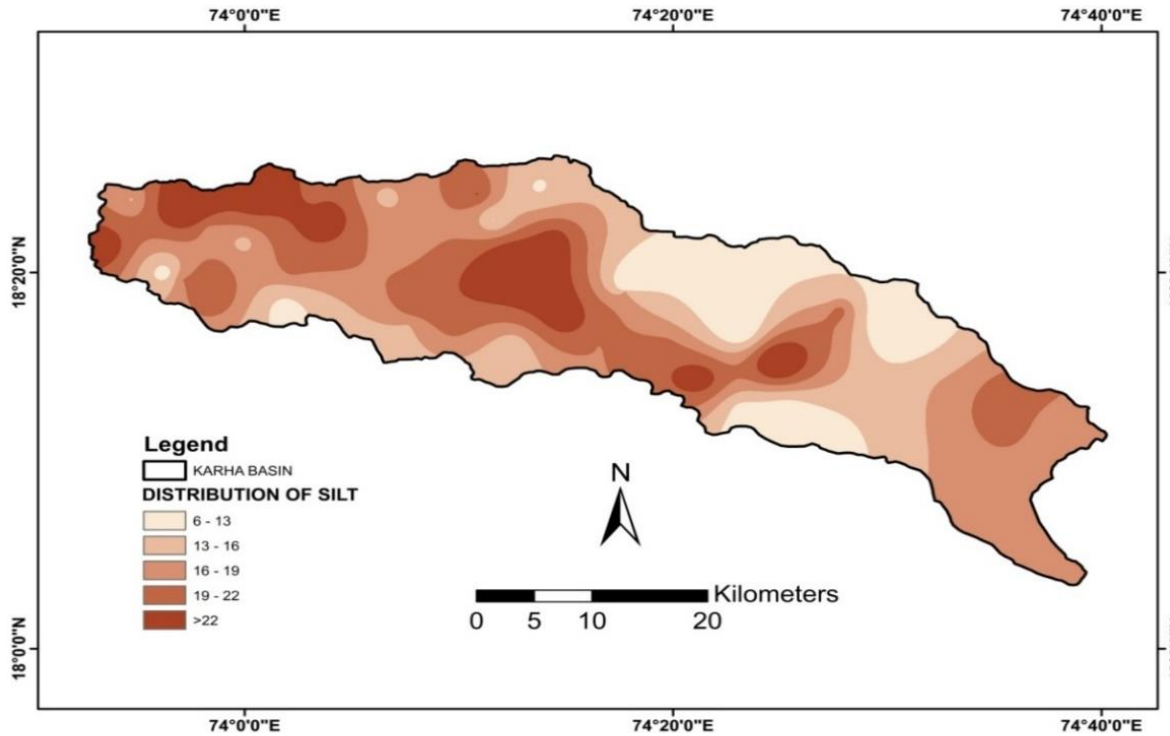


Map No. 3.6 : Sand Distribution of Soil in Karha Basin

Map 3.6 shows the Sand Distribution of soil in Karaha River Basin. In Karha river basin south, west, south east, part of basin show high percentage of sand soil found. Askarwadi, Karkhel, Hiware, babhurdi,Garadi,Somundi,Amble, Hiware in these village area more concentration sand soil Maximum percentage i.e.34% therefore these area less agricultural crop production. Saswad, chambli,Narayanpur,Sawantwadiin these area 3.5% less Sand soil observed.

3.14.3 SILT

Silt is the 0.05 to 0.002 millimeter (2 microns) fraction. At the 0.05 millimeter particle size separation, between sand and silt, it is difficult to distinguish by feeling the individual particles. Silts and clay particles are generally make good agricultural soils. Silt particles are largely made up of resistant residues of rock minerals. Because they are intermediate-size separates, they might be fairly well-drained, but they usually retain more water than sandy soils. Soils with a greater percentage of silt separates have a floury appearance when dry and a smooth feel when moist, and they occasionally form some ribbons when pressed between the fingers. These soils have the tendency to compact easily when moist and form crusts when wet.

