केन्द्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

ANUPPUR DISTRICT
MADHYA PRADESH

उत्तर मध्य क्षेत्र, भोपाल

North Central Region, Bhopal

भारत सरकार

Government of Iindia

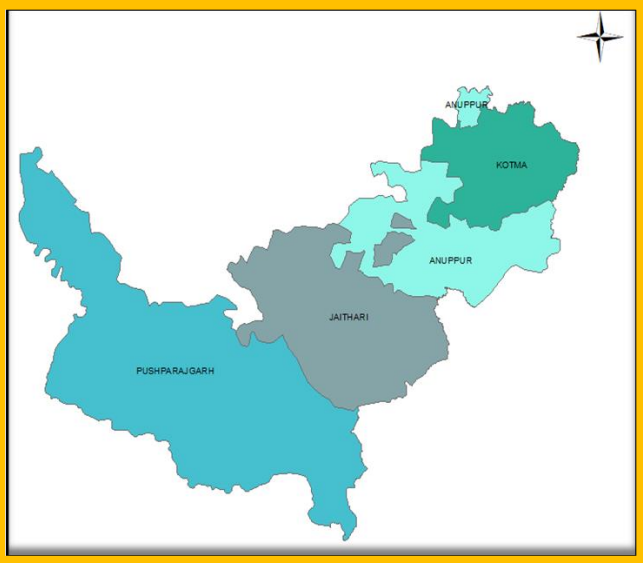
जल शक्ति मंत्रालय, जल संसाधन, नदी विकास एवं गंगा संरक्षण विभाग

Ministry of Jal Shakti, Water Resources, River Development & Ganga Rejuvenation Department

केंद्रीय भूमि जल बोर्ड

Central Ground Water Board

Aquifer Mapping and Ground Water Management Plan, Anuppur district, Madhya Pradesh



By

लता उदसैईया / Lata Udsaiya

वैज्ञानिक – बी / Scientist-B

कें. भू. ज. बो. , उत्तर मध्य क्षेत्र, भोपाल / CGWB, NCR, Bhopal

2021-2022

भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
केन्द्रीय भूमि जल बोर्ड, उत्तर मध्य क्षेत्र

Government of India
Ministry of Jal Shakti
Department of Water Resources, R D & G R
Central Ground Water Board, North Central Region

PREFACE

Aquifer mapping can be defined as a scientific process, wherein a combination of geologic, geophysical, hydrologic, and chemical field and laboratory analyses are applied to characterize the quantity, quality, and sustainability of groundwater in aquifers. Systematic aquifer mapping is expected to improve our understanding of the geologic framework of aquifers, their hydrologic characteristics, water levels in the aquifers and how they change over time, and the occurrence of natural and anthropogenic contaminants that affect the portability of groundwater.

Under the project on National Aquifer Mapping (NAQUIM), Central Ground Water Board (CGWB) North Central Region, Bhopal has taken up Anuppur district to prepare the Aquifer Maps for the entire district and formulate Aquifer Management Plan. Anuppur district occupies an area of 3724 sq km, out of which the groundwater recharge worthy area is 2942 sq km and the rest is covered by hilly and forest area. Excepting small and narrow belt along the south-west boundary in Pushprajgarh tehsil which is drained by the river Narmada, entire Anuppur district forms of the Ganga system. The district is occupied by hard rock; comprising Deccan Traps, Lameta, Talchir and Bijawars. The water level in shallow aquifer ranges upto 15 meter below ground level. As per the Dynamic Ground Water Resource Assessment Report (2020), the annual extractable ground water resource 377 MCM and groundwater draft for all uses are 76 MCM which results in the Stage of Groundwater extraction being 20 % as a whole for the district. After successful implementation of the supply-side and demand-side management plan the stage of extraction in Anuppur district will be changed and improve condition of the district in terms of ground water and socio economic conditions of the district. The interventions suggested in the report will not only have a positive impact on the groundwater regime but would also play a key role in augmenting the net cropping area and would ultimately enhance the agricultural productivity and economy of the district.

I would like to place on record my appreciation of the untiring efforts **Ms. Lata Udsaiya, Scientist-B** for preparing the Aquifer maps and Management plan and compiling this informative report. I fondly hope that this report will serve as a valuable guide for the sustainable development of Ground Water in the Anuppur district, Madhya Pradesh.

Rana Chatterjee
(Regional Director)

पर्यावास भवन, ब्लाक–1, चतुर्थ तल, अरेरा हिल्स, जेल रोड, भोपाल–462011,
फोन : 0755–2557639, 2525201, 2760090, ई–मेल : rdncr-cgwb@nic.in, वेब साइट : www.cgwb.gov.in
Paryavas Bhawan, Block -1, 4th Floor, Arera Hills, Jail Road, Bhopal-462 011
Ph.:0755-2557639, 2525201, 2760090, E-mail : rdncr-cgwb@nic.in, Websites : www.cgwb.gov.in

CHAPTER 1

INTRODUCTION

Aquifer mapping is a multi-disciplinary scientific approach for aquifer characterization or it can be defined as a scientific process, wherein a combination of geologic, geophysical, hydrologic and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers. According to the present condition of groundwater related issues there is an urgent need for an accurate and comprehensive picture of groundwater resources available in different hydrogeological settings. Therefore Central Ground Water Board has taken up the **National Aquifer Mapping Projection (NAQUIM)** on a scale of 1:50,000 to formulate sustainable aquifer management plan. Effective and systematic aquifer mapping study is expected to improve our understanding of the geologic framework of aquifers, their hydrologic characteristics, water levels in the aquifers and how they change in a space and time, and the occurrence of natural and anthropogenic contaminants of ground water.This National Water Mission is very helpful in conservation of water, minimizing wastage and ensuring its equitable distribution all over the country (at district and block level also) through **integrated water resources development and management.**Central Ground Water Board extensive study has remarkably brought out comprehensive regional picture of the aquifers in terms of their water quality and yield potential. In CGWB various studies such as ground water monitoring, ground water resource assessment, artificial recharge and ground water exploration is going which is one of the main important tools in this aquifer mapping project all over the country.

1.1 Objectives

The objective of this study is

- To provide more adequate, accurate and precisedataof aquifers present in the study area – shallow and deep including dry and saturated zones.
- Delineation of lateral and vertical disposition of aquifersand their characterization.
- Quantification of ground water availability and assessment of its quality to formulate aquifer.
- Aquifer wise assessment of ground water resources.

- Management plans to facilitate sustainable management of ground water resources at appropriatescales through participatory management approach with active involvement of stakeholders.
- Identify the hydrogeochemicalcharacteristics of aquifer systems and the extent of contamination in groundwater.

1.2 Scope of Study

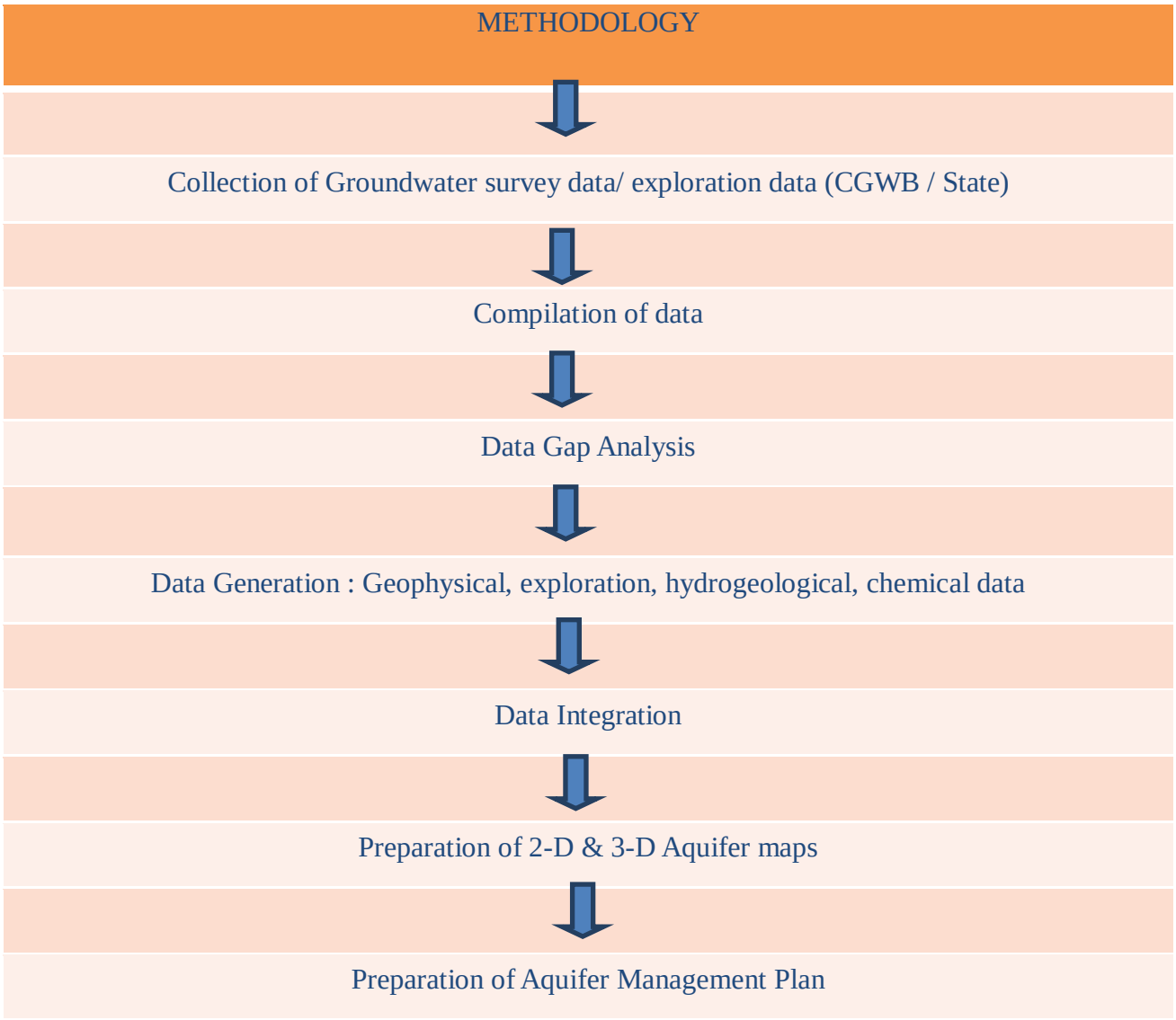
To understand the scope of this study it is very important at present time when there is very large scarcity of freshwater even for essential requirement, drought condition unavailability of drinking water and lack of management of groundwater in Anuppur district.This has necessitated for a systematic mapping of aquifers. Further hydro-geological investigation either by geophysical technique or by exploration may be proposed for the aquifer mapping. The study will provide **adequate and precise subsurface information in terms of aquifer lithology and geometry leading to 3-dimensional aquifer dispositions (vertical and lateral extend), their yield, quantification of groundwater, etc.** Also it will establish the most appropriate technique or combination of techniques for identifying the aquifers in different hydrogeological terrains which will help in management of groundwaterresources in an efficient and equitable manner, for sustainable development of groundwater and for its recharge.

At present a generalized picture of aquifer-dispositions and their characteristics are known from the existing hydrogeological and surface geophysical data, the borehole lithological and geophysical logs and the aquifer performance tests conducted by CGWB and other central and state agencies. But it is not enough to prepare aquifer maps because of the inadequate density of data vis-à-vis geological heterogeneities. The extrapolation and interpolation within the existing boreholes may not yield accurate information on aquifer disposition unless they are tied up further by close-grid geophysical measurements conducted in between. This has necessitated in a systematic mapping of aquifers. Further hydro-geological investigation either by geophysical technique or by exploration is proposed for the aquifer mapping. It is to provide adequate and precise subsurface information in terms of aquifer lithology and geometry leading to 3-dimensional aquifer dispositions. Also it is to establish the most appropriate

technique or combination of techniques for identifying the aquifers in different hydrogeological terrains.

1.3. Approach and Methodology:

National Aquifer Mapping Programme basically aims at characterizing the geometry, parameters, behaviour of ground water levels and status of ground water development in various aquifer systems to facilitate Major Aquifers planning of their sustainable management. The major activities involved in this process is compilation of data, data gap analysis, data generation, data integration, preparation of maps and 3-D aquifer model, 2D sections of the district and finally aquifer management plan of the study area (figure1).The ongoing activities under NAQUIM includes data acquisition supported by geological, geophysical and hydro-chemical investigation with groundwater exploration to the depth of 200 mt.



Methodology flow chart

1.4 Study Area

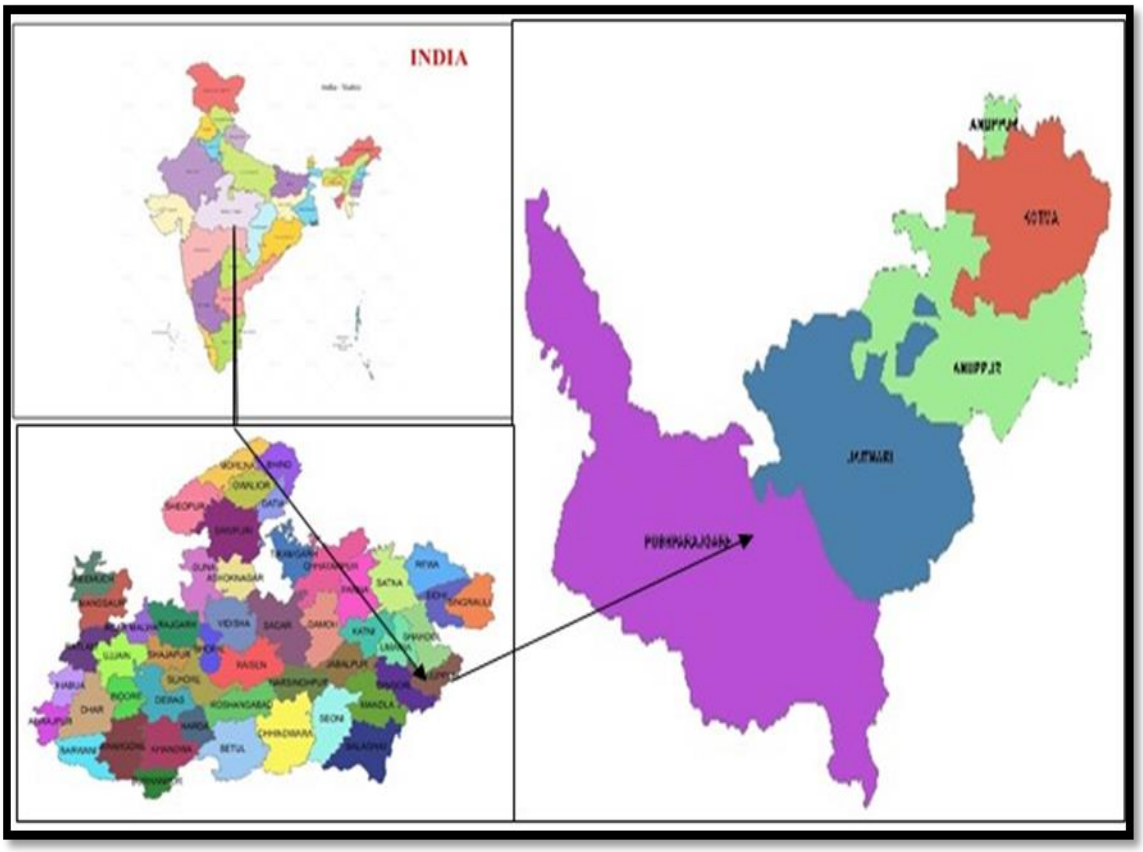


Figure.1 : Index Map of Anuppur district

Anuppur is situated in eastern corner of Madhya Pradesh. It came into existence on 15th August 2003, by reorganization of Shahdol district. The Anuppur is one of the tribal district of Madhya Pradesh. Anuppur is also famous for Amarkantak hill and pilgrim station, where from two important rivers namely, Narmada and the son originates. District Anuppur is surrounded by Shahdol district in north, Umariya and Dindori districts in west and south-west, Bilaspur and Korea districts of Chhattishgarh State in southern and eastern side. The district lies between North latitude 22º 7' and 23º25' and East longitude 81º10' and 82º 10', falling in Survey of India toposheet nos. 64E, 64F and 64 I. It extends for about 86 Km from north to south and 117 Km from east to west. As per the census 2011, total population is 749237 out of which 358543 are from scheduled tribes while74385 are from scheduled castes, it is because of the huge tribal population that Anuppur district is also know as tribal dominated district. The total literacy

percentage of this district is 67.90%, which is less than of the national literacy percentage recorded as 69.30%.