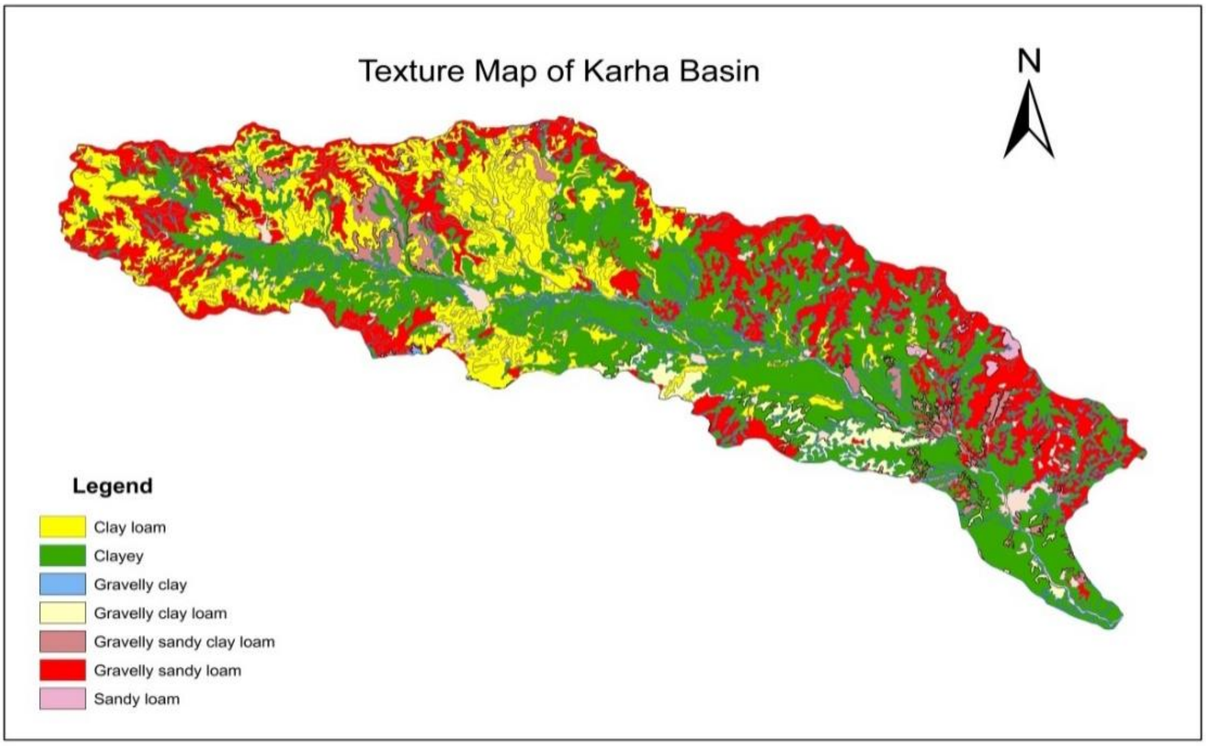


Map No. 3.7: Silt Distribution of Soil in Karha Basin

Map No.3.7 indicates Silt distribution of Karha Basin. In Karha river basin north, north west ,south, south west, east, south west part of basin show high percentage of sand soil found. In Karha 41 % Silt observed Jalkewadi, Wanjarwadi, Amble, Pargoan ,Songoan,in this village area more concentration silt soil and 3.5% less Silt found Hiware, Pimple, Shivari, Babhurdi, karkhel, Malshiraj, Askarwadi.

3.15 SOIL TEXTURE

Texture relates to the amount of sand, silt, and clay in the soil, and structure relates to the arrangement of the sand, silt, and clay into peds. Texture and structure greatly affect plant growth by influencing water and air relationships. Soils that expand and shrink with wetting and drying affect the stability of building foundations.is important soil characteristic because it helps to determine water intake rates, amount of aeration and important factor which affect on soil fertility. Texture refers to the relative amounts of differently sized soil particles. Soil texture depends on the relative amounts of sand, silt, and clay. Texture define soil quality and productivity, which is one of the main factor for land suitability. Clays are the main source of nutrients in the soil. Soil texture also affects soil strength.



Map 3.8. : Texture Distribution of Soil in Karha Basin

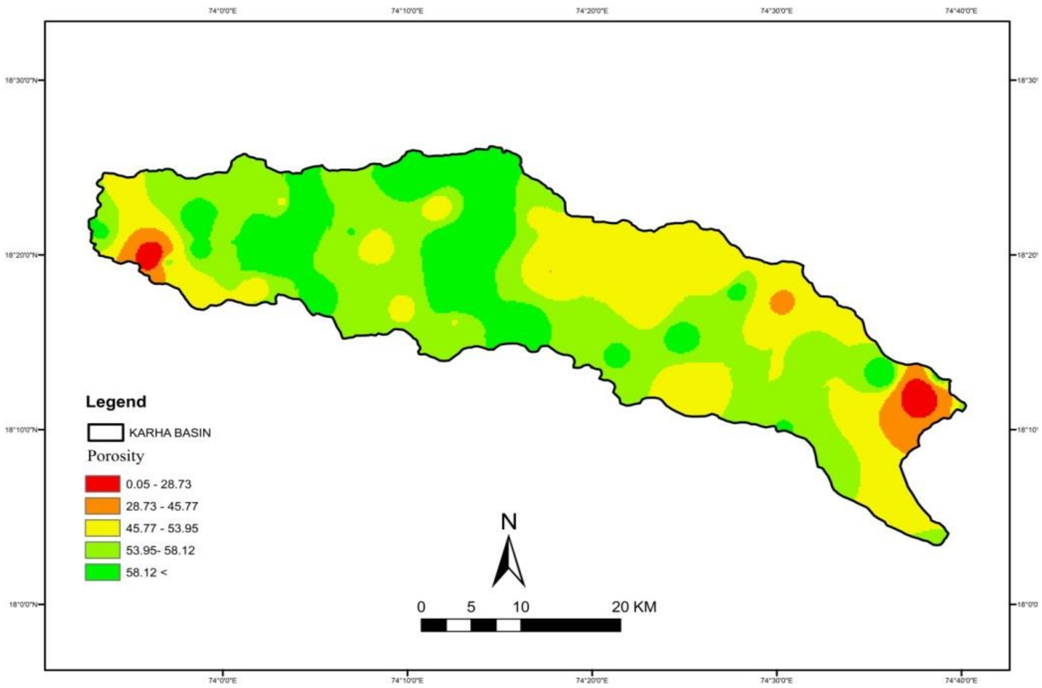
Map No. 3.8 indicates texture distribution of Karha Basin. Middle part of Karha basin shows concentration of clay soil, also near confluence part of basin having more percentage of clay soil. Source region of basin show the high percentage sandy clay and It also appears in the North, North west and East side of Karha basin. In Karha basin 42 % area is under the clay texture of soil, Clay loam under area is covers 21.52% and Gravelly sandy loam soil covers 25.61% area. While, Gravelly sandy clay loam soil cover 3.77% area, Gravelly sandy clay soil cover 2.66 % area ,Sandy loam soil cover less area that is 0.38%, Gravelly clay soil also cover less than 0.057 % area.

3.16 SOIL STRUCTURE

Soil structure, the arrangement of soil particles into various sizes and shapes, is important because it affects soil tilth. Agricultural producers can control soil structure through methods of cultivation, times of cultivation, and applications of organic matter and lime. Soils with good structure contain a large number of crumbs or aggregates, which indicates good tilth. Good soil structure permits deep root penetration and a large particle area from which plants can secure nutrients. Soil structure influences many important functions of soil. One such function is infiltration rate of water. Soil with a single grain or granular structure possesses a rapid infiltration rate. Soil with a blocky or prismatic structure has a moderate infiltration rate. Platy and massive soil structures have slow infiltration rates Soil structure is described in terms of its form and its stability. There are three types of soil structures: deep black, medium black and coarse shallow which are identified in the Karha basin. Structure modifies the influence of texture with regard to water and air relationships and the ease of root penetration

3.16.1 POROSITY

The pore space or porosity of a soil is defined the ratio of the volume of the pores to the total soil volume. Total porosity is an important soil attribute but the character of the pore space is important for water and air movement as well as root growth and the activity of microorganisms. Pores can be assigned to different size classes according to their significance for different processes. It is greater in clayey and organic soils than in sandy soils. A large number of small particles in a volume of soil produces a large number of soil pores. Fewer large particles can occupy the same volume of soil so there are fewer pores and less porosity. Soil porosity is important for many reasons. A primary reason is that soil pores contain the groundwater that many of us drink. Another important aspect of soil porosity concerns the oxygen found within these pore spaces. All plants need oxygen for respiration, so a well-aerated soil is important for growing crops. Compaction by construction equipment or our feet can decrease soil porosity and negatively impact the ability of soil to provide oxygen and water.

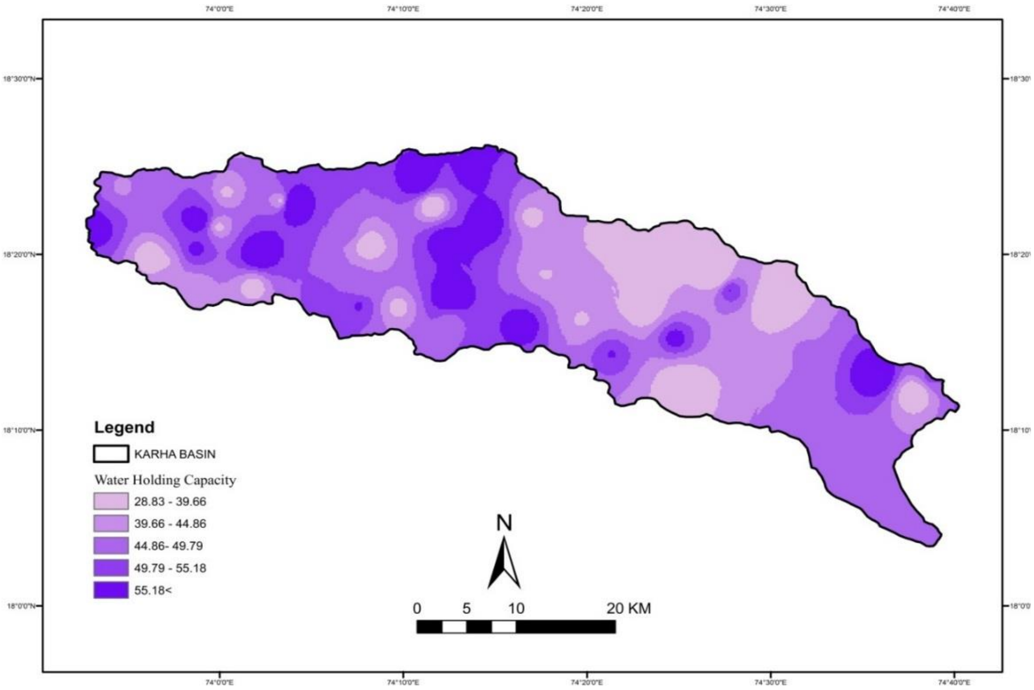


Map No. 3.9: Porosity Distribution of Soil in Karha Basin

Map No. 3.9 express porosity distribution of Karha basin. In middle part of Karha basin area having high porosity and source region of basin have low porosity observed. porosity highly impact on agricultural productivity, 41 % porosity observed in these area like Shivari, Nazere, Mudi Supe, Malshiraj, malegan, Saswad, Sonari,ect.1.25% less porosity found Karkhel, Amble, Garadi, Jejuri, Wanjarwadi.

3.16.2 WATER HOLDING CAPACITY

Soils hold different amounts of water depending on their texture and structure. Water holding capacity is affected by soil texture, presence and abundance of rock fragments, and soil depth and layers. Water holding capacity increases with increasingly fine textured soil, from sands to loams and silt loams. Coarse textured soils have lower field capacity since they are high in large pores subject to free drainage. Water holding capacity is affected by organic matter, compaction, and salt concentration of the soil. Organic matter increases a soil’s ability to hold water, both directly and indirectly. When a soil is at field capacity, organic matter has a higher water holding capacity than similar volume of mineral soil. Low water holding capacity reduces root and plant growth, and it can lead to plant death if sufficient moisture is not provided before a plant permanently wilts. Low water holding capacity this leads to higher total runoff, increased pressure on storm water drainage systems, a higher likelihood of flooding, and generally poorer water quality in streams and lakes



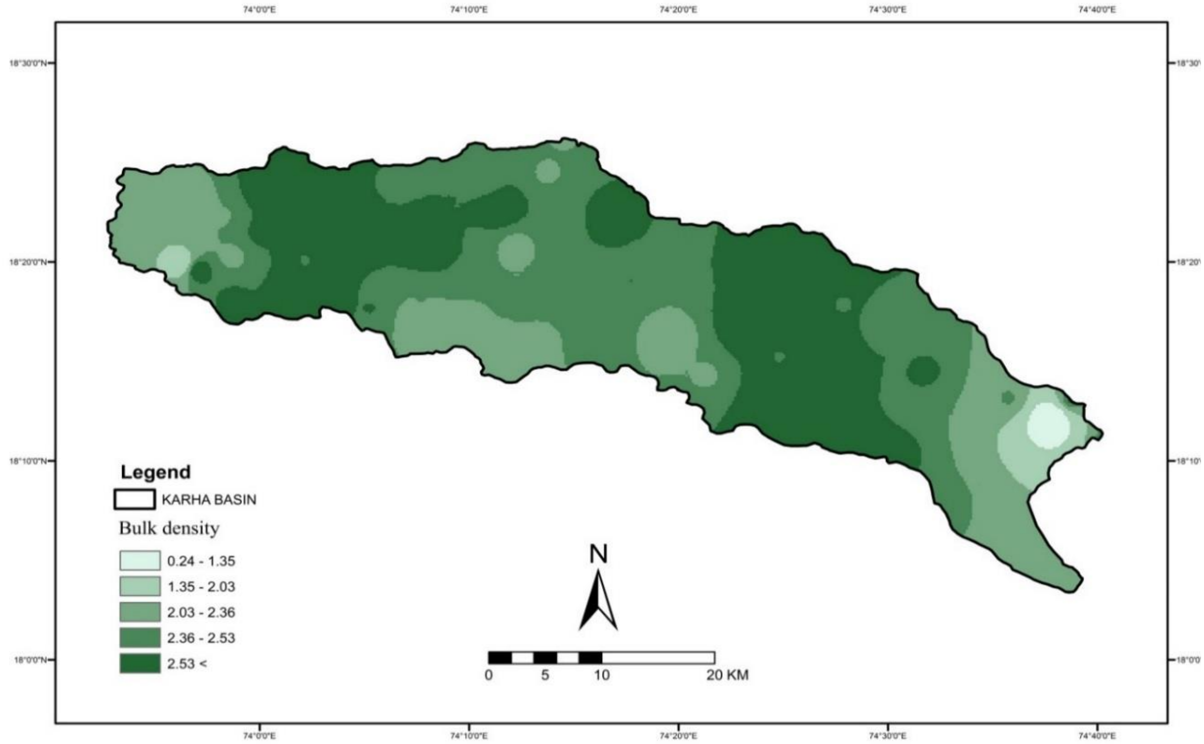
Map No. 3.10: Water Holding Capacity Distribution of Soil in Karha Basin