The area of district is 3724 Sq. Km, and it has been divided into four tehsils and blocks (Fig.1). Details of administrative divisions of the district are given in Table-1.

The rivers flows in the Anuppur district are Son, Johilla, Tipan, Narmada, Kewai and Chandas rivers. The Maikal mountain range located in the district extends from southern part of generally regarded as hilly area. Climate wise, Anuppur has a marked temperature climate with monsoon season lasting from June to October.

About 20 % of the total area of the district consists of dense forests and regarded as a hilly area. The main trees found in the Anuppur district are Sarai, Teak and Shrisham. The flowers of Guli and Malua grown in the district provided the inhabitants with edible oil. The tribal person of the district also uses the flowers of the Mahua tree for making wine. Anuppur district is laso very rich in mineral resources and the names of the minerals found in this district are bauxite, coal and fire clays. Most of the coal mines of the distrct are located in the Kotma sub division. The region of he Amarkantak is known for its deposits of bauxite. According to the survey of the year 1998, the region is recorded to have an establishment of 106 industries both large scale and small scale. The orient paper mill and soda factory are situated in the region of Amlai small –scale industries of polythene and baskets of bamboo are also run in the district. A bidi factory is laso situated in the region of the Venkatnagar in the Anuppur district. For the production of electricity Amarkantak Thermal Power Plant is established. About 94 % of the village of the district are electrified. The total generating capacity of the Chachai Power house is 290 MW.

There are 111 post offices in the total and their branches are in regular operation in the whole district. There are also 6 telegram offices and the district is also recorded with the provision of 2038 telephonic connections. The district alos has provisions of public health. There are several community health centers, district hospitals, official insemination centers.

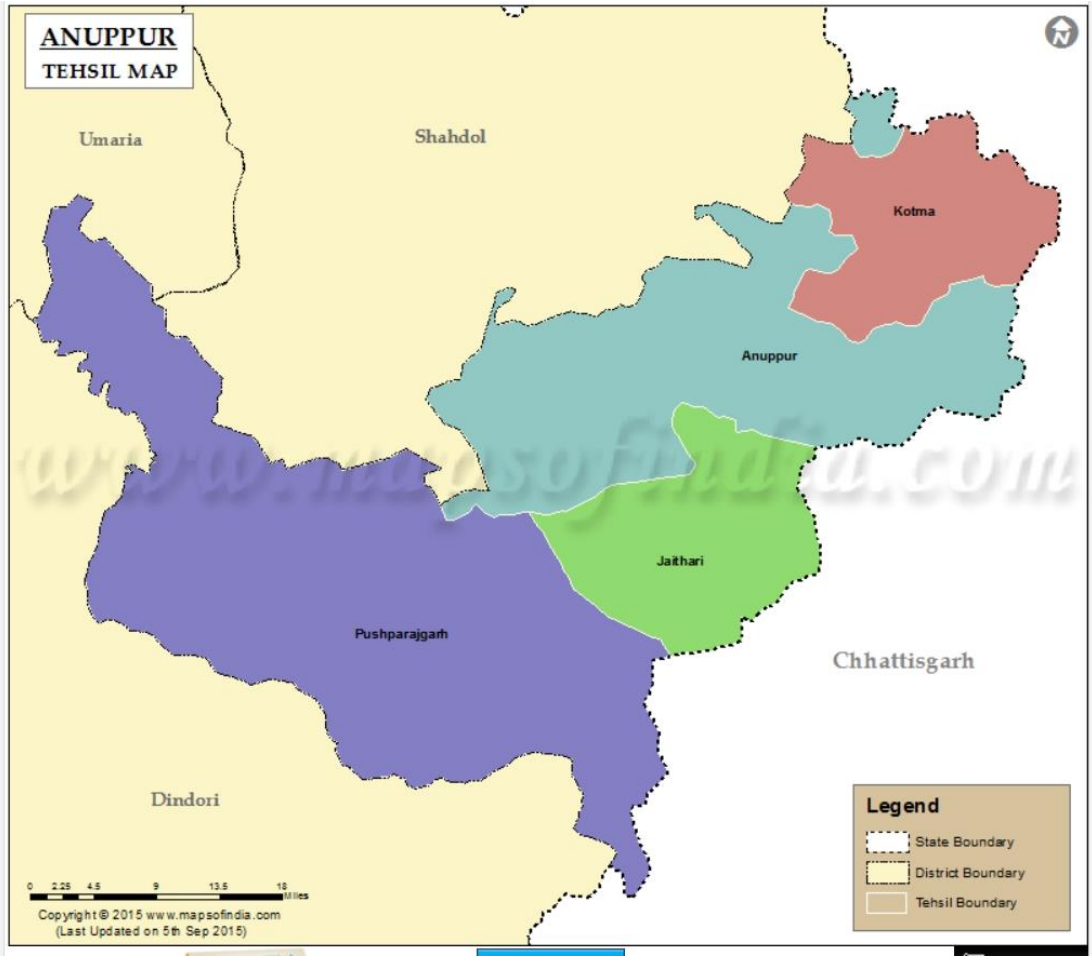


Figure 2 : Adminstrative Map Of Anuppur District

Table 1: Administrative Units of Anuppur district.

Total Blocks	Area (sq km)
Total Geographical Area (sq km)	3724
Recharge worthy Area (sq km)	2942 (79 %)
Hilly/Forest (sq km)	782 (20.9%)

Table 2: Block-wise area of the district

Block	Geographical Area (Sq Km)	Recharge Area (Sq Km)	Number of villages	Number of towns
Anupur	590	33	139	2
Jaithari	970	130	99	1
Kotma	400	60	69	2
Pushprajgarh	1764	559	271	1
DISTRICT TOTAL	**3724**	**782**	**578**	

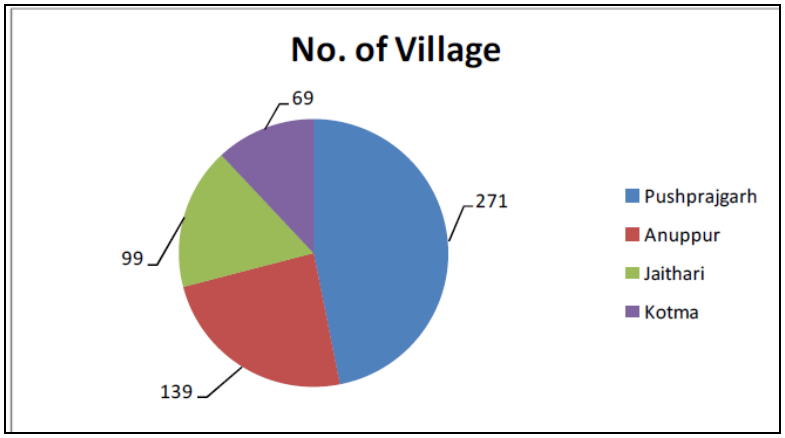


Table 3 : The demographic Information of Anuppur district is as follows

S.No.	Specifications	Numbers
1	Total Population	749237
2	Total Male Population	379114
3	Total Female Population	370123
4	Rural Population	543996
5	Urban Population	205241
6	Total households	170715
7	Population Density (No. of persons/sq.mt)	200/sq.mt
8	Population Growth Rate	12.30%
9	Male Literacy percentage	78.30%
10	Female Literacy Percentage	57.30%
11	Schedule Caste Population	358543
12	Schedule Tribe Population	74385
13	Total Working Population	346471
14	Working Population percent with Total population	46.24%

1.5 Rainfall and Climate

The climate of Anuppur district, Madhya Pradesh is characterized by a hot summer and general dryness except during the south west monsoon season. The district is characterized by four seasons. The cold season, December to February is followed by the hot season from March to about the middle of June. The period from the middle of June to September is the south west monsoon season. October and November form the post monsoon or transition period.

For preparation of rainfall report five years IMD rainfall data has been utilized. Anuppur received mostly rainfall during the south west monsoon season. 90% of the rainfall received during monsoon season. Normal monsoon rainfall is 1099.6mm and normal post monsoon rainfall is 72.7 mm. During monsoon season district receive highest rainfall in August and lowest in June. In the Year 2021 district received 1146.3 mm rainfall in monsoon season (4% above normal) and 48.5 mm during post monsoon season (33% below normal).

To find the long term changes in rainfall, rainfall trend for last five years (2016-20) has been. Thus surplus water for ground water recharge is available only during the south west monsoon period.

Table 4: Blockwise monthly Rainfall data for the year 2015 for Anuppur district

S. No.	Block	Jan. (2015)	Feb. (2015)	Mar. (2015)	Apr. (2015)	May. (2015)	Jun. (2015)	Jul. (2015)	Aug. (2015)	Sep. (2015)	Oct. (2015)
1	Anuppur	807.9	824.1	867.8	881.4	881.4	75.8	354.4	501.9	546.6	584.9
2	Jaithari	1058	1068.6	1126.8	1141	1141	56.2	308.2	494.2	551.6	576.2
	Venkat Nagar	396.8	403.3	411.2	411.2	411.2	80.1	438.3	630.2	678	706.5
3	Pushprajgarh	1229.2	1265.2	1348	1373	1373	94.4	291.0	558.4	661.2	677.6
	Amarkantak	1607.9	1636.3	1697.7	1721.1	1721.1	190.7	382.3	633.1	886.3	916.7
	Benibari	776.5	787.5	809.8	819.8	819.8	58.4	262.4	169.2	489.6	510.6
4	Kotma	1301.4	1308.4	1336.4	1336.4	1336.4	44.2	302.4	570	596.1	634.9
	Bijuri	864.9	872.5	878.9	880.5	880.5	57.7	249.7	390.5	465.5	494.9
Average Rainfall		**955.75**	**970.04**	**1007.40**	**1017.65**	**1017.65**	**77.35**	**328.90**	**499.48**	**592.81**	**623.20**

Source : DIP, Anuppur district

Table 5 : Monthwise Rainfall data from 2016 – 2020 year for the Anuppur district.

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F	R/F
2016	13.5	0	12	0	5.1	127.4	309.8	362.7	203.2	19.7	0	0
2017	1.2	12.6	2	0	2.1	169.5	236.8	357.2	129.3	24.2	0	0
2018	0	10.3	0	27.2	22.8	134.6	306	283.8	119.4	0	0	23.1
2019	27.5	16.5	42.6	8.6	8.9	123	324.6	447.2	447.6	20.1	0	9.2
2020	48.7	39.9	92.1	28.1	24.6	247.5	286.7	466.5	177.3	74.5	3.7	1.6

Source : IMD Rainfall Data

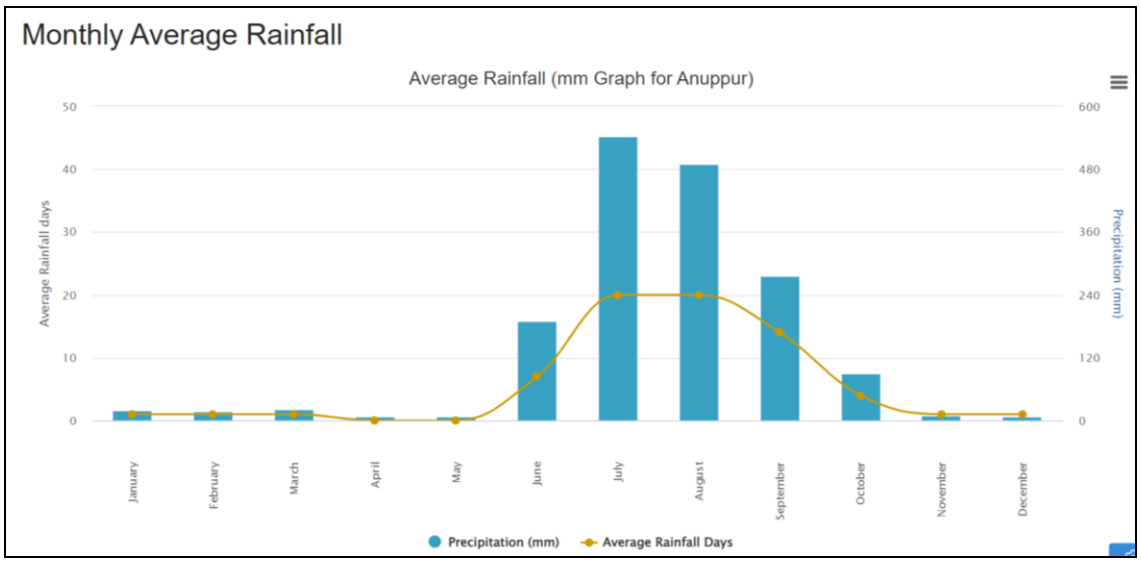


Figure 3 : Monthly Average Rainfall of Anuppur district

1.6 Temperature, Humidity and Wind Velocity

The normal maximum temperature recorded during the month of May and minimum during the month of December. The normal annual means maximum and minimum temperatures of Anuppur district are 31.6º C and 18.2º C respectively. During the south-west monsoon, the relative humidity generally exceeds 80 % during month of August. Relative humidity decreases during non-monsoon season. In summer season, relative humidity's are less than 38 %. May is the driest month of the year. The wind velocity in the area is higher, during pre-monsoon period as compared to postmonsoon season. The maximum wind velocity is observed during the month of June and minimum is recorded during month of November. The average normal annual wind

velocity of Anuppur district is 4.3 Km/hr The climate of Anuppur district, is characterized by a hot summer and general dryness during the south-west monsoon season. The year may be divided into four seasons. The cold season is December to February and followed by the hot season from March to about the middle of June. The period from middle of June to September is the south-west monsoon season. October and November form the post-monsoon or transition period. The following are the graphs of temperature variation, humidity and wind velocity (*(Source : worldweatheronline.com).* In the almost last 10 years the maximum wind velocity is observed in the year2010 and 2011which is 10 km/h and lowest wind velocity is observed in the year 2016 which is 4 km/h. Highest humidity 88 % in the district is observed in the year 2010 and lowest humidity 69% is observed in 2009. Highest cloud cover 75% in 2017 is recorded and lowest cloud cover 10 % is recorded in 2009.

Table 6 : Wind velocity, Rainfall , Humidity, Cloud and Pressure, Anuppur district

Year	Weather	Max	Min	Wind	Rain	Humidity	Cloud	Pressure
2009		34 °c	23 °c	4 km/h WSW	0.0 mm	64%	10%	1008 mb
2010		27 °c	22 °c	10 km/h ESE	2.6 mm	88%	66%	1002 mb
2011		30 °c	21 °c	10 km/h WNW	7.8 mm	86%	58%	1006 mb
2012		32 °c	21 °c	6 km/h W	0.0 mm	69%	24%	1006 mb
2013		33 °c	23 °c	8 km/h NE	0.9 mm	65%	28%	1002 mb
2014		33 °c	23 °c	6 km/h S	5.5 mm	70%	29%	1005 mb
2015		30 °c	22 °c	8 km/h SW	3.8 mm	77%	61%	1005 mb
2016		31 °c	24 °c	4 km/h WNW	28.2 mm	86%	52%	1005 mb
2017		30 °c	24 °c	7 km/h WSW	37.4 mm	86%	75%	1003 mb
2018		31 °c	22 °c	8 km/h NW	0.0 mm	68%	10%	1006 mb
2019		30 °c	21 °c	8 km/h E	11.1 mm	86%	33%	1009 mb
2020		33 °c	26 °c	6 km/h WNW	1.2 mm	70%	33%	1002 mb
2021		30 °c	22 °c	7 km/h WSW	3.3 mm	87%	69%	1008 mb
2022		31 °c	23 °c	7 km/h WNW	5.9 mm	83%	63%	1004 mb

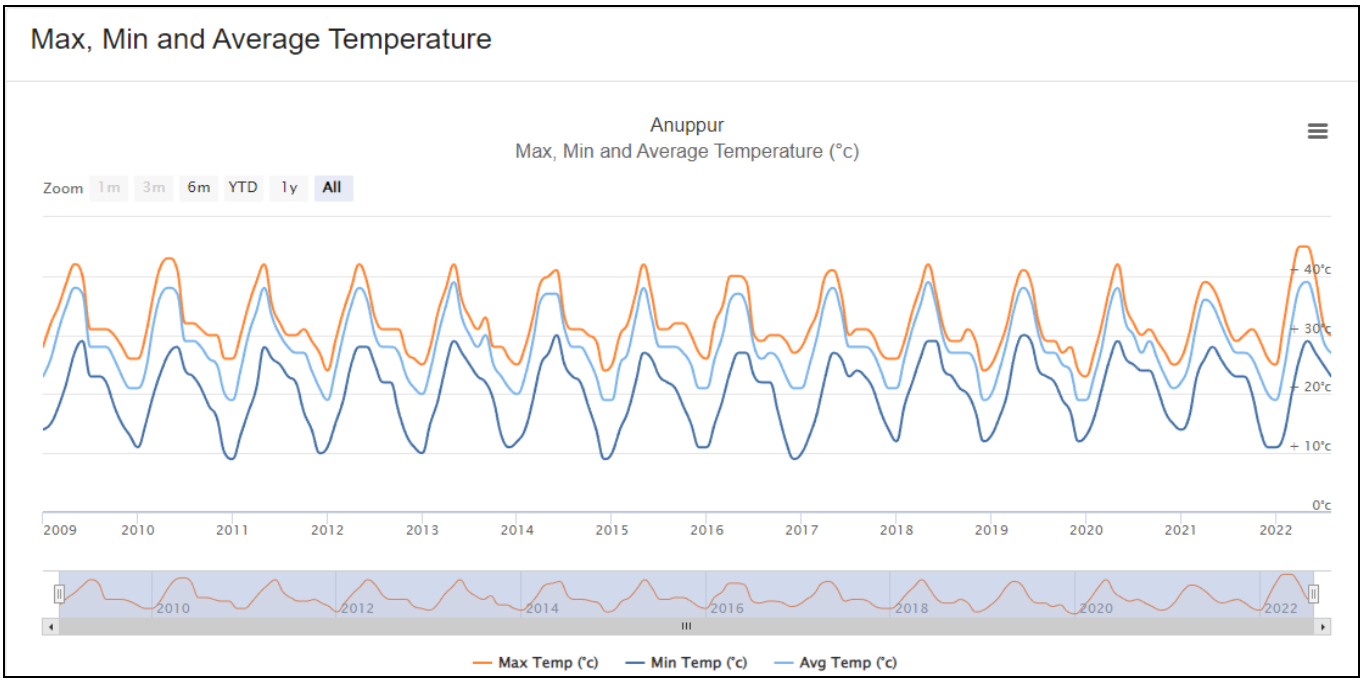


Figure 4 : Maxiumum, Minimum and Average Temperature Graph of Annupur district

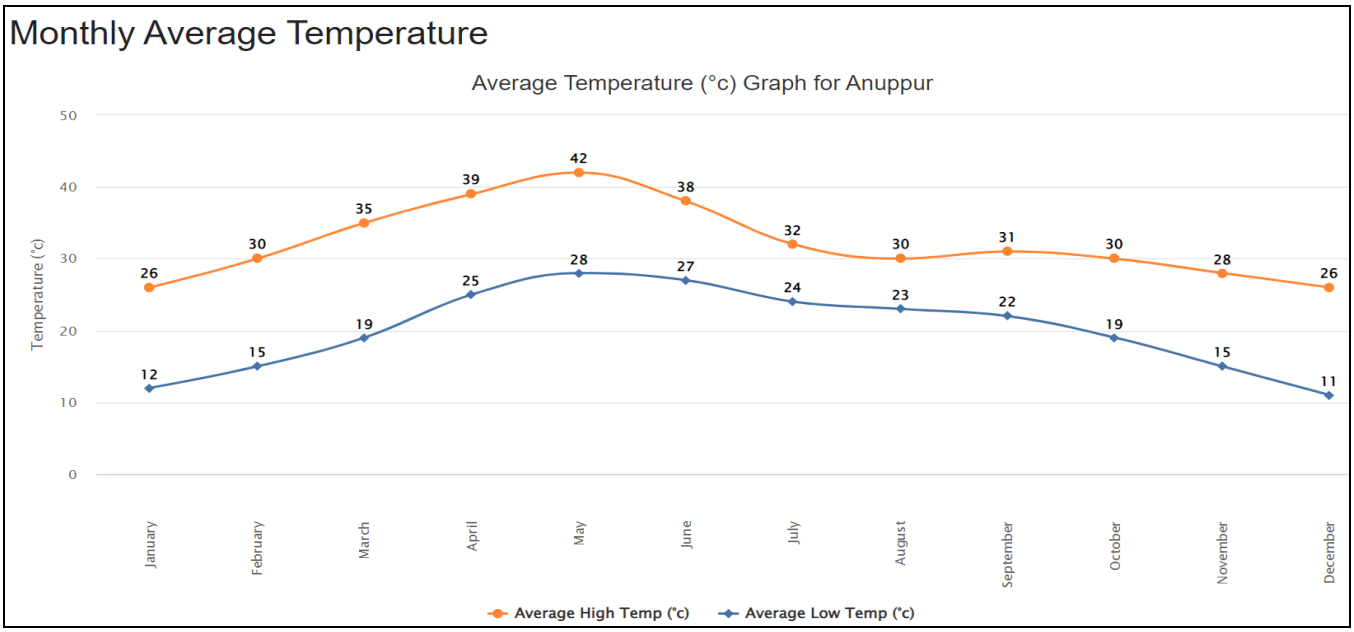


Figure 5 : Monthly Average Temperature Graph of Annupur district

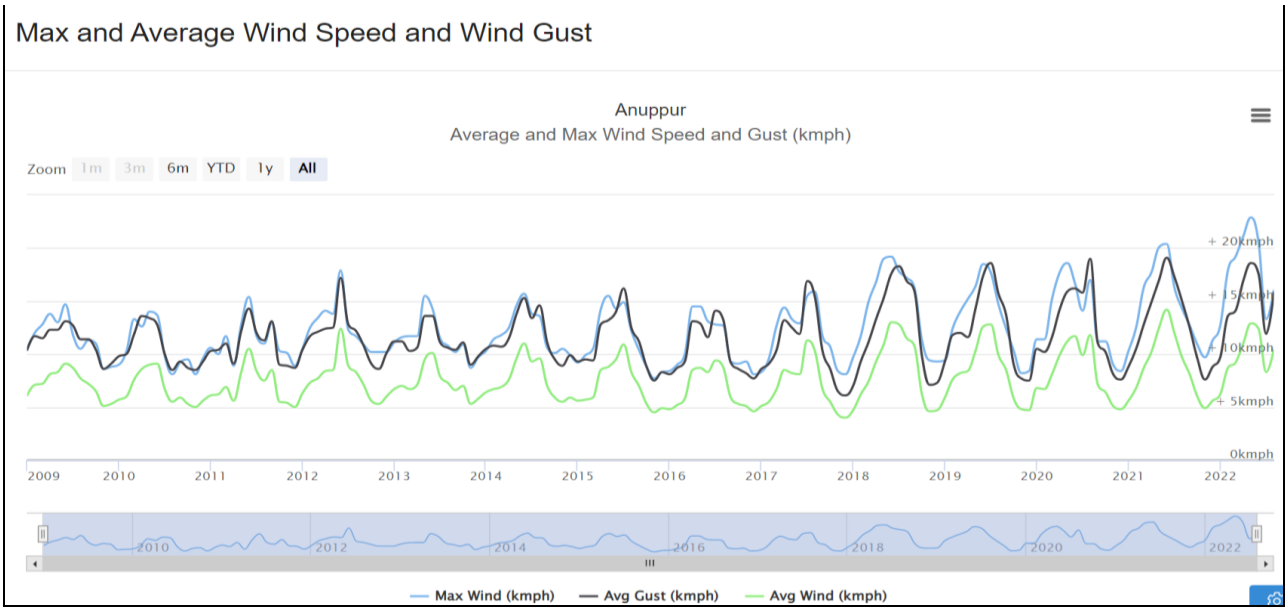


Figure 6 : Maximum and Average Wind Speed and Wind Gust Graph of Annupur district

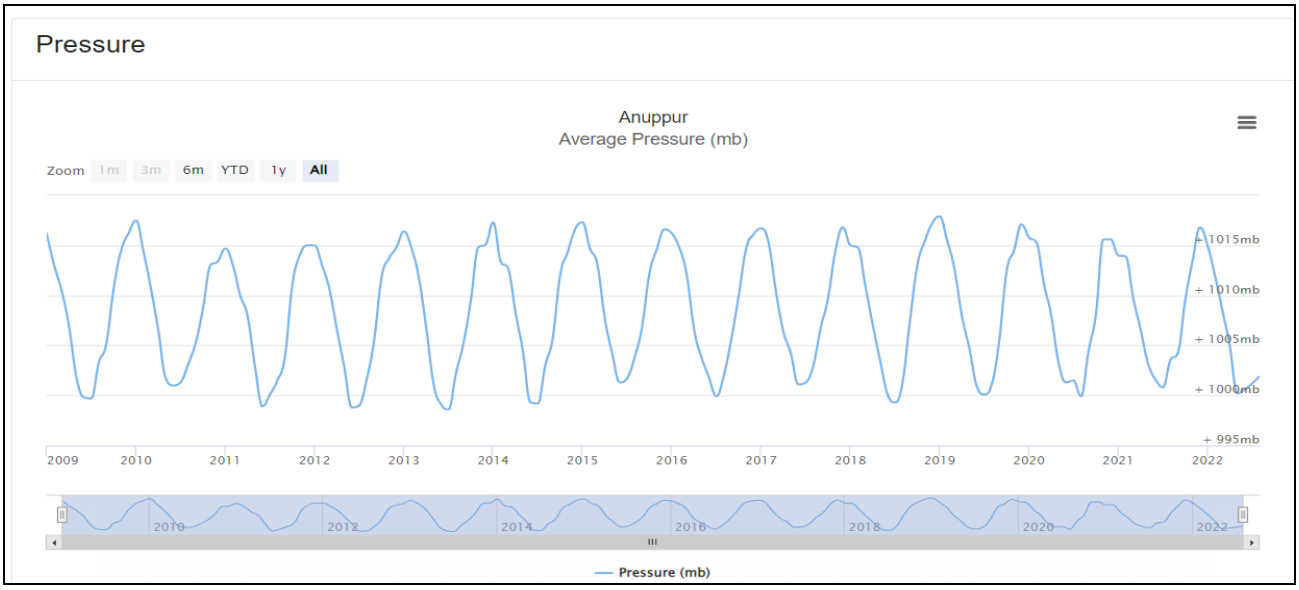


Figure 7 : Yearwise average pressure of Annupur district

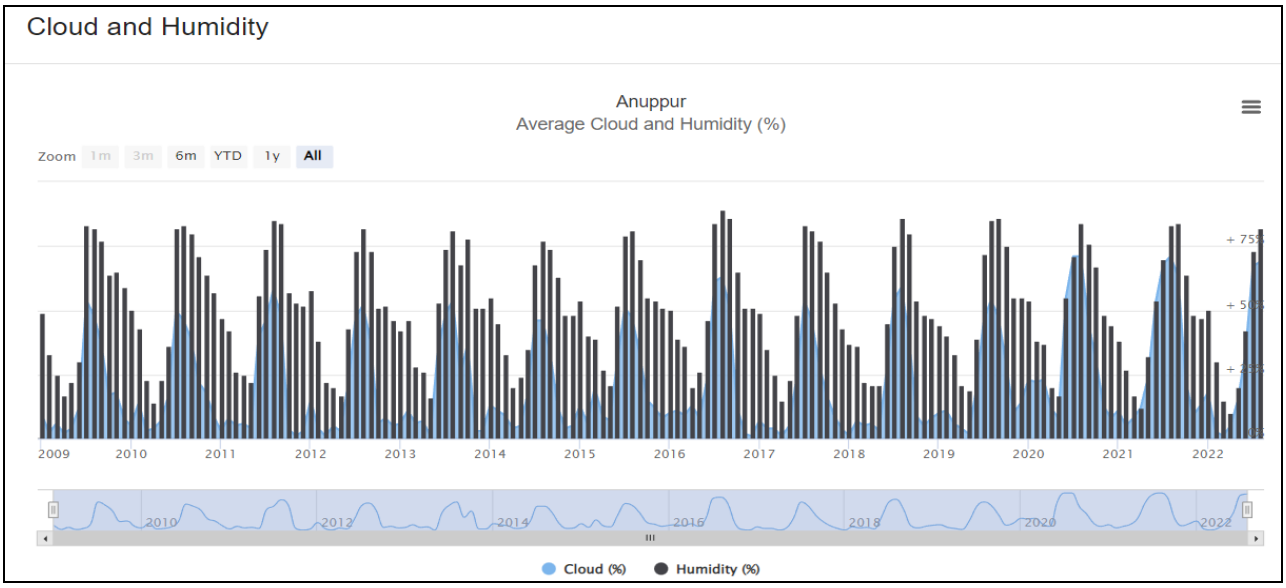


Figure 8 : Cloud and Humidity Graph of Annupur district

1.7 Physiography/Dem and Geomorphology Physiography

Anuppur is predominantly hilly and forested district. In general district is characterized by hilly to undulating terrain with an altitude above mean sea level ranging between 470 m to 1170 m approximately.

The main high relief features of the area are the Maikal Range and Maikal Plateau (Rajendragram plateau). The Maikal Range is a westerly off shoot of the Satpura Range. The later splitsinto two near Amarkantak hence it spreads in one branch towards west-north-west along an arcute axis as the “Maikal Range” almost westward. The two together define within themselves, the northern and southern boundaries of the Basaniha Plateau. The Secondary range of the Maikal bifurcates to the west (rather west-north west) from Parkighat. It runs nearly parallel to the main gauge and forms the Great Central Water Divide Line of India . It separates the waters of the Narmada in the south, from that of the Johila in the north. It is a narrow and disconnected chain in the east, enclosing the Basaniha Plateau. But after entering the Dondori district, it extends in a widemass of dissected hills. Here it almost joins the Main Range in the north, the greater course of the Johila, lying merely in the groove rather than the valley. Prominent peaks on this range area Bahnabgarh (about 1127m amsl) , Singargarh (ablut 1123 m

amsl), Jaithari(1071 m amsl) and Badargarh (about 1173 m amsl). There are other physiographic features like steep escarpments, buttes and Mesa that are quite distinct in Pushprajgarh tehsil.

The river Son is forming the valley in the district. The valley of Son extends in a narrow belt along the river. It is sequence of small open plains interrupted by closely approaching hills. The entire valley is in the midst of the plateau along the north-eastern course of the river and along the northern boundary. As the Son enters the Anuppur district fro Bilaspur district in Chhatisgarh state, it flows through an area of undulating topograpgy which extends for about 80 km, long up to the meeting point of the river Morne.

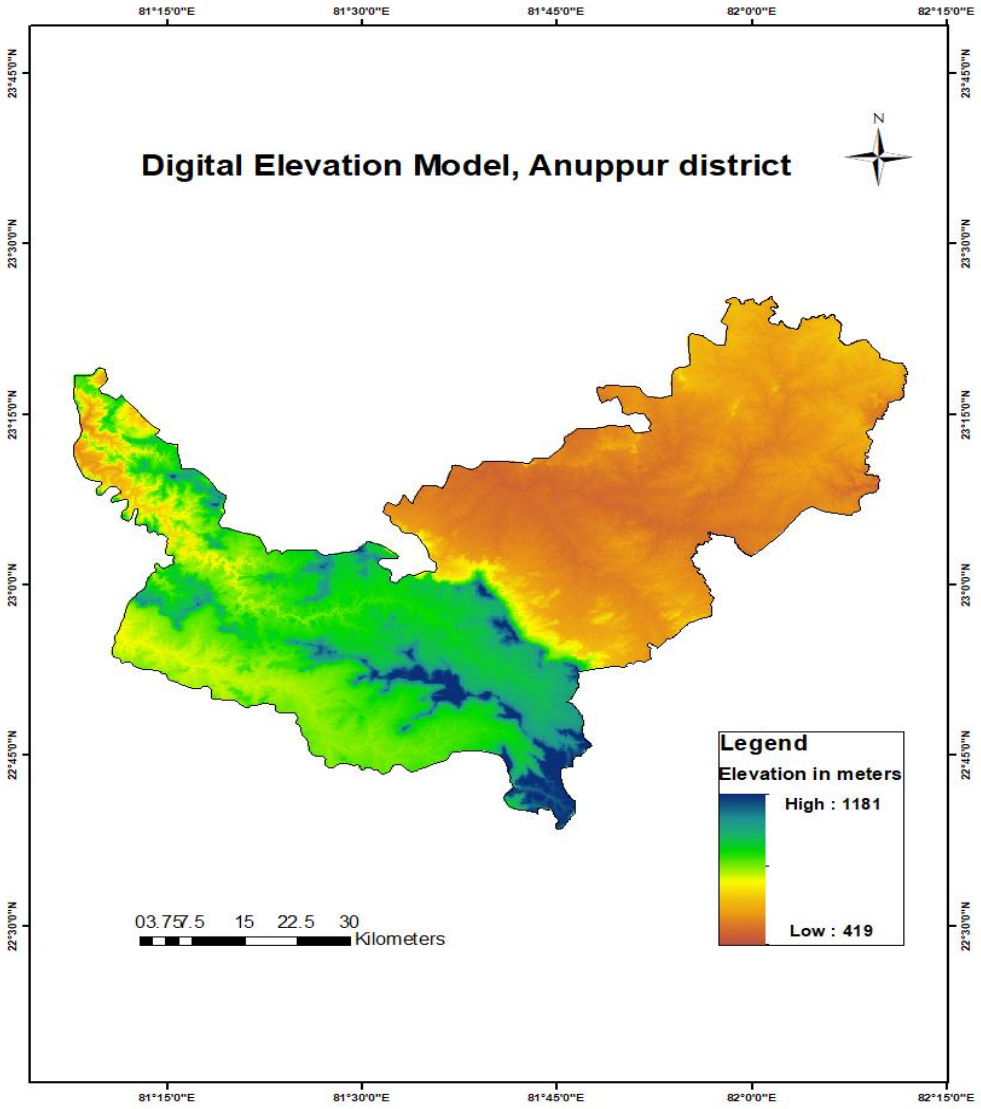


Figure 9 : Digital Elevation Model of Anuppur district

1.8 Geomorphology

From Geomorphological point of view, the district consists of series of mountain ranges and rivers. It can be divided into three geographical divisions:

1. High land of mountain ranges
2. The central plateau and
3. Low land of valley areas.

In general, Anuppur district is characterized by hilly to undulating terrain with altitude ranging between 470 m and 1170 m, above mean sea level. The main high relief features of the area are the Maikal Range and Maikal Plateau (Amarkantak Plateau) in south-east part of the district covered with deccan Trap Basalts. Some denudational hills/ hillocks are at foot hills of Rajendragram plateau. Linear ridges of intrusives (Dolerites) at northern and north-eastern part, and Plateaus in remaining part of the district. The river Son is forming valley in the district. The district is charactersied by different landforms which includes piedment, pediplain, butte, lateral bar, residual hills, scarp, bench, etc but mainly district is characterized pediment zone , pediplain and butte.