Map No. 3.10 show water holding capacity distribution of Soil in Karha Basin over all observed that Karha basin having good water holding capacity. Middle part of basin having high water holding capacity it's 34%. Undwadi supe, Wanjarwadi, Malegaon, Deulgaon Rasal , Morgoan, Vanpuri these area of basin having high water holding capacity. In Karha basin less water holding capacity observed 10% supe, Askarwadi, Amble, Garadi, Jalkewadi ,Karkhel, Mostly observed North east ,South east, south west part of basin low water holding capacity.

3.16.3 BULK DENSITY

Bulk density is an indicator of soil compaction. It is calculated as the dry weight of soil divided by its volume. This volume includes the volume of soil particles and the volume of pores among soil particles. Bulk density is typically expressed in g/cm3.Bulk density is dependent on soil texture and the densities of soil mineral as well as organic matter particles Generally, loose, porous soils and those rich in organic matter have lower bulk density. Sandy soils have relatively high bulk density since total pore space in sands is less than that of silt or clay soils. Bulk density typically increases with soil depth Bulk density is changed by crop and land management practices that affect soil cover, organic matter, soil structure and porosity. High bulk density is an indicator of low soil porosity and soil compaction. It may cause restrictions to root growth, and poor movement of air and water through the soil. Compaction can result in shallow plant rooting and poor plant growth, influencing crop yield and reducing vegetative cover. Organic soils have very low bulk density compared with mineral soils. Considerable variation exists, depending on the nature of the organic matter and the moisture content at the time of sampling to determine bulk density.

Bulk density is also used to convert between weight and volume of soil. It is used to express soil physical, chemical and biological measurements on a volumetric basis for soil quality assessment and comparisons between management systems.



Map No. 3.11: Bulk Density Distribution of Soil in Karha Basin

Map No. 3.11 express bulk density distribution of Karha Basin. Middle part of Karha basin shows high concentration of bulk density. such as north west, south west part, or upper part of Karha basin shows 37 % high bulk density found. Karkhel, Wanjarwadi, Garadi, Jejuri, Malshiraj these village show less bulk density observed it’s is 0.87 % in Karha basin. these area of basin.

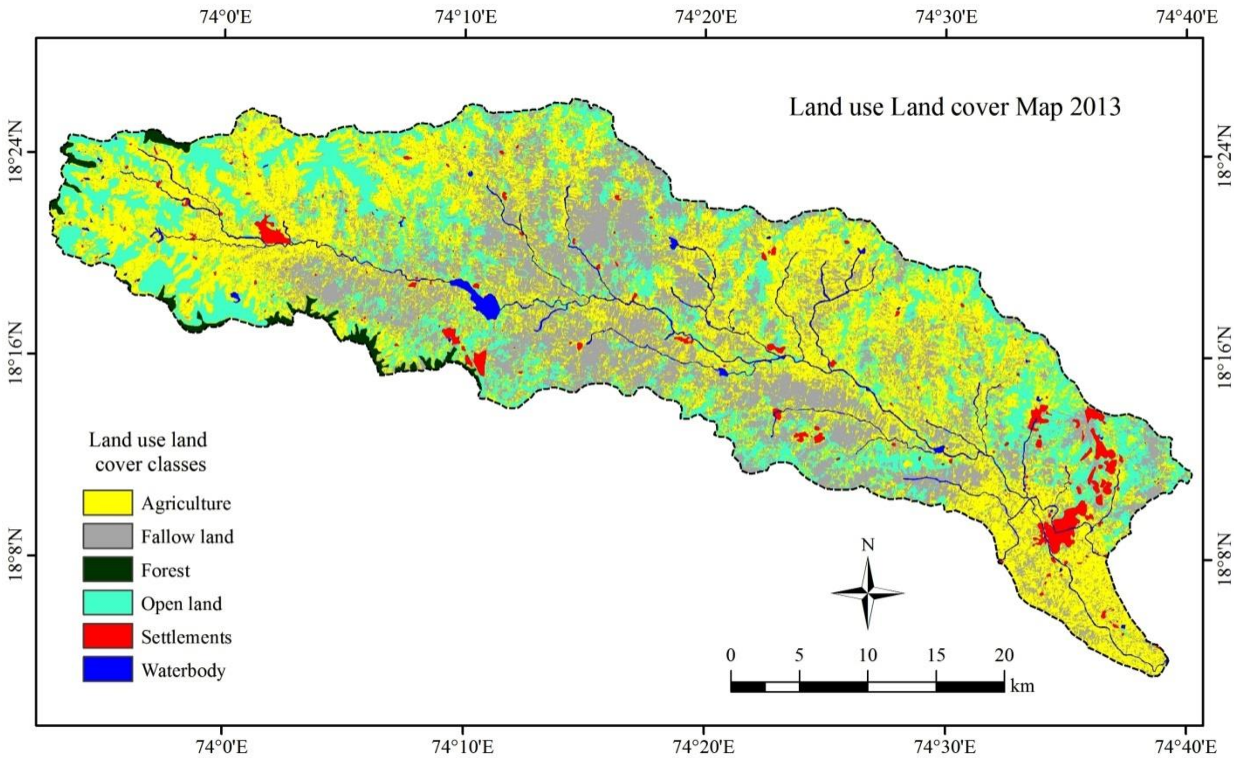
3.17 LAND USE CLASSIFICATION

Knowledge of land use is important for planning and management activities in the region concentrate physical, cultural, social, and economical factors have combined influence on the land use pattern of study area. The land use pattern of study area is divided into five categories. Following table shows land resource categories and the area occupied by them respectively.