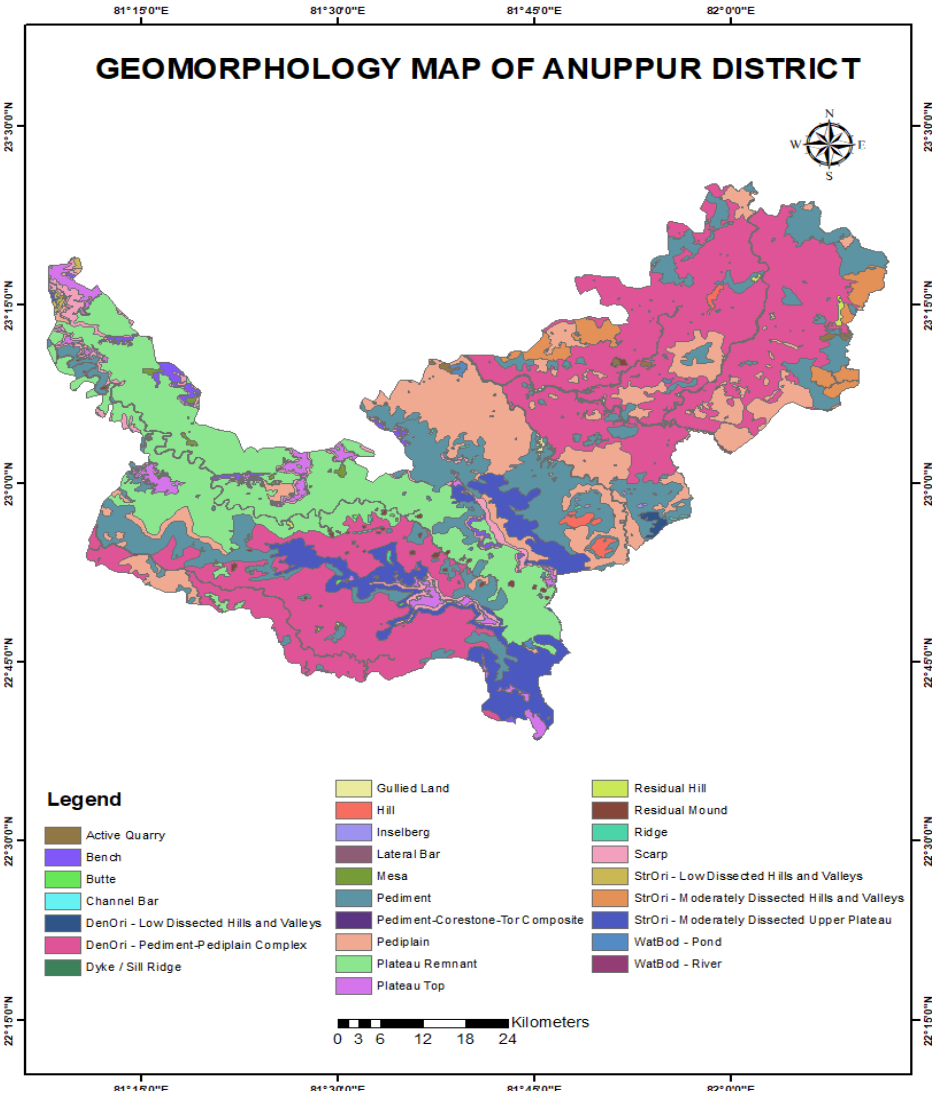


Figure 10 : Geomorphology map of Anuppur District

1.9 Hydrology And Drainage

Excepting small and narrow belt along the south-west boundary in Pushprajgarh tehsil which is drained by the river Narmada, entire Anuppur district forms of the Ganga system. The river Son is an important Tributary of the Ganga basin, drains the major part of the district. In between the river Narmada and Son the great central represented by north western branch of Maikal Range, which separates the river Narmada from the Son river.

The Narmada rises from the Amarkantak hill i.e. at 1057 m elevation. The place is locate at a somewhat wider place on the Maikal Range in the southern projection of Anuppur district. The

origin source is a small tank is called the Narmada Kund. The Narmada is one of the important rivers of India , flowing into the Arabian sea. At the initial stages of the Narmada is a placid stream flowingamidst the rocks and forests. About 7 km west it falls un a gorge named **Kapildhara** which is associated with the ancient sage "Kapil" by name. Within half a kilometer further down is the "Doodhhara" Fall with a lesser magnitude. While the drainage area of the Narmada extebds only about 6 to 12 km, to the north in Pushprajgarh tehsil, it receives the waters of Dindori district from a far off area, marked by the southern part of the Maikal Range. The Samrar nala is the only stream worth mentioning flowing into the Narmada in Anuppur district.

The Son is the main river of the district which flows from south east to north-west direction. The son rises from feeders of Son Kund at 22º42'30" and 82º02'10" E about 19 km south east of Pendra Road Railway Station in Bilaspur district (C.G.). The place is called Sonmuda and is marked by few Shiv temples. The son flows to the north for about 29 km and turns to the north west before it enters the Marwahi plateau in Chhatisgarh. The important tributaries of the Son in its early course in Bilaspur district are the Khujinala, The Ganganai nala and the Gujar nala. The ujar joins the sons at a point where it enters Anuppur district, the river is joined by the Keuai and Gohira on the right bank and Tipan and Gular Nadi on the left bank.

The Johila is an important tributary of the Son in the district. It is also one of the scared river. Actually main water divide is running between river the Johila and the Narmada, which separates the Ganga basin from the Narmada basin. TheJohila rises on the western slopes of the Maikal Range (Main) at the foot of Deoshani peak (3687 feet). The river flows to the north west and it collects the waters between the main range and the central water divide. Its course is somewhat open only initially on the high plateau around Basaniha village. About 10km west of Basaniha, the river enters such hilly tract that its entire north-western course remains nearly a precipitous grove about 500 meter below the marginal hill tops. Its meanders in the hills are numerous and defined.

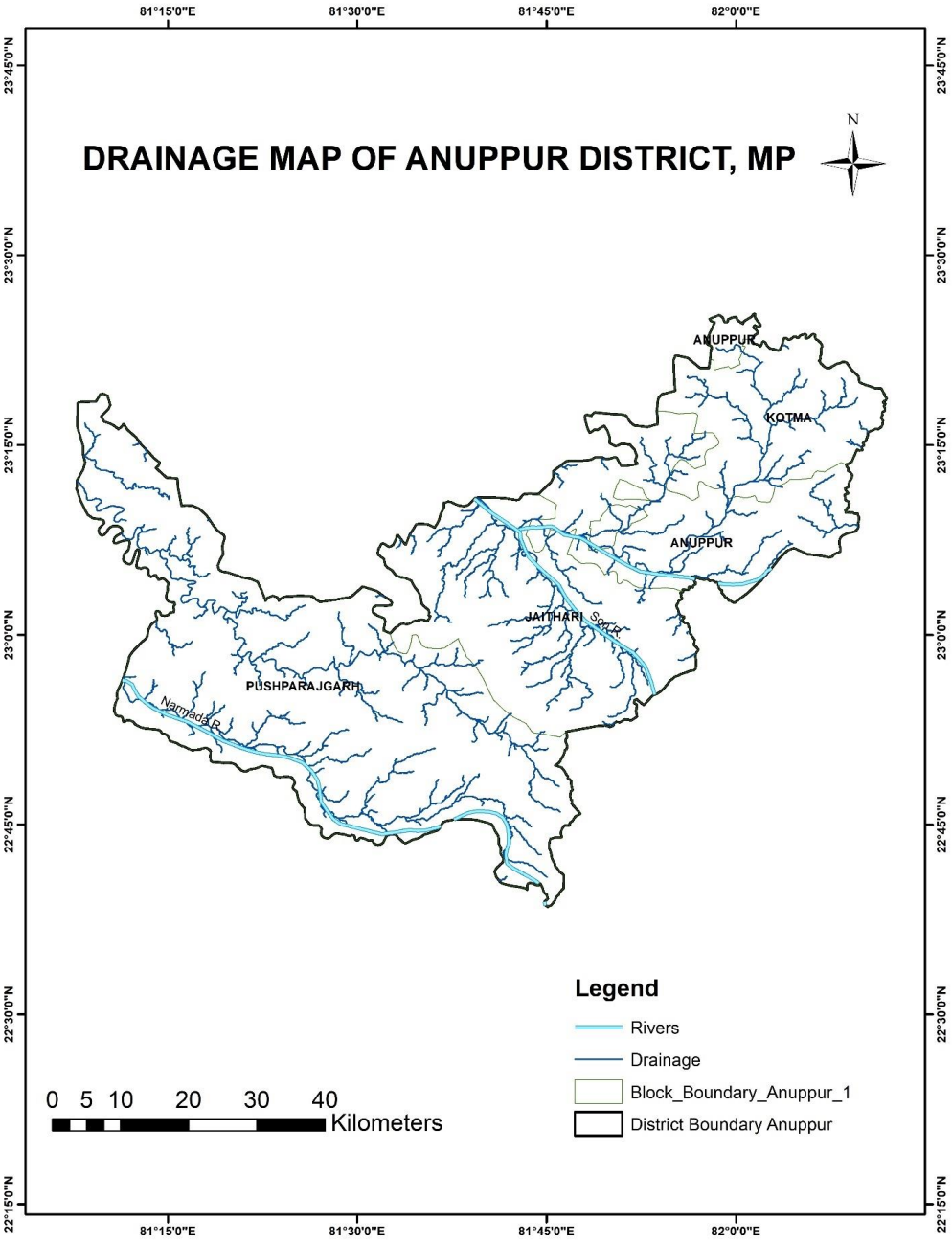


Figure 11 : Drainage Map of Anuppur district

1.10 Soil Cover

The district is mainly covered by three types of rocks, namely bsalts, Lamets and Gondwanas. Soil is also depending upon lithology od the area. Hence soils of the area has been classified into three groups

1) Soils of Basaltic rocks

2) Soils of Lameta rocks
3) Soils of Gondwana rocks.

Soils of Basaltic rocks are occupying major south west part of the area. Soils of Lameta rocks is reported in isolated patch in south west corner of the district surrounded by basaltic soils. Soils of Gondwana rocks area covering north-east part of the district. Soils of three categories are further calssified as per the classification of National Bureau of Soil Survey and Land Planning, Nagpur and they are described in the given map.

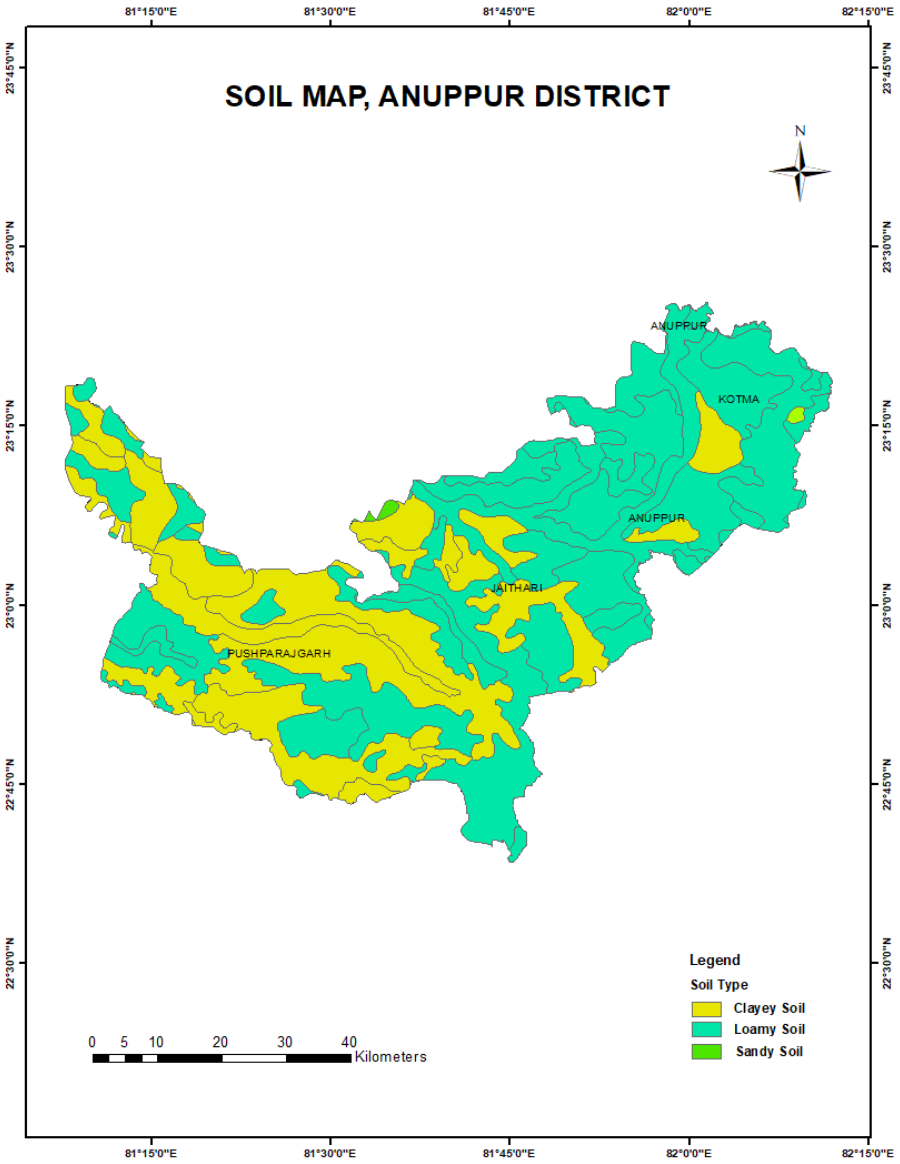


Figure 12 : Soil Map of Anuppur district

1.11 Geology

Geologically, Anuppur district is occupied by rocks of different ages right from Archeans to recent period. The generalized geological succession of the district is given below-

Geological succession of the Anuppur district

Age	Lithology	Formation
Cenozoic	Laterite	Reddish Brown, Hard massive rock
Upper Cretacceous	Deccan Trap	Basalt
Eocene		
.....Unconformilty.....		
Creatacceous	Lameta Beds	Limestone, green felspathic sandstone
.....Unconformity.....		
Permian	Barakar formation	Coarse feldspathic sandstone
(Lower Gondwana)		
Carboniferous,	Talchir Group	Light grey well sorted sandstone, olive green
to Permian Shale		silty
.....Unconformity.....		
Archean	Crystalline Rocks	Granite, granitic gneiss

Archeans

Archeans are the oldest formations forming basement for various rocks in the district. Granites and granitic gneiss are the main rocks of archean group occurring in the district.