Table No. 3.3: Distribution of land use in Karha basin

Sr. No.	Land Use	Area in sq.km	Percentage of total Geographical area
1	Agricultural	515.99	38.01
2	Fallow land	448.52	33.04
3	Open land	316.79	23.34
4	Settlements	30.96	2.28
5	Water body	29.1	2.14
6	Forest	16.04	1.18

(Source – complied by Research)



Map No. 3.12: land use classification in Karha Basin

Urbanization has progressed at an extraordinary rate in recent decades and this growth is projected to continue throughout the century. Urban areas are the hubs of social processes, driving many changes through material demands that affect land use and cover, biodiversity and water resources, locally to globally. Forests play a crucial role in terrestrial ecosystems and provide a multitude of services such as shelter, habitats, fuel, food, fodder, fibre, timber, medicines, security and employment; regulating freshwater supplies; storing carbon and cycling nutrients; and helping to stabilize the global climate. Historically, forests have been under pressure due to increasing demands for shelter, agricultural land, and fuel and timber extraction, but in recent decades this pressure has increased due to competing demands for agricultural expansion and biofuel production, rapid urbanization and infrastructure development, and increased global demand for forest products. Karha basin cover forests over 16.04 sq.km., 1.18 percent of the total land area. water is one of the important resource for human being. In Karha basin total Water body area cover 29.10 sq.km. 2.14% out of the total basin area. Agricultural area under 515.99 sq.km 38.01% area cover. Normally recognized that higher area cover in agricultural zone in karha basin. Fallow land cover 448.52 sq.k.m 33.04 percent Open land under the area is 316.79 sq.km 23.34 percent.

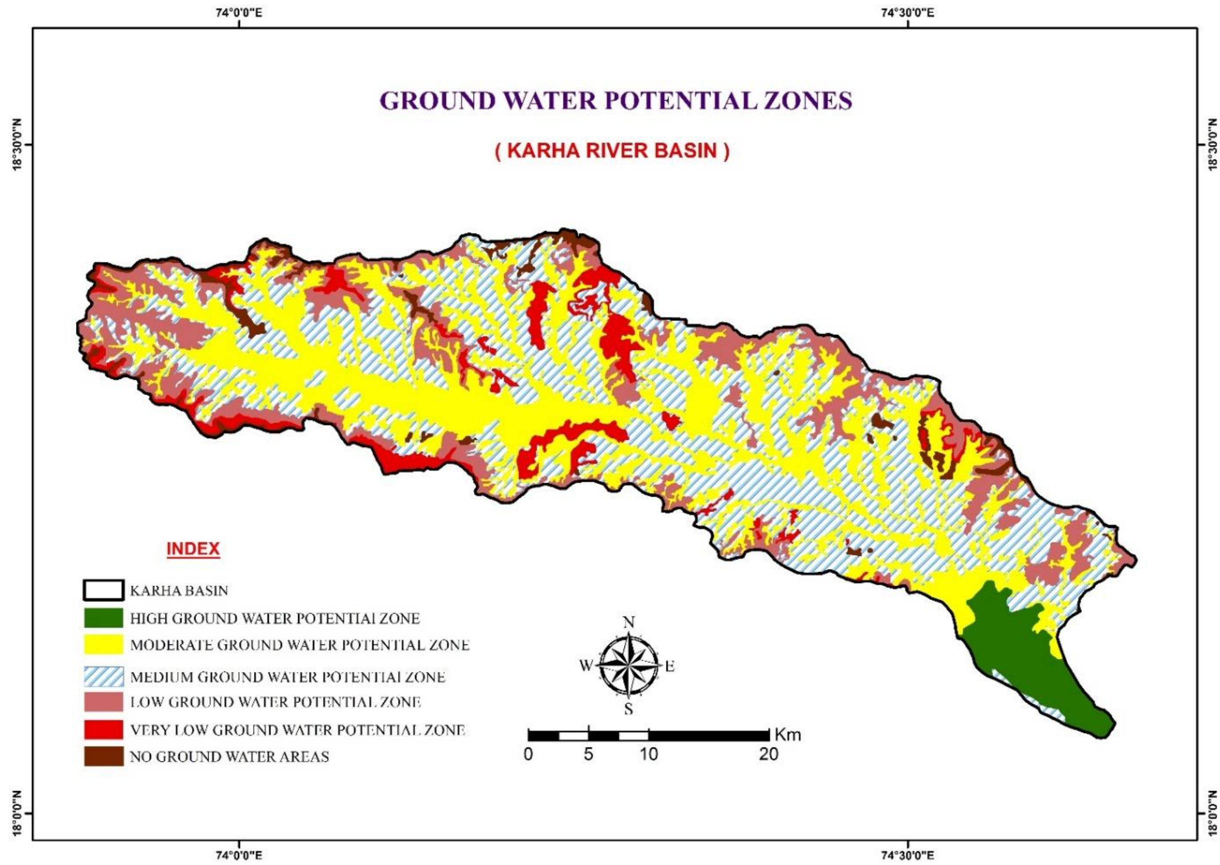
3.18 VEGETATION COVER

The type and quality of vegetative cover on watershed lands influence runoff, infiltration rates erosion and sediment production and the rate of evapotranspiration. Dense cover of vegetation is a most powerful weapon for reducing erosion. The area under study experience semiarid climate hence the vegetation cover in the study area show variation from tropical ever green to tropical deciduous forest. The study area is partly covered by the Western Ghats thus a large variety of the vegetative cover in this area.

Forest land of the study area is divided into three categories i.e. Deciduous, evergreen and mixed. All these types are found in study area. The southern and southeastern part of study area is occupied by the tropical evergreen type of dense vegetation. This vegetation is found on the hill tops and on moderate to gentle slopes. Vegetation consist of trees like Mango, Jambhul , Bamboo, Jackfruit, Herbs, Shrubs, weeds and grasses are mostly observed along the valley flats, gently sloping ground and on the flat ridges. As compare with the southern part the northern and western part of the study area is occupied by the sparse vegetation comprising of Xerophytes and deciduous types of vegetation.

3.19 GROUNDWATER POTENTIAL ZONES OF KARHA BASIN

For calculating the groundwater zones we have use Raster overlay analysis in which waited overlay method has been implemented. As we know that GIS is newly emerged technology which provide wide range of tools and techniques to Carried out raster calculation along any spatial geographic areas. In the present study thematic layers related Groundwater Potentials are separately generated using GIS technique and then those layers have been take in to consideration for waited overlay index method. While calculating waited overlay index we take several thematic layers i.e. Lineament, Landuse – Land cover, Soil Texture, Geomorphology/ Landforms, Drainage Map etc.

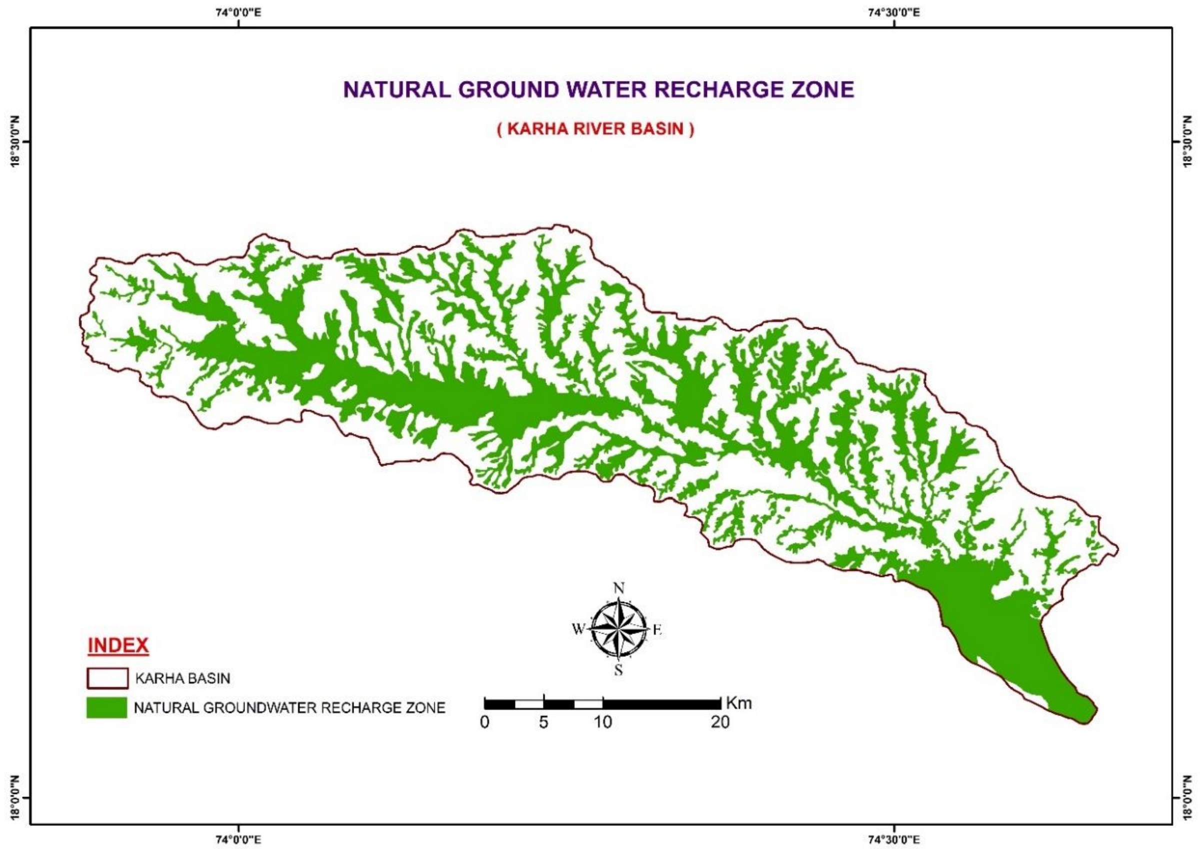


Map 3.13 showing Groundwater Potential Zones.

From the waited overlay index method we have six different Groundwater potential Zones along the Karha River Basin namely High, Moderate, Medium, Low, Very Low and No Groundwater Zone. Present map Shows that the area having high Groundwater potential is very less it is along the confluence point of Nira and Karha River. Most of the areas are covered under Moderate and Medium Groundwater Potential Zone. In the source region and along the no erosion zone / basin border no Groundwater is observed it may be because of the area lies on structurally hilly areas having hard rock terrain.

3.20 NATURAL GROUNDWATER RECHARGE ZONE

Accurate estimation of groundwater recharge is extremely important for proper management of groundwater systems. Many different approaches exist for estimating recharge. The water-table fluctuation method may be the most widely used technique for estimating recharge; it requires knowledge of specific yield and changes in water levels over time. Advantages of this approach include its simplicity and an insensitivity to the mechanism by which water moves through the unsaturated zone. Uncertainty in estimates generated by this method relate to the limited accuracy with which specific yield can be determined and to the extent to which assumptions inherent in the method are valid. The theory underlying the methods is explained. Examples from the literature are used to illustrate applications of the different methods.



Map 3.14 showing Natural Groundwater Recharge areas.