Archeans are exposed in the south eastern part of the district in Anuppur amd Jaithari block areas. Exposures of granitic rocks can be seen on ropad cuttings near village Kirar on Anuppur – Amarkanta road at foothill of Rajendragram plateau. Granitic rocks are also exposed along railway track between Jaithari and Venkatnagar on Anuppur – Bilaspur railway section. The gneissies are traversed by aplitr and pegmatite bodies.

Out crops of Archeans in Johilla valley show development of augen structures in pinkish granite-gneisses having foliation dips towards north west direction.

Talchir Formation

Talchir formation are overlying archean rocks unconformably in south easter part of the district. The lithological assemblags of Talchir formations include light grey well sorted sandstone, olive green silty shales, tillites and basal conglomerate.

Barakar Formation

Major north eastern part of the district is underlain by Barakar sandstones of lower Gondwana group. Barakar formation conformably overlies the Talchir formation. The Barakar formation consist of three stages. The lower stages varies in thickness from 30m to 110m the Johilla basin. It consist of coarse to medium grained sandstone with subordinate carbonaceous shale. The middle member contains most of coal seams. It consists of grey shale, carbonaceous shale, sandy shales and coal seam. The upper member is characterized by massive coarse grained sandstone with minor amount of grey shale.

Lameta Beds

Lameta Beds occur along the fringes of Deccan Trap covered hills in the south western part of Anuppur district. They rest unconformably over the Gondwana strata consisting of greenish and reddish feldspathic sandstone with cherty limestone thicjness of Lameta beds varies from few meters to 75 m observed in CGWB exploratory well drilled at Keolari located in south west boundary of Anuppur district.

Deccan Traps

Deccan Trap basalt of creataceous to Eocene age is exposed in major south-western part pf the district. Dykes and sills of dolerite are common in the area, trending ENE-WSW to east west direction. There are the vast stretch of thick basaltic lava flows that occupies the huge area of the south weatern part of the district called Pushprajgarh. There are quite a few number of successive lava flows which are now carved out in varieties of geomorphic units. The thickness of the flows varies from 13 to 17 m . The total thickness of the lava flows is of the order of 600 m.

Laterites

The laterites belonging to Cenozoic (sub recent) period are found over basalts as capping. Development of lateritic profile due to weathering of the trap rock in the south western part of the district resulted in the formation of bauxite bodies. Amartantak area below the peak peak, is known for bauxite deposites. As per estimates that bout 5 millions tones of bauxite reserves of more than 45% Al2O3 are present in the area.

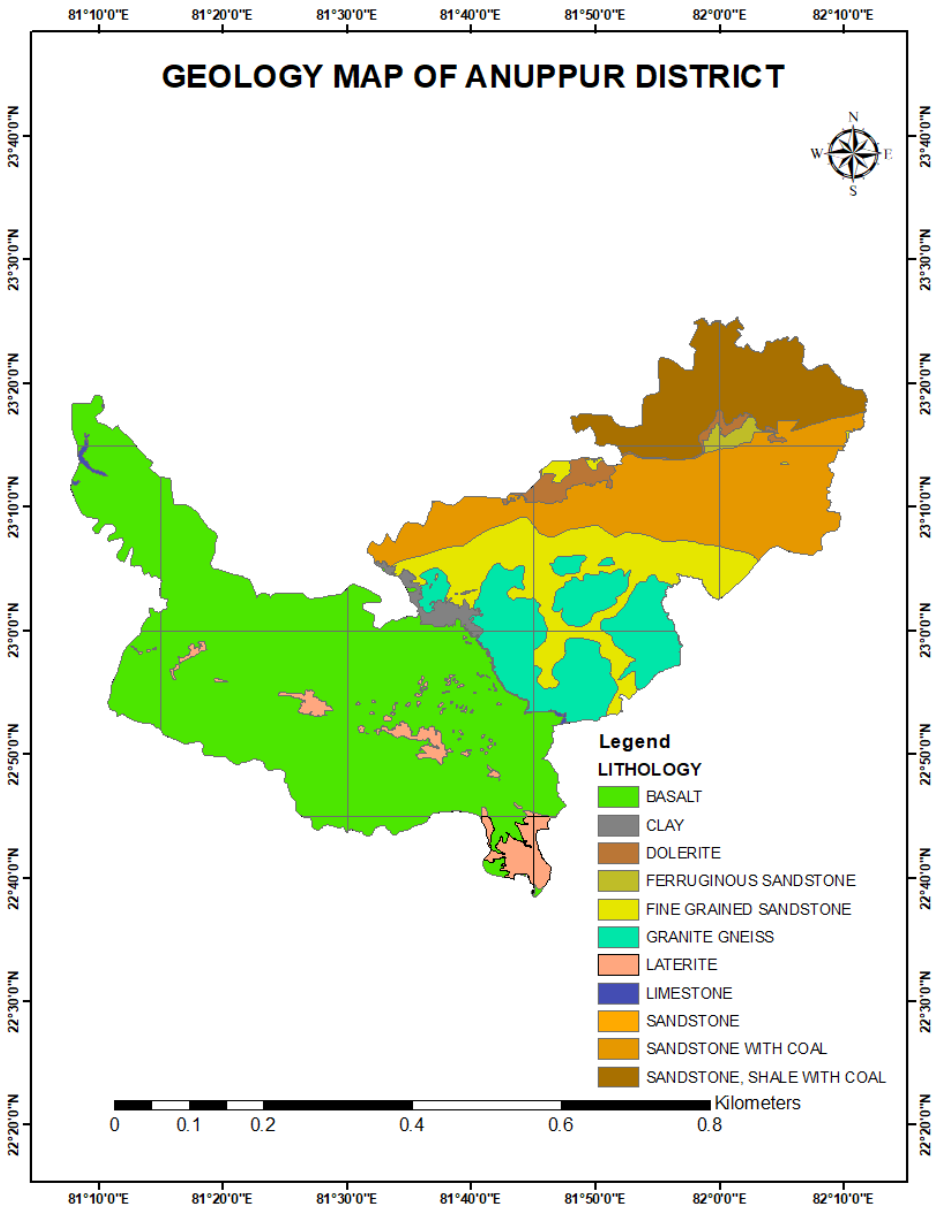


Figure 13 : Geology Map of Anuppur district

1.12 Land Use, Irrigation, And Cropping Pattern

Total land area available in Anuppur district is estimated as 374671 Ha. Out of that 162131 Ha is net sown area, 89028 Ha is forest land, 49884 Ha is fallow land, 52913 Ha is that geographical area which is uplift for agricultural purposes. 4039 Ha is grass land and 16676 Ha is other land area. The detailed description of land utilization is given below-

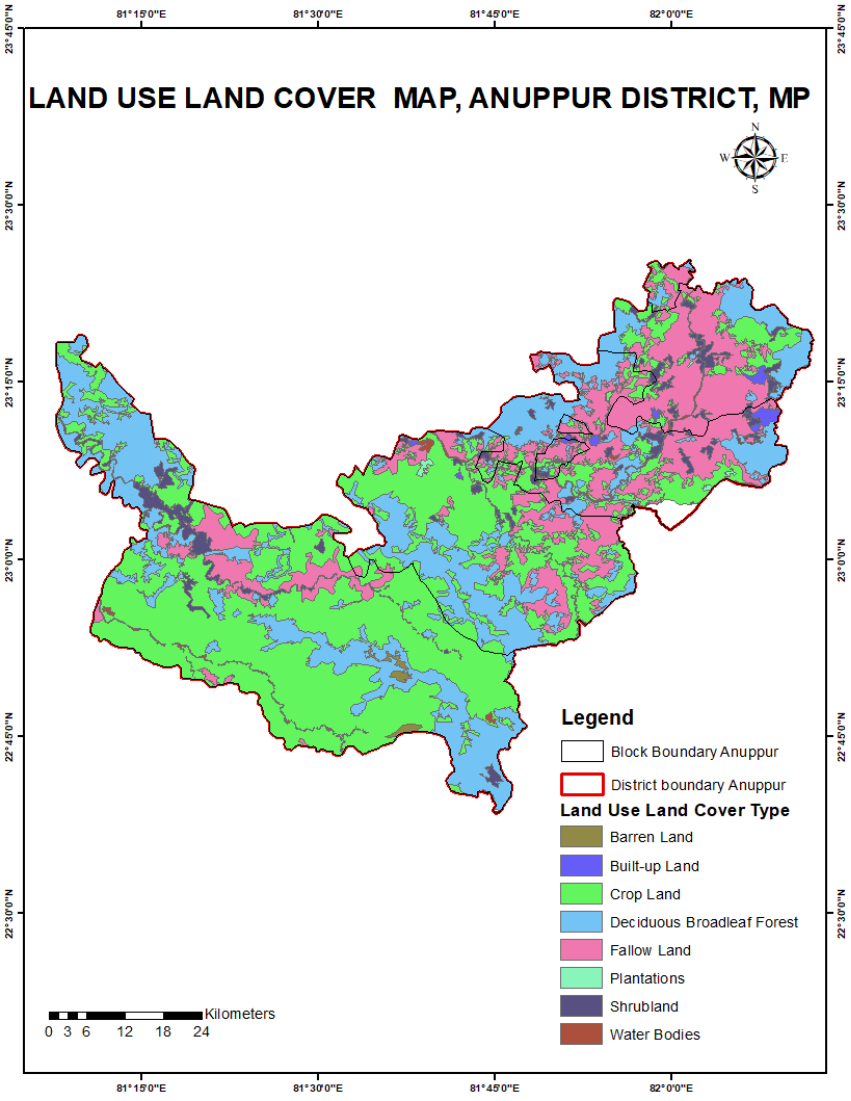


Figure 14 : Landuse Map of Anuppur district

Table 7 Land Utilization Statistics

Block	Geographical Area	Forest Area	Land Unnder Non-Agricultural Use	Cultivable Waste	Permanent Pastures	Current Fallow	Net sown area	Area sown more than one	Gross Crop Area
	Ha								
Anuppur	30211	15291	7556	639	7440	6447	29285	1410	10719
Jaithari	97247	25835	11941	1117	12530	11358	45764	6145	12341
Pushprajgarh	176372	28848	28813	1910	26032	38601	95769	25834	16790
Kotma	40841	11479	5659	654	4598	4533	18451	505	7341
Total	374671	76453	53969	4380	50600	60939	189269	33894	47191

Table 8: Area wise, crop wise irrigation status												
	Kharif Area (Ha)			**Rabi (Ha)**			**Summer (Ha)**			**Total Area (Ha)**		
	Irrigated	**rainfed**	**Total**	**Irrigated**	**rainfed**	**Total**	**Irrigated**	**rainfed**	**Total**	**Irrigated**	**rainfed**	**Total**
Anuppur	0	25473	25473	806	1457	2263	25	0	25	831	26930	27761
Jaithari	1	38844	38845	4046	5869	9915	145	0	145	4192	44713	48905
Kotma	0	16312	16312	381	595	976	18	0	18	399	16907	17306
Pushprajgarh	0	72829	72829	1461	40452	41913	52	0	52	1513	113281	114794
Total		153458	153459	6694	48373	55067	240	0	240	6935	201831	208766

Table 9 : Existing Irrigation in the Anuppur district											
	Srface Irrigation					Ground Water Irrigation					
	Cansal based		Tanks/Ponds/Reservoir			Tubewell		Openwell		Borewell	
	Govt canal	Community/private canal	community pond	indiviual/pvt ponds	Govt reserv/dam	Govt	Private	Community/Govt	Pvt	Govt	Private
Anuppur	0	0	0	0	1341	0	0	0	13770	0	266
Jaithari	0	0	0	0	3102	0	0	0	2059	0	485
Kotma	0	0	0	0	343	0	0	0	1375	0	270
Pushprajgarh	0	0	0	0	5006	0	0	0	2058	0	315
Total	0	0	0	0	9792	0	0	0	19262	0	1336

CHAPTER – 2

DATA COLLECTION AND GENERATION

The data collection and compilation for various components was carried out as given below.

Hydrogeological Data – Current and historical water levels along with water level trend data of monitoring wells. In the district exploration not carried out except 5 piezometers constructed. Therefore 64 key wells established to know the hyrogeological condition of the district. The weathered zone thickness (aquifer-I), lithology, water level data and various details of key wells extablished in the Annupur district were collected and compiled.

Hydrochemical Data - Ground water quality data of NHS monitoring wells of CGWB & Dugwell established representing shallow aquifer and borewell/Handpump samples collected representing deeper aquifers.

Exploratory Drilling – Ground water exploration data of 5 piezometers of CGWB.

Hydrometeorological Data - Rainfall data for the whole district from District Irrigation Plan and Indian Meterological Department, Annupur district

2.1 Data Availabilty

The compiled data were plotted on a 1:50000 scale map, and analysis of the data gap was carried out. The available data of the Exploratory wells drilled by Central Ground Water Board, North Central Region, Bhopal, Geophysical Survey carried out in the area, Groundwater monitoring stations and groundwater quality stations monitored by Central Ground Water Board we recompiled and analysed for adequacy of the same for the aquifer mapping studies. The summarized table presenting the data requirement, data availability, and data gap analysis is presented in the following table.

Table 10: Data Requirement and Data Availability

S.No	Items	Data Requirement	Data Availability	Data Gap
1	Rainfall Data	Meteorological stations spread over the project area.	hydro.imd.gov.in District Irrigation Plan, Annupur district	
2	Soil	Soil map and Soil infiltration rate	Prepared in ArcGIS	
3	Land Use	Latest Land Use Pattern	Prepared in ArcGIS	
4	Geomorphology	Digitized Geomorphological Map	Bhukosh.	
5	Geophysics	Geophysical data in each Quadrant	No VES done till now	VES Required
6	Exploration Data	EW in each Quadrant with Aquifer Parameters	12 Borewell and 5 piezometer has been drilled till date (salient features of 12 BW and 5 piezomter litholog details are available)	Exploratory wells required
7	Aquifer Parameters	Aquifer parameters for all the quadrants	Not Available	
8	Recharge Parameters	Recharge parameters for different soil and aquifer types based on field studies	Recharge parameters are given in Ground Water resource estimation	
9	Discharge Parameters / Draft Data	Discharge parameters for different GW abstraction structures	Discharge parameters are given in Ground Water Resource Estimation GEC 2020	
10	Geology	All the maps on a 1:50000 scale	Bhukosh (Prepared in ArcGIS)	

Table 11 : Summarised Hydrogeological Data of Boreholes

S.No.	Location	Latitude	Longitude	Year of Construction	Depth Drilled (mbgl)	Depth of Construction (mbgl)	Major Lithology encountered	Zones Tapped (mbgl)	Static Water Level	Discharge (lps)	Drawdown (m)	S EC (micromhos/cm)
1	Bakho	23°12'56"	81°36'00"	1988-93	232		Barakar sandstone	35-38, 59-66, 69-74, 105-113, 139-150	12.36	2.51	10	
2	Anuppur	23°07'04"	81°42'13"	1988-93	166.81		Talchir Sandstone	36-46, 85-95, 99-108	70.43	0.25	39.54, 22.31	950
3	Karanpathar	22°58'15"	81°20'00"	1988-93	153.13		Basalt/Lameta	10.50-14.50, 32-35, 48-53, 61-70, 103-108, 131.83-151	7.44	3		
4	Ghoghari	22°55'35"	81°15'50"	1988-93	158.16		Basalt	18-20	8	3.4	11	193
5	Benibari	22°54'45"	81°20'15"	1988-93	104.1		Basalt	73.70-104.10	39.6	6	0.98	

S.No.	Location	Latitude	Longitude	Year of Construction	Depth Drilled (mbgl)	Depth of Construction (mbgl)	Major Lithology encountered	Zones Tapped (mbgl)	Static Water Level	Discharge (lps)	Drawdown (m)	S EC (micro mhos/cm)
6	Khetgaon	22°52'00"	81°25'15"	1988-93	111.32		Basalt/Lameta	60-72	21.1	15.9		
7	Keolari	22°46'25"	81°29'45"	1988-93	83	83	Lameta	48-75	17.43	25.27		
8	Basaniha	22°54'10"	81°36'00"	1988-93	171.5	171.5	Basalt/Lameta	134-170	39.38	meagre		
9	Karaundi	22°53'05"	81°43'45"	1988-93	106.5	106.5	Basalt	43.44-52.63, 61.73-70.93, 88-93	14.1	1	20	
10	Pipraha	22°51'30"	81°40'30"	1988-93	122.16		Basalt/Lameta	60-70	>30	6	20	142
11	Bhejri	22°49'15"	81°42'18"	1988-93	122.1		Basalt/Lameta	31.68	4.7			
12	Jamuna Colliery	22°09'00"	81°55'00"	1978-80	90.4	90.4	Barakar Sandstone	13.65	14	13.4		122

2.2 Data Generation

Data on all the attributes of Aquifer Mapping has been generated based on the data availability and data gap analysis. The data generated and data collected from various state governments agencies are summarized in the following table.