Natural recharge areas are the low laying areas along the Karha river basin which allows the infiltration of rain water in the ground where the porosity of soil is high. B zone showing high recharge due to maximum infiltration.

CHAPTER – IV

CONCLUSIONS

4.1 INTRODUCTION

Studying morphometry is essential because surface drainage basin directly describe about underground occurrence of water from the linear, areal and relief aspect anybody can study sub surface groundwater movement and its dynamics. The linear aspect deals with the hierarchical order of streams number’s and lengths of stream segments and various relationships, which describes availability of water for percolation and furtherly that water has been converted in to the groundwater. The areal aspect includes the analysis of basin parameters, basin shape, basin area and related morphometric laws. If the basin is circular in shape then the time of concentration of water flow is low, so its results in less percolation and because of this enrichment of groundwater is impossible. But if the basin shape is elongated then the time of concentration is more and it helps to enrich groundwater table. The term morphometry is used in several disciplines to mean the measurement and analysis of form characteristics. In geomorphology it is applied to numerical examination of land form, which may be referred to a geomorphometry. Calculating morphometry with the help of GIS is very useful now a day because it reduces time witch is utilized to measure the streams. Manually stream measurements is very time consuming practice and it also has rigorous nature of work, So GIS is the beneficial tool to calculate morphometry and carried out morphometric analysis. In the present study GIS base morphometric tools has been used to calculate the morphometry of Karha river basin

In the morphometry various parameters representing the geomorphologic characteristics of a basin covering the linear, areal and relief aspects have been discussed together with the mechanics of their determination. Prominently drainage basin morphometry is significant approach that reflects existing geomorphic process operating in fabric of a drainage basin. Drainage basin morphometry explicitly reveals quantitative information on landform. One of the purposes of studying morphometry of watershed is to obtain information in quantitative form with relation to the geometry of the watershed that can be correlated with hydrologic information. Remote sensing studies allow the assessment of regional structures and their trends. In the Karha river basin bifurcation ratio ranges from 2.74.to 7.25 to The mean bifurcation ratio for Karha river basin is 4.23. This means that on an average, there are 4.23 times as many channel segments to any given order as of the next higher order. The average bifurcation ratio of the basin reveals that there appears to be strong geological control in the development of the drainage. Karha basins are not circular in shape. Drainage density is a significant factor affecting the flow, infiltration capacity etc. drainage density of Karha basin is 2.90. The studied Karha river basin has a dendritic drainage pattern with good drainage texture showing a 7th order stream network. In Karha drainage basin it is observed that the texture of this basin is in good quality. The drainage basin is being frequently selected as an ideal geomorphological unit. Watershed as a basic unit of morphometric analysis has put on importance because of its topographic and hydrological unity. Drainage density and stream frequency are the most useful criterion for the morphometric classification of drainage basins which certainly control the runoff pattern, sediment yield and other hydrological parameters of the drainage basin.

4.2 GROUNDWATER QUALITY

Water from beneath the ground has been exploited for domestic use, livestock and irrigation since the earliest times. Although the precise nature of its occurrence was not necessarily understood, successful methods of bringing the water to the surface have been developed and groundwater use has grown consistently ever since. In previous few years, the increasing threat to groundwater quality due to human activities has become a matter of great concern. A vast majority of groundwater quality problems present today are caused by contamination and by overexploitation, or by combination of both. Rapid urbanization in the study area resulted in steep increase of generation of wastes. Due to lack of adequate infrastructure and resources the waste is not properly collected, treated and disposed; leading to accumulation and infiltration causing groundwater contamination. In the Study area groundwater is only source of drinking water, thus a large population is exposed to risk of consuming contaminated water. Now a day due to fast increasing urbanization, the people of this area has to face Groundwater Scarcity and Whatever the Groundwater is available it is not in good condition. That's why the attempt has been made hear is great concern with Groundwater Contamination.

In the present study 30 groundwater samples were collected and analyzed its quality under the light of various physico-chemical parameters such as pH, EC, TDS, Cl, Ca, Mg, CO_3, HCO_3 Na, K, SO_4, NO_3, TA, TH. It is shown that the average concentration of all the physico-chemical parameters are within the permissible limit. The towering values of some physico-chemical parameters such as EC and TDS It increases as the amount of dissolved mineral (ions). The groundwater quality of the study area is also evaluated view point of agricultural and irrigation purpose also by taking into consideration of the Piper-Hill diagram (1953) and U.S. Salinity Diagram, only 10% samples are unsuitable for irrigation purpose it may be the cause of higher concentration of Electrical Conductance. As above mentioned it must be said that the groundwater quality of study area is good for drinking and agricultural purposes.

Hydrogen exponent, pH, measured at the sampling site, ranges from 6.8 to 8.8, average pH is 7.6. all sampled water is either weakly acidic or neutral. Electrical Conductivity (EC) is an indirect measurement of ionic strength and mineralization of natural water EC ranges from 372.4 to 1871.4 µs /cm as an average value 1401.8 µs /cm was observed in the water samples from study area. It observed that 23 water sample having high saline nature and 4 samples shows very high saline nature (Pimple, Bhivri, Pathar Vasti, and Jejuri). 3 Samples show medium saline nature in the Study area (Zende wadi,Garade, Chambhli).

The total dissolves solids (TDS) indicate the general nature of salinity of water. TDS are a direct measurement of the interaction between ground water and subsurface minerals, the total dissolved solids (TDS) are the concentrations of all dissolved minerals in water indicate the general nature of salinity of water. The principle component of TDS is calcium, Magnesium, Sodium, Potassium, cations and Carbonates chloride, sulphate and Nitrate inions. The BIS specifies a desirable total dissolved solids limit of 500 mg/L. Total Dissolved Solids, according to table 1, range in from 242.1 to 1866.4 mg/l on average 906 mg/l. Thus, Total Dissolved Solids are highly above the desirable of BIS drinking water standards (500 mg/L). The TDS results suggest that all water samples are not fit for Agricultural purpose except (Zende Wadi, Kodit Budruk, Garade, Sonori). It is possible that shallower parts of the aquifer are more affected by residential pollution than deeper parts.