Table 12 Data Generated and Data collected for Aquifer Mapping Area

S.No	Items	Data Generated	Data Collected
1	Rainfall Data	-	hydro.imd.gov.in and District Irrigation Plan
2	Ground Water Exploration	64 Key wells	5 piezometer
3	GW Regime Monitoring	64 Key wells established	Water level samples collected
4	Chemical Quality	64 Samples of NAQUIM in 2022 and 17 samples of NHS in 2022.	Water samples collected for analysis

2.3 Hydrogeology

Occurrence of Ground Water

The major source of groundwater recharge in Anuppur district is rainfall. Anuppur district is underlain by various geological formations, forming different types of aquifers in the area (Fig 2). Main lithological units of the area are, Archaeans, Gondwanas, Lametas and Basalts. Occurrence and movement of ground water in hard rocks is essentially by development and nature of secondary porosity through joints and fractures. Primary porosity in Gondwana rocks and vesicularity in basalts play and important role. Lametas are also potential aquifers made up of relatively loose and friable material. Ground water in general occurs under unconfined to semi-confined conditions. The occurrence and movement of ground water in different lithological units is described below:

Archeans :

Granites and Granitic-Gneisses are main rock types, occurring in south-east part of the district. They are crystalline hard rocks, forming basement in the district. They yield water through fractures, joints and secondary porosity developed in weathered portions. In Jaithari block area, quite many dug wells exists in these formations and wells yield moderate quantity of ground water. The yield depends upon the saturated thickness of the weathered mantle overlying the massive rock. The open wells that exists in these formations, range in depth from 8m to 20mbgl. The general yield potential of Archeans is less than 180 L.P.M..

Gondwanas :

The semi-consolidated Gondwana group of rocks, that bears coal deposits are forming main ground water reservoir in this district. The felspathic, medium to coarse grained sand stone, bears ground water in the interconnected primary pores in the formation, as well as the contact planes between shales and sand stones. Coal seams in Gondwana formations are acting as confining layers giving rise to artesian conditions at several places. Ground water is also mined out along with the coal in almost all coal fields of the district. Ground water occurs in unconfined, semi-confined and confined conditions in the Gondwana formations of the district. It is reported that due to excessive pumpage of ground water from the underneath coal mines, there has beenappreciable lowering of water levels in the phreatic ground water regime overlying the coal field area, particularly in Kotma block area. Gondwana formation particularly the upper part of Barakar Sandstone support development of phreatic aquifers, which extends from few metres below ground level to 25 m below land surface. The Talchir formation of lower Gondwana group, comprising of well sorted sandstone, olive green shales and basal conglomerates are forming poor aquifer in the area. These formations are occurring southwards of Anuppur town. Exploratory well drilled by CGWB in Anuppur town has yielded only 15 L.P.M.discharge in Talchir formation. The Barakar formations which are upper part of lower Gondwanas are forming potential aquifers in the area. These formations are covering north and eastern part of Anuppur district. The yield of Barakar formations in the district is recorded between 150 and 960 L.P.M.

Lametas :

These are sedimentary deposits resting over Archeans /Gondwana formations and are overlain by Basalts. siliceous Lime stones of Lametas are compact and impervious in nature. Nodular lime stone and poorly consolidated sand stone of Lametas are forming good aquifers in the area. Lametas occurring below Basalts, are under semi-confined to confined conditions. Lametas are occupying hilly and forested area, where population and habitation is rather poor. Dug wells in this formation is generally used for drinking/domestic purposes by tribal population. It is observed that 80 % of dugwells are within the depth range of 8 m to 16 m, below ground level; with diameter of 3-4 m. CGWB had taken up exploratory drilling in Rajendragram plateau of Pushprajgarh Block, where Lameta beds are occurring below Basalts at deeper level. Since lametas are relatively loose and friable rocks found below Basalts at depth (more than 100 m), there is difficulty in drilling in this formation deploying DTH or DTH-Rotary Combination rigs. After penetrating basalts, drilling in loose and friable Lameta beds at depth more than 100 m becomes unserviceable using these rigs, because available rigs can not function to operate using rotary system at depth. Because of this reason CGWB had abandoned many exploratory wells in Rajendragram plateau area , where Lametas are occurring below Basalts. Thickness of Lameta Beds is recorded as 80 m at Keolari exploratory well site. Yield of Lameta beds recorded during exploratory drilling vary from 180 to 1500 L.P.M.

Deccan Traps :

These are Basaltic flows, forming hill ranges in south-western part of the district. Rajendragram plateau of Pushprajgarh Block is fully occupied by basaltic rocks. In basaltic terrain , ground water generally occurs under phreatic conditions in shallow weathered, jointed and fractured horizons. Basalt does not exhibit uniform nature, both vertically and laterally. Physiographic locations, thickness of weathered mantle, degree of joints, fractured or sheared zones, characteristics of vesicular horizons and their inter-connections are important factors, that play a decisive role in the yield capacity of open wells, tapping shallow aquifers. The deeper aquifer system appears to be under semi-confined conditions. Jointed/fractured form of massive unit is creating possibility of their acting as leaky confining bed, consequently resulting into semi-confined conditions for water bearing vesicular unit occurring beneath it. On the other hand if massive unit is compact and have not developed fractured porosity, then under favourable

conditions they may act as a confining bed for the water bearing vesicular horizon, occurring below it and thus leading to confined conditions. Dugwells in basaltic flows of Deccan Traps vary in depth from 6 to 15 m, below ground level and diameter ranges between 2 m to 3 m. CGWB had drilled number of tube wells in Rajendragram plateau of Anuppur district, and thickness of Basalt vary from 1 m (at Keolari) to 127 m (at Karanpathar). Yield of exploratory wells ranges between 60 to 240 L.P.M.

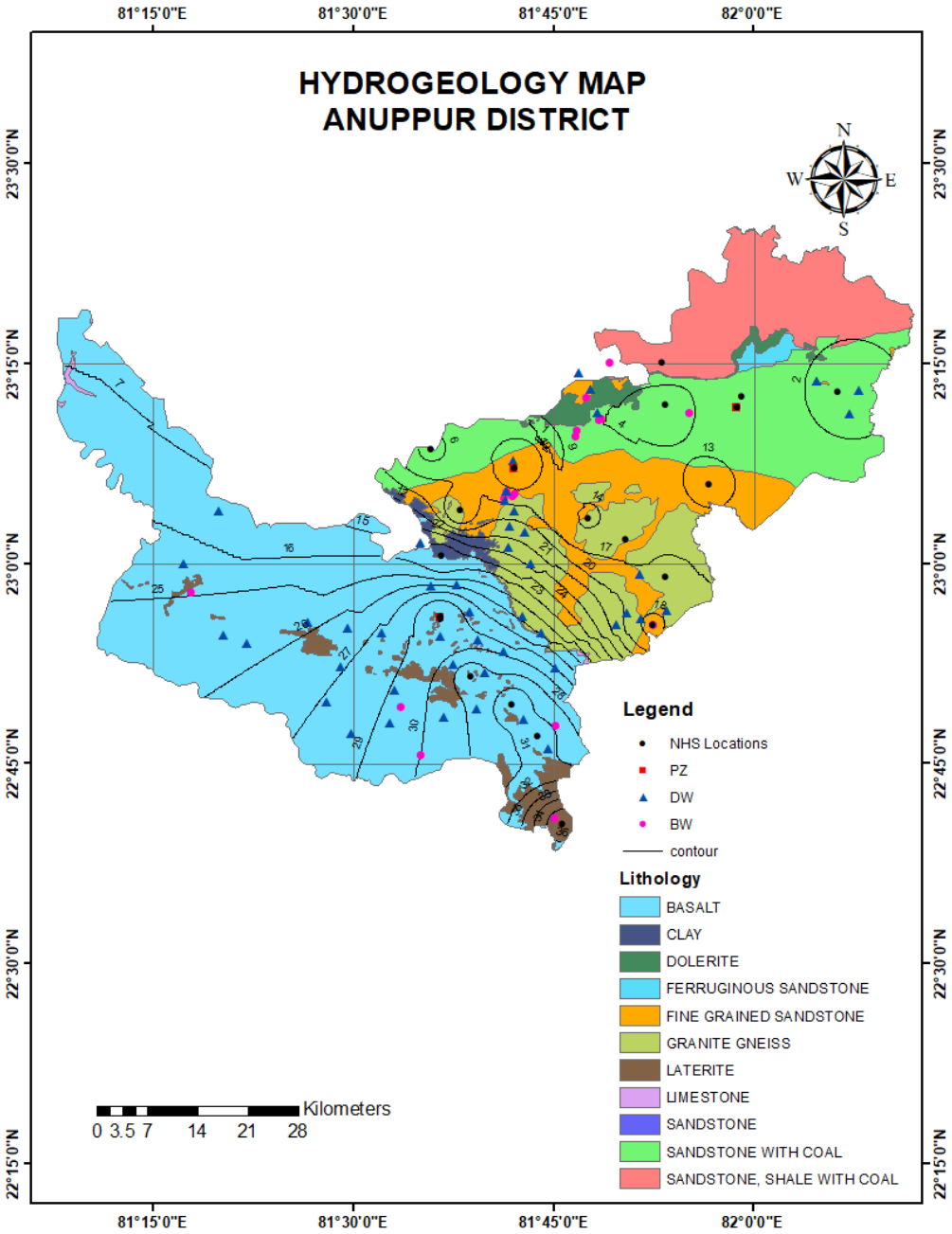


Figure 15 : Hydrogeology Map, Anuppur district

2.4 Ground water scenario

2.1 Water Levels

Ground Water levels form a very important parameter of the ground water system, as these are its physical reflection. Water level data, including historical data are essential for not only to know the present ground water conditions but also for forecasting future trends in response to ground water reservoir operations.

Pre monsoon Depth (May 2021) :

Pre-Monsoon depth to water level in the year 2021 range from **1.55 mbgl at Nagara Bandh site**, Kotma block (minimum) to **15.86 mbgl Venkat Nagar at site**, Jaithari block (maximum). In the district 80 % area is having the water level ranges from 2 – 5 mbgl and only in small patch water level is below 10 mbgl.

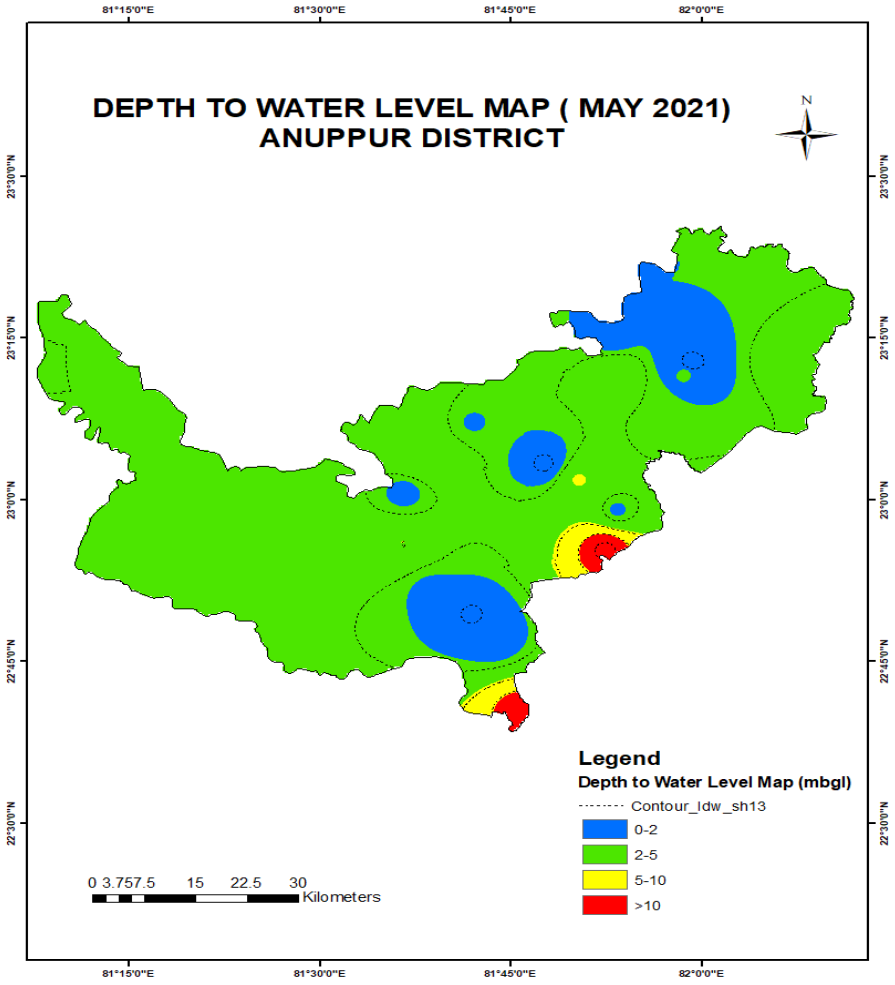


Figure 16 : Pre-monsoon Depth to Water Level Map 2021

Post Monsoon (November 2021)

During post monsoon period, water level ranges from 1.25 **mbgl at Nagara Bandh site**, Kotma block to **15.86 mbgl at Venkat Nagar site, Jaithari** block. In the district about 75 % -80 % area water level ranges from 1 – 2 mbgl specially in the block Kotma, Anuppur and Pushprajgarh.

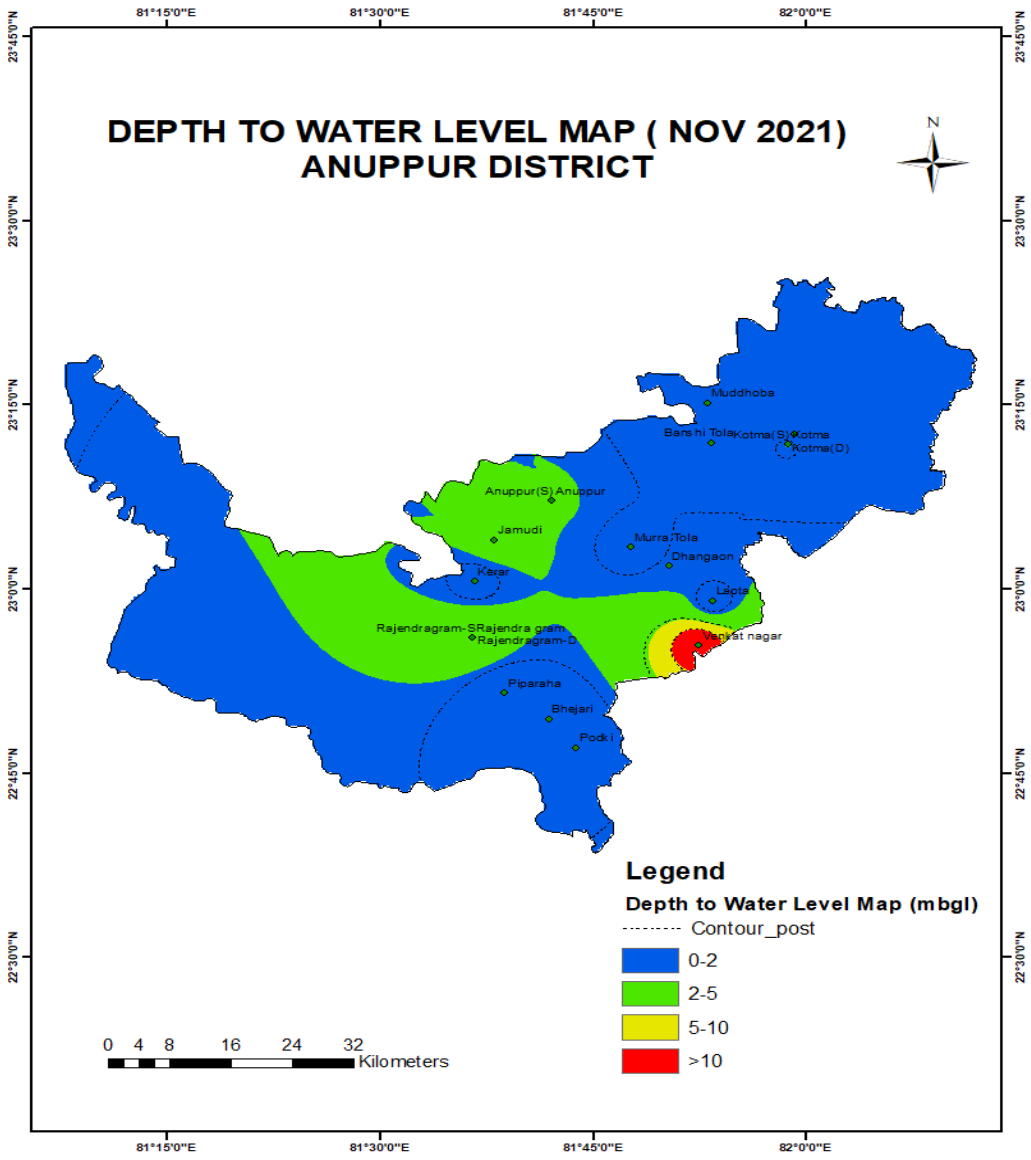


Figure 17 : Post monsoon Depth to Water Level Map (Nov 2021)

Pre monsoon Water Level Fluctuation Map (May 2012 – May 2021)

In the district water level fluctuation of 10 years (2012 – 2021) for the block Pushprajgarh and Jaithari block is below 2 m whereas for the block Anuppur and Kotma block water level fluctuation is 2 – 5 m. Only in small patch water level fluctuation is greater than 10 meter.

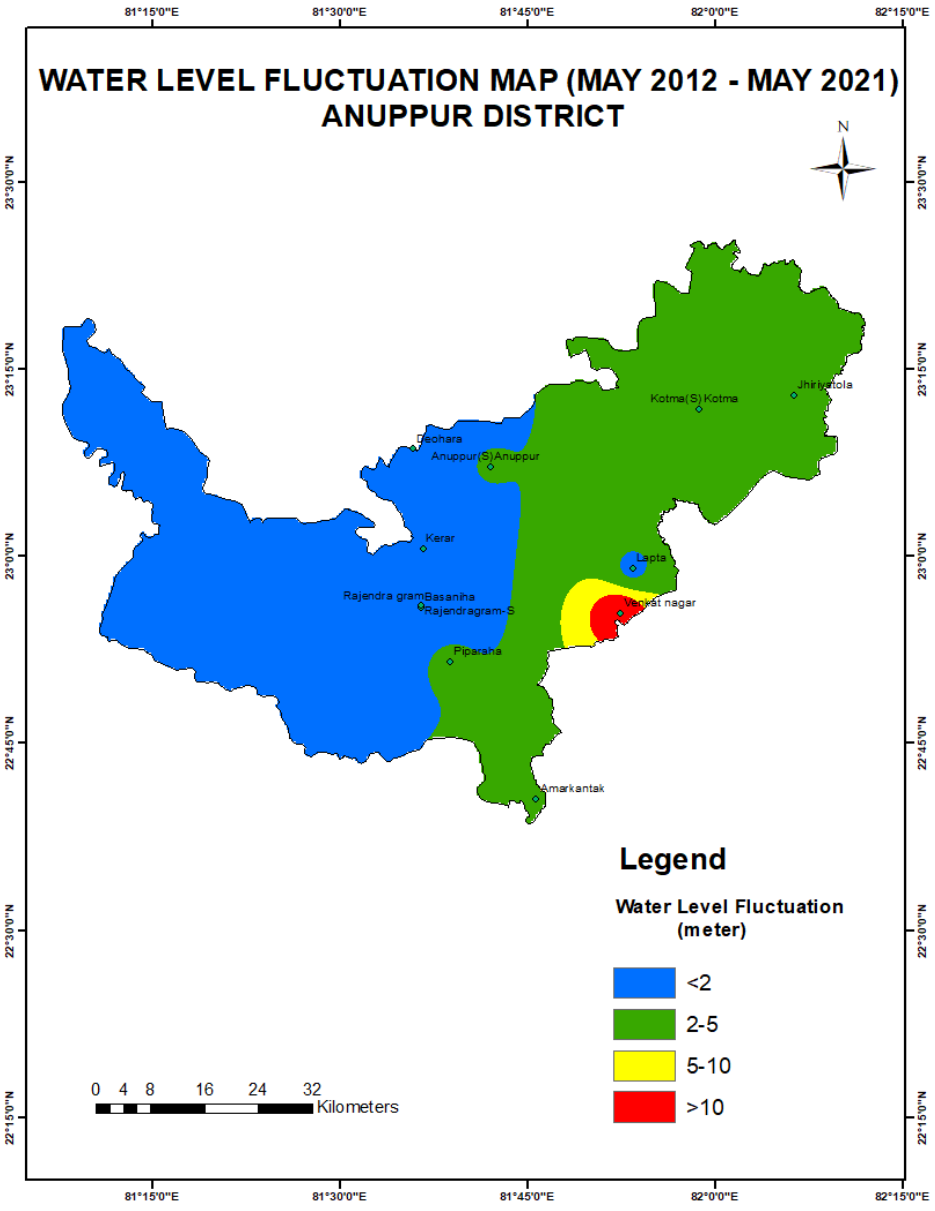


Figure 18 : Pre monsoon Water Level Fluctuation Map (May 2012 – May 2021)

Post Monsoon Water Level Fluctuation (Nov 2012 – Nov 2021)

In the district water level fluctuation of 10 years (2012 – 2021) for the block Pushprajgarh, in small part of Jaitheri block and Kotma block ranges from 5 -10 m whereas in the Jaitheri block and some part of Anuppur block water level fluctuation is 2 – 5 m. Only in small patch water level fluctuation is greater than 10 meter and below 2 meter.

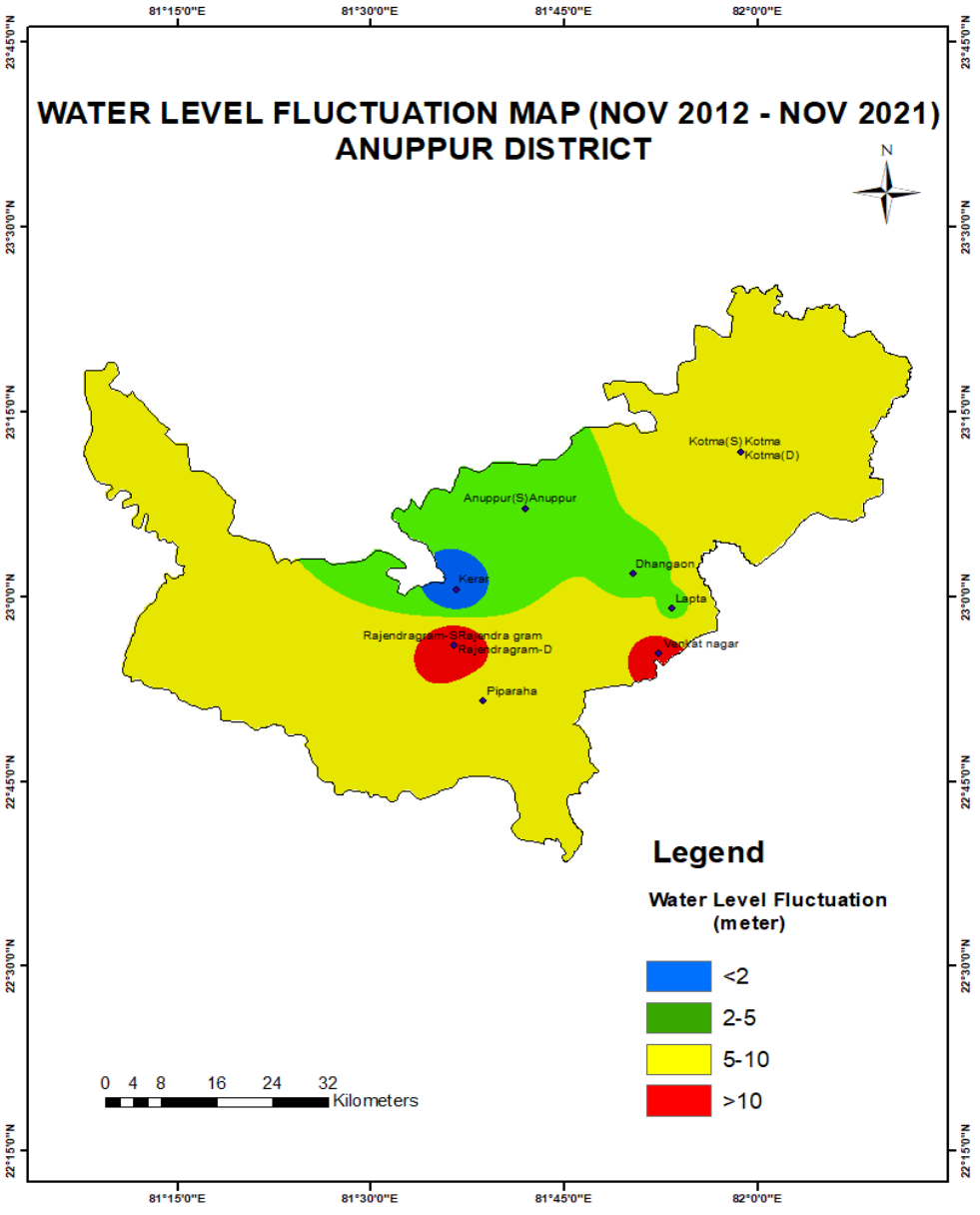


Figure 19 : Post Monsoon Water Level Fluctuation (Nov 2012 – Nov 2021)

2.5 Ground water Exploration:

CGWB has drilled 5 piezometers - one in Anuppur block, 2 in Pushprajgarh block and 2 in Kotma block. On the basis of samples collected during drilling, litholog have been prepared. Further 64 key well established in the four block of Anuppur district. The salient details of the some of the drilled bore wells and piezometers is given in Table 3

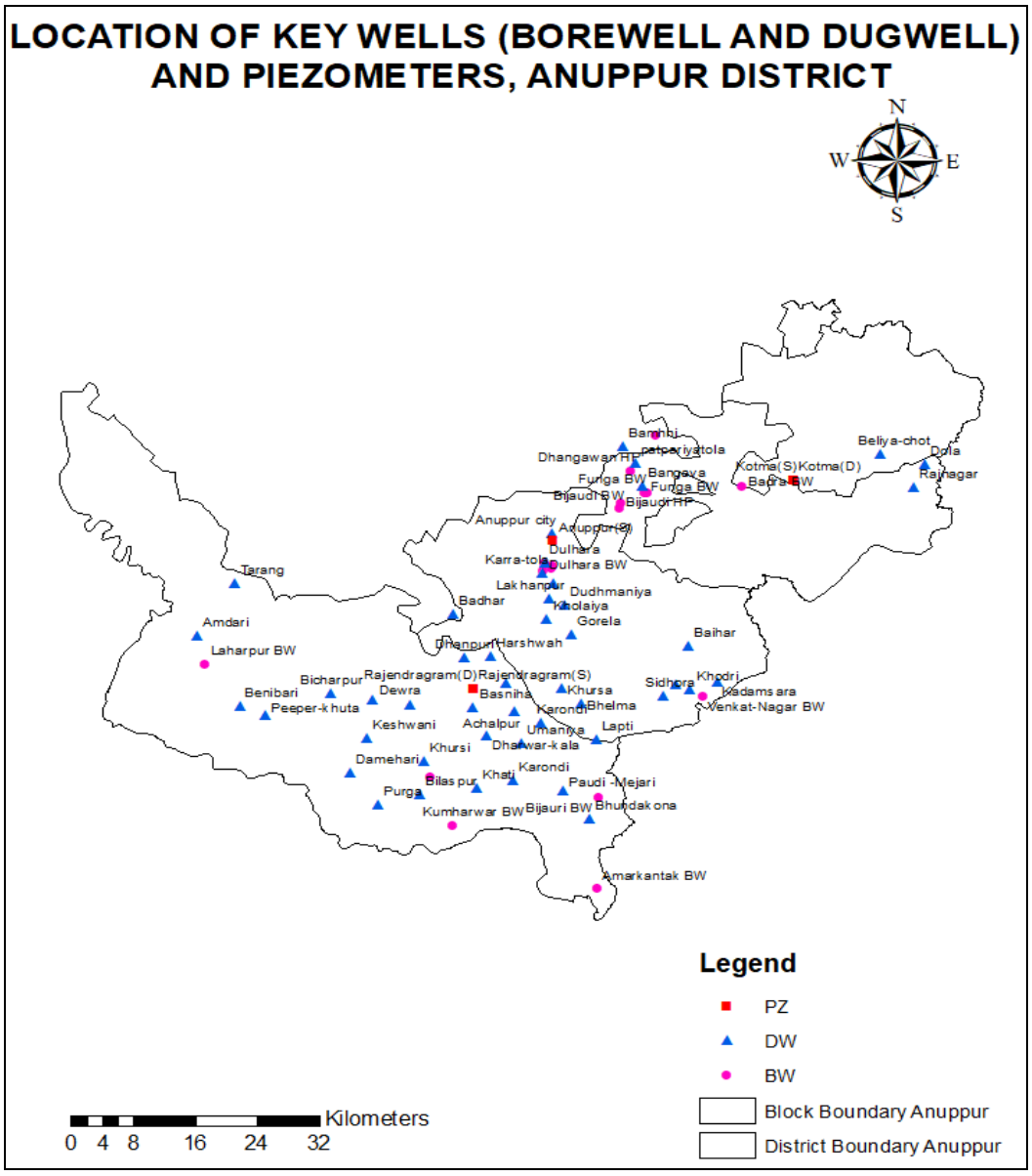


Figure 20 : Location Map of Key well established (BW & DW) and piezometer, Anuppur District

Table 13 : Salient Features of the constructed Piezometers and Key Well Established (BW & DW) in Anuppur District

Location of DW	**latitude**	**longitude**	RL
Bamhni	23.23739	81.781331	521.41
Anuppur city	23.12779	81.698875	479.43
Bangava	23.18831	81.804265	526.71
patpariyatola	23.21725	81.79578	507.35
Dulhara	23.09063	81.690543	476.97
Karra-tola	23.0789	81.688728	473.92
Paudi-khurd	23.06483	81.700311	498.37
Lakhanpur	23.04594	81.695314	547.18
Kholaiya	23.01948	81.692938	565.31
Dudhmaniya	23.03867	81.714186	518.56
Gorela	23.00023	81.72122	553.44
Kadamsara	22.94171	81.890281	534.71
Khodri	22.93125	81.858893	510.42
Bhena-Dongri	22.93805	81.841782	545.18
Sidhora	22.92379	81.828644	552.71
Bhelma	22.91362	81.733592	773.26
Khursa	22.93356	81.711182	680.01
Baihar	22.98668	81.856887	726
Badhar	23.02589	81.584193	604.79
Rajnagar	23.18640	82.118446	554.55
Dola	23.21561	82.131069	543.35
Beliya-chot	23.22720	82.078804	545.07
Bhundakona	22.76885	81.742817	934
Paudi -Mejari	22.80519	81.711640	937
Umaniya	22.86411	81.663738	872
Karondi	22.89002	81.687072	879.06
Lapti	22.86959	81.751455	862.51

Achalpur	22.90379	81.655636	856.29
Basniha	22.90861	81.608248	854.08
Karondi	22.81777	81.653604	830.07
Khati	22.80845	81.612404	805.64
Dharwar-kala	22.87391	81.624214	900.25
Dhanwahi-tola	22.93933	81.645376	873.7
Dhanpuri	22.97195	81.597397	843.25
Harshwah	22.97361	81.628341	856.38
Girari-khurd	22.91313	81.535653	843.27
Keshwani	22.87103	81.484509	792.28
Damehari	22.82641	81.465881	765.92
Purga	22.78746	81.497735	726.68
Bilaspur	22.80035	81.545535	799.92
Khursi	22.84132	81.551616	807.34
Tarang	23.06467	81.331919	751.56
Amdari	22.99944	81.288336	859.71
Benibari	22.90993	81.337937	750.46
Peeper-khuta	22.90014	81.367073	757.81
Bicharpur	22.92688	81.443635	833.01
Dewra	22.91922	81.492223	847.24

Location of BW and HP	**Latitude**	**Longitude**	RL
Bijaudi BW	23.15964	81.777542	507.69
Bijaudi HP	23.16701	81.779766	489.92
Chilpa BW	23.2514	81.819878	534.23
Funga BW	23.1801	81.807271	558.44
Dhangawan HP	23.20753	81.79149	518.5
Funga BW	23.18027	81.810295	520.18
Dulhara BW	23.09096	81.691516	496.45
Karra-tola BW	23.08129	81.688789	521.18

Pipariya BW	23.08726	81.701573	505.36
Pipariya HP	23.08452	81.699518	483.17
Venkat-Nagar BW	22.92298	81.875129	469.71
Badra BW	23.18816	81.91941	534.15
Amarkantak BW	22.68144	81.752025	2420
Bijauri BW	22.79706	81.753477	946
Kumharwar BW	22.76112	81.585689	785.08
Kekariya BW	22.82154	81.559719	737.9
Laharpur BW	22.96404	81.298612	790.75

Location of Piezometer	latitude	longitude	RL
Anuppur(S)	23.11944	81.70055556	492
Kotma(S)	23.19583	81.97861111	517
Kotma(D)	23.19583	81.97861111	517
Rajendragram(D)	22.93361	81.60833333	835
Rajendragram(S)	22.93361	81.60833333	835

2.6 Ground Water Quality of Anuppur District

Hydrochemical scenario of Anuppur District

The water samples were collected from National Hydrograph Stations in clean double stoppered poly ethylene bottles from 17 different locations of Anuppur district during May 2021.