4.3 GROUNDWATER FLUCTUATION STUDIES

The water-table fluctuation method gives the opportunities to estimate the groundwater recharge by studding water-level fluctuations with the help of measuring water levels from observation wells. The method is purely stands on the general formula that a rise in water-table elevation measured in shallow wells is because of the addition of recharge across the water table. Groundwater fluctuation is nothing but seasonal variation or seasonal change in the level of groundwater table due to continuous increase in recharge. From the fluctuation anybody correlate the groundwater availability.

From the groundwater fluctuation studies we clearly understand the availability of groundwater in the different seasons. It also gives the information about potentiality of groundwater. In present study three zones has been identify by the researcher like as run-off zone, recharge zone and zone of saturation. From the study it is observed that the maximum fluctuation of groundwater is observed in the recharge zone of the given basin. The minimum fluctuation is observed nearby Run-off zone of the study area. zone of saturation has high groundwater table which observed at confluence point of Nira River and Karha River at the location of Sonagaon.

Groundwater availability is much higher in the month of October and it may be because of rainfall of monsoon season in the study area. In the zone of recharge maximum storage is observed it may be because of low laying area and the areas where the slope of ground is moderate.

Natural recharge zone areas are the low laying areas of the Karha River and these are the sites where Groundwater can automatically have recharged during monsoon season. The residents who resides in the study area should have to implement some methods like bore well dug well and CCT, KT wears to increases the natural recharge along the study area. The total depth of open wells ranges from 3.3m to 15.1m BGL with an average of 8.01m BGL. The well diameter ranges from 2.3m to 12.2m with an average of 7.27m. Water table fluctuation ranges from 3.3m to 15.1m BGL in post monsoon season.

4.4 GROUNDWATER POTENTIALS

Landform are playing major role in groundwater occurrence and potential of the groundwater. There is wide scope to study the landforms and other groundwater related parameter geographically. In the present study researcher found that the Basin area of Karha River facing the problem of water scarcity during summer season because of hard rock topography. Source region of Karha river basin having very limited Groundwater potential and most of the area comes under Moderate and Medium Groundwater potential areas. Some places have no groundwater zone areas along the study region.

Physiography is the main component of Surface that allows the groundwater percolation due to the gravitational pull. Physio graphically Karha River has been divide in the Hill region, Relatively Flat region and Flat region. In the flat region the groundwater table is near to the surface and in the hilly region the ground water table is very much low from the surface. It means that physiography has main concern with Groundwater availability and Landforms are also have core relevance to the availability of Groundwater, Potential of Groundwater.

Structural hills found in the Karha Basin are devoid of water bearing aquifers however gloomy aquifer available due to highly jointed and fractured basalt with thin soil cover at the hill top and on the slopes. Generally, the groundwater potential is very poor in structural hills owing to their poor permeability where surface runoff is greater.

Lineaments have been observed during field work in the Karha Basin, in the southeastern and northern part. Two most prominent lineaments having NE-SW trend are running between the village saswad, Morgaon, and baramati. These lineaments are running almost parallel to main stream of Karha River. These lineaments had given an advantage of groundwater convergence from western and eastern part of the basin. The lineament observed as the manifestation of straight stream course near Jejuri region. Along this lineament, high moisture zone and dense vegetation is noted during field check. Dykes have moderate to good groundwater potentials. During field work set of two dykes approximately trend in NE-SW, discontinuously observed from Saswad to Karkhel. Hills are marked by sharp to blunt crestline's with rugged tops indicating that the surface runoff at the upper reaches of the hill has caused rill erosion. Groundwater potential is moderate to poor in this region. These hills are observed near, Garade, Songaon, Kapurhol, Jejuri, Morgaon region of Karha Basin.

Generally pediments do not favour much infiltration and therefore, these areas are not favorable for groundwater explorations. In the present Karha Basin, pediments are observed along the down slopes of structural hills and foothill zones. Foothill zone found all along the periphery of the Karha and its tributaries. From the groundwater point of view this unit falls in poor to moderate groundwater potential zone. In this zone most of irrigation depends on dug wells.

Pedeplain are found to be good for groundwater potentiality. Groundwater exploration can be done mainly through dug wells. Pedeplain is the gently sloping undulating plain of large areal extent. Pedeplain, are located between pediment and alluvial plains in the Karha Basin. And another part of the basin, they are observed between pediments and valley fills. Pedeplain have fairly weathered thick mantle underlain by weathered and fractured basalt locally known as murum, indicates high porosity and permeability. In the Karha Basin pedeplain unit has an average elevation of 550 to 750m ASL. Pedeplain have moderate to good groundwater potential.

Fluvial depositional plains are developed on either sides of the river and their tributaries. From the river banks it extends from few hundred meters to 1-2 km laterally. It is highly permeable zone helping in partial bank recharge and subsurface flow. Groundwater in alluvial plain occurs under semi confined to perched water table conditions with shallow water levels. Groundwater prospects in alluvial plain is invariably found to be good and it is a promising zone for the same through which groundwater has been tapped by digging numerous wells and tube wells, giving high yield of water.

Valley fills are observed in the Karha Basin along Baramati and Dorlevadi region This hydrogeomorphic unit is characterized by high porosity and high permeability resulting in high infiltration rate. Most of the wells have been dugged in this zone to get the high yield of water. Groundwater potential in this zone is fairly good. In the Karha Basin valley fills zone is mostly occupied by cultivation. Owing to large amount of recharge from both valley side slopes, they are most favorable groundwater zones.

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1. ORIGIN OF THE KARHA RIVER

2. CCT AT GARADE VILLAGE

3. RED BOLE WELL AT NARAYANPUR

4. HIGH GROUNDWATER TABLE AT PIMPLE

5. RED BOLE WELL AT TATHEWADI

6. WELL HAVING CONTAMINATED WATER AT KODIT BUDRUK

7. VERY HIGH GROUNDWATER TABLE AT ASKARWADI

8. VERY LOW GROUNDWATER TABLE AT MORGAON

9. APPROXIMATLY DRY WELL AT KHALAD

10. APPROXIMATLY DRY WELL AT JEJURI