Quality of Ground Water for Drinking Purpose:

The ground water samples from Anuppur district have varied range of pH from 6.54 to 7.55. As per BIS (IS 10500:2012) recommendation, all the water samples have pH recorded within the permissible limits of 6.5 to 8.5, the maximum pH recorded in the water sample of Bhejari (7.55). The pH of ground water can be assessed as slightly acidic to slightly alkaline in nature. The electrical conductivity of ground water samples in Anuppur district varies from 130 to 1431 µS/cm at 25°C. The electrical conductivity of ground water from 14 location of Anuppur

district shows within 1000 µS/cm whereas three locations are in between 1000 - 1500 µS/cm and the maximum electrical conductivity has been observed in the village of Deohara (1431 µS/cm). So, overall ground water quality of Anuppur district is good quality in nature except few pockets of the districts.

The fluoride concentration in Anuppur district lies in between 0.01 to 1.19 mg/l, which represent that all the samples are within the permissible limit i.e. 1.5 mg/l of BIS standard. The maximum concentration of fluoride has been observed in the dug well of Jamudi village i.e. 1.19 mg/l. The nitrate concentration in the Anuppur districts ranges in between 1 to 32 mg/l. In the district, all the ground water samples recorded nitrate concentration within the permissible limit of BIS standard i.e. 45 mg/l. The maximum concentration of nitrate has been recorded in the village of Kotma (32 mg/l).

The total hardness in the ground water of the districts ranges between 30 to 580 mg/l. In the district, all the ground water samples recorded total hardness less than BIS permissible limit of 600 mg/l. The maximum concentration of total hardness has been observed in the village of Deohara (580 mg/l).

Piper diagram has three parts: a Cation triangle, an Anion triangle, and a Central diamond-shaped field. In Cation triangle, the relative percentages of the major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) are plotted. In Anion triangle the major anions ($HCO_3^{-}+CO_3^{2-}$, SO_4^{2-}, Cl^{-}) are plotted. These points are then projected to the central diamond shaped field.

In the district; piper diagram shows that the samples are Calcium-Bicarbonate type (temporary hardness); Mixed types of water.

2.7 Quality of Ground Water For Irrigation Purpose

The classification of water for irrigation purpose, it is assumed that the water will be used for irrigation purpose based upon its soil texture, infiltration rate, drainage and climate. There are various parameters from which suitability of ground water can be determine which includes salinity, chlorinity and sodicity indices. Various indices such as SAR (**Sodium Absorption Ratio**), SSP (**Soluble Sodium Percentage**) %Na, KI (**Kelly's Index**), PI (**Permeability Index**), RSC (**Residual Sodium Carbonate**) are used for quality criteria for irrigation water. The ground samples that are collected are analysed, compared with the standard values for determining the suitability for irrigation purpose.

The chemical data of all the water samples from Anuppur district is plotted on U.S. Salinity Laboratory diagram. The USSL diagram shows that the districts falls under C_1-S_1 Class (Low Salinity & Low Sodium), C_2-S_1 Class (Medium Salinity & Low Sodium); C_3-S_1 Class (High Salinity & Low Sodium). The ground water of the district may be used for irrigation with proper soil management.

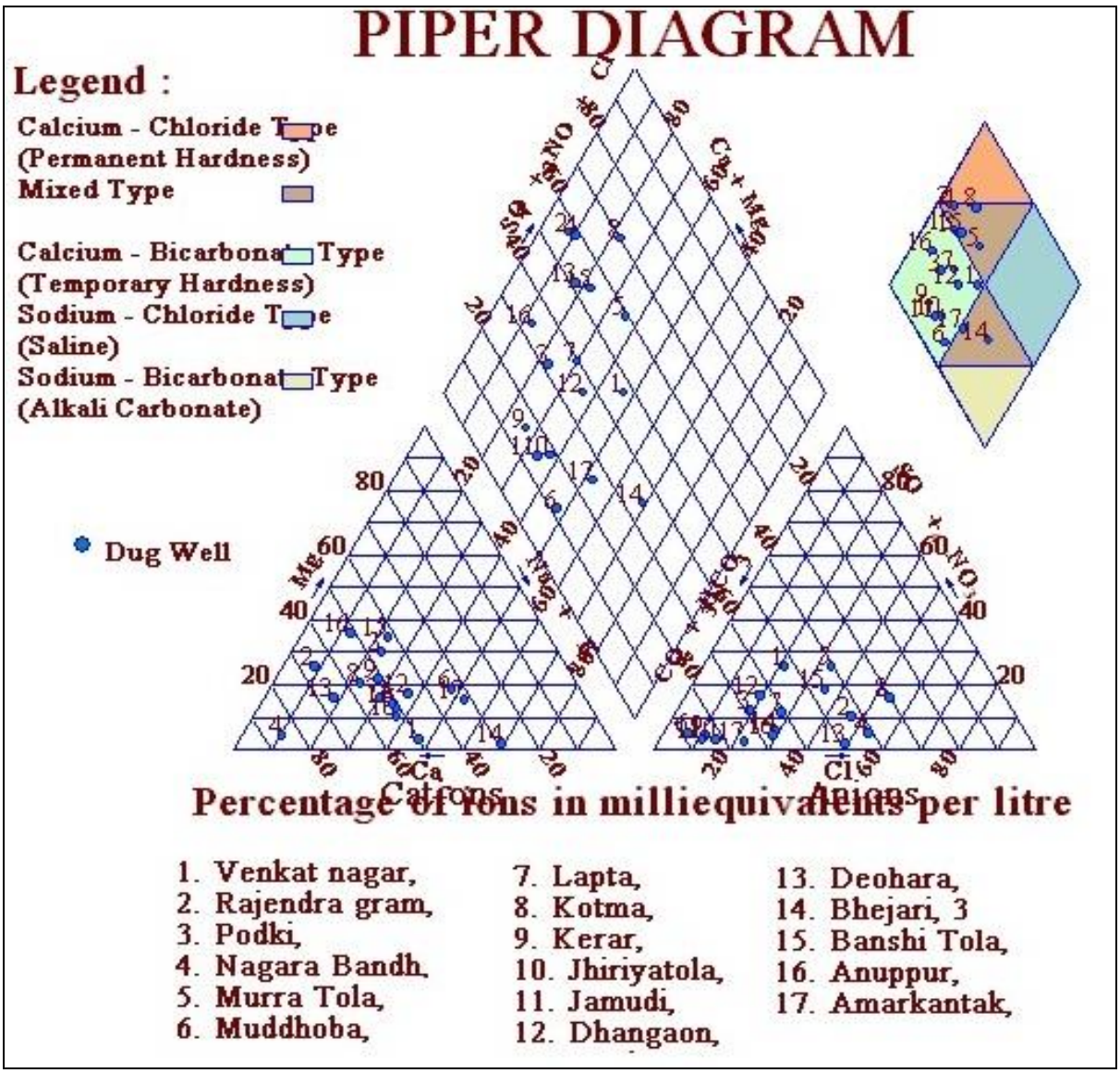


Figure 21: Piper Diagram representing classification of water samples collected from National Hydrograph Stations, Anuppur District, Madhya Pradesh

Table 14: Ranges of Indices and Suitability of Ground Water for irrigation

	Standards for Irrigation (not sutaible for irrigation greater than)	Minimum	Maximum	No of samples not suitable for irrigation	Location of Max value
Salinity (EC)	3000	785	2025		
Soluble Sodium Percentage	50	24.17	57.71	1	Bhejari, Pushprajgarh block
Sodium Absorption Ratio	26	1.1	5.66	0	
%Na	60	24.81	57.83	1	Bhejari, Pushprajgarh block
Residual Sodium Carbonate	2.5	-1.7	6.9	0	
Kelly's Index	2	0.32	1.36	1	Bhejari, Pushprajgarh block
Mg2+ Ratio	50	10.38	45.47	0	
Permeability Index	75	46.34	133.5	5	Amarkantak, Bhejari in Pushprajgarh blcok, Dhangaon, Venkat Nagar in Jaitheri block, Muddhoba in Anuppur block

Quality of Ground Water for Industrial Purpose

Ground water quality for industrial purposes is one of the important as majority of the industries consume huge quantities of water in various processes, water with in specific quality is a must to protect the necessary machinery from scaling or corrosion effects. The Corrosivity ratio (CR) is calculated for all the samples collected duringpre-monsoon. The CR value of water with less than or equal to 1 is considered good whereas more than 1 indicates corrosive nature and is not fit for transportation through metal pipes (Ryner 1944; Raman 1985) and it is not suitable for industrial or domestic purposes. The CR values for all the samples is calculated and values are less than 1, so the Ground water of shallow aquifer of Anuppur district is suitable for industrial purpose (Annexure-VII).

Chada Plot

Chada Plot shows that most of the water samples falls under the fourth quadrant and type of the water is Ca-Mg-SO4/Cl water type. Alkaline earth metal exceeds earth metals and strong acidic anion exceeds weak acidic anion (Annexure-VIII).

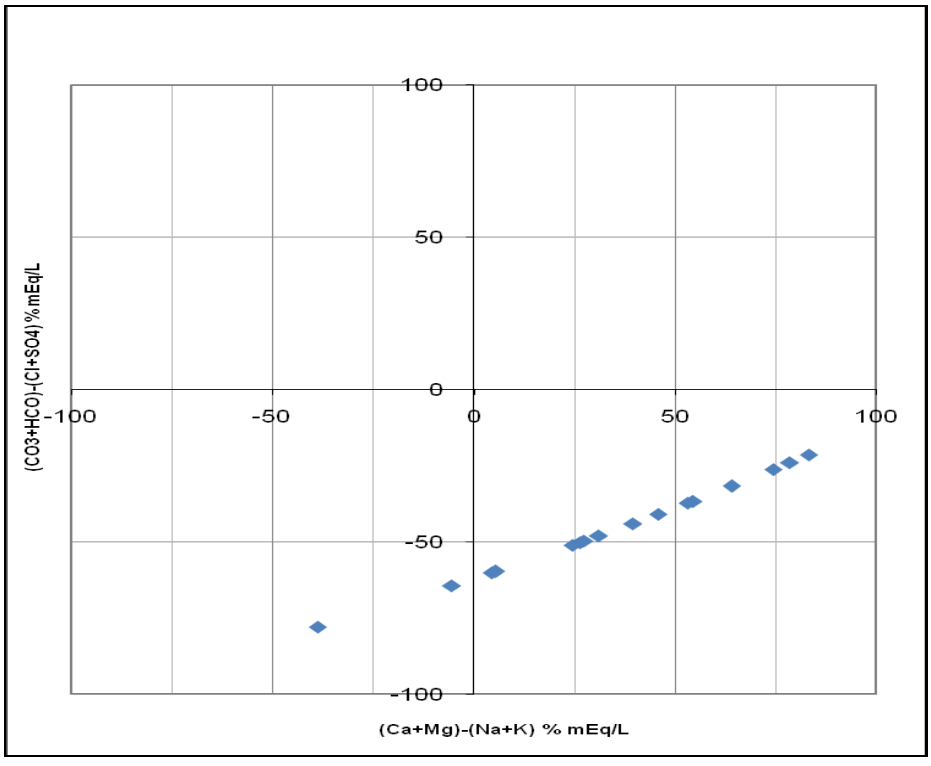


Figure 22: Chada Plot, Anuppur district

Table.15 : Ground Water Quality of Anuppur district

S. No.	Block	Location	Lat.	Long.	pH	EC	CO_3	HCO_3	Cl	SO_4	NO_3	F	PO_4	SiO_2	TH	Ca	Mg	Na	K	TDS
					at 25°C	µS/cm at 25°C	mg/l													
1	Pushprajgarh	Amarkantak	22.674	81.761	6.75	130	0	55	10	1	1	0.01	0.08	11	30	8	2	10	9.2	85
2	Anuppur	Anuppur	23.119	81.701	7.53	987	0	371	97	15	8	0.52	0.10	22	425	100	43	28	1.1	642
3	Kotma	Banshi Tola	23.198	81.889	6.54	282	0	79	37	8	23	0.30	0.12	32	110	24	12	14	1.6	183
4	Pushprajgarh	Bhejari	22.823	81.698	7.55	469	0	176	47	5	11	0.46	0.06	19	70	26	1	70	5.4	305
5	Jaithari	Deohara	23.143	81.597	7.36	1431	0	437	265	8	8	0.41	0.23	34	580	186	28	56	4.1	930
6	Jaithari	Dhangaon	23.031	81.839	7.23	305	0	109	20	22	2	0.33	0.05	15	90	26	6	22	3.6	198
7	Jaithari	Jamudi	23.066	81.633	7.18	578	0	279	22	9	1	1.19	0.07	27	185	58	10	38	11.4	376

S. No.	Block	Location	Lat.	Long.	pH	EC	CO_3	HCO_3	Cl	SO_4	NO_3	F	PO_4	SiO_2	TH	Ca	Mg	Na	K	TDS
					at 25°C	µS/cm at 25°C	mg/l													
8	Anuppur	Jhiriyatola	23.214	82.104	7.25	895	0	437	47	12	5	0.52	0.11	23	275	92	11	75	2.8	582
9	Jaithari	Kerar	23.010	81.610	7.46	1140	0	559	45	25	2	0.39	0.05	28	410	114	30	65	8.7	741
10	Kotma	Kotma	23.196	81.979	6.70	596	0	97	104	17	32	0.12	0.08	22	225	66	15	28	4.5	387
11	Jaithari	Lapta	22.984	81.889	6.80	388	0	134	37	19	2	0.52	0.08	18	130	40	7	25	1.6	252
12	Anuppur	Muddhoba	23.252	81.884	7.32	410	0	225	10	9	3	0.59	0.16	27	110	28	10	45	2.3	267
13	Jaithari	Murra Tola	23.056	81.793	6.91	487	0	109	54	51	6	0.52	0.12	20	150	48	7	36	5.6	317
14	Kotma	Nagara Bandh	23.209	81.985	7.27	1130	0	267	208	13	18	0.23	0.09	32	505	192	6	27	1.6	735

S. No.	Block	Location	Lat.	Long.	pH	EC	CO_3	HCO_3	Cl	SO_4	NO_3	F	PO_4	SiO_2	TH	Ca	Mg	Na	K	TDS
					at 25°C	µS/cm at 25°C	mg/l													
15	Pushpra jgarh	Podki	22.784	81.729	7.53	604	0	237	40	15	26	0.13	0.05	39	225	54	22	30	2.9	393
16	Pushpra jgarh	Rajendra Gram	22.933	81.608	6.95	591	0	152	99	22	11	0.04	0.06	41	265	76	18	8	5.3	384
17	Jaithari	Venkat Nagar	22.923	81.873	6.81	315	0	91	22	29	8	0.69	0.05	22	80	30	1	32	1.7	205

CHAPTER-3

DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

After the study and analysis of the historical data, lithological data collected from 5 CGWB piezometers and key well established data were compiled, accordingly 2-Dimensional (2-D) Cross section has been prepared. It has been interpreted that 2-D section is presented as below.

3.1 2-D Cross Section of Anuppur District

Sub-surface lithological section has been prepared based on the based on the existing key well established and piezometer data to know the lithological continuity, its vertical and lateral extent. 2-Dimensional cross-section along the section line **A-A'(Kotma - Kekariya)**, representing covering the wells has been prepared using Mapinfo The cross-section shows that the aquifer (Weathered basalt, massive basalt, weathered sandstone and hard & compact sandstone) is not continuing for the whole region of Anuppur district, sandstone is encountered at shallower depth towards the northern part of the district.The basaltic lava flows in the entire district is almost horizontal and followed the topography.The section line **A-A'** represents **Kotma – Badra – Funga – Bijaudi – Dulhara – Kekariya. Similary section line B – B' represents** and section line **B-B'** represents **Dewra – Girari Khurd – Basniha – Achalpur – Lapti** and section line **C-C' represents Laharpur – Kekariya - Kumarhwara.**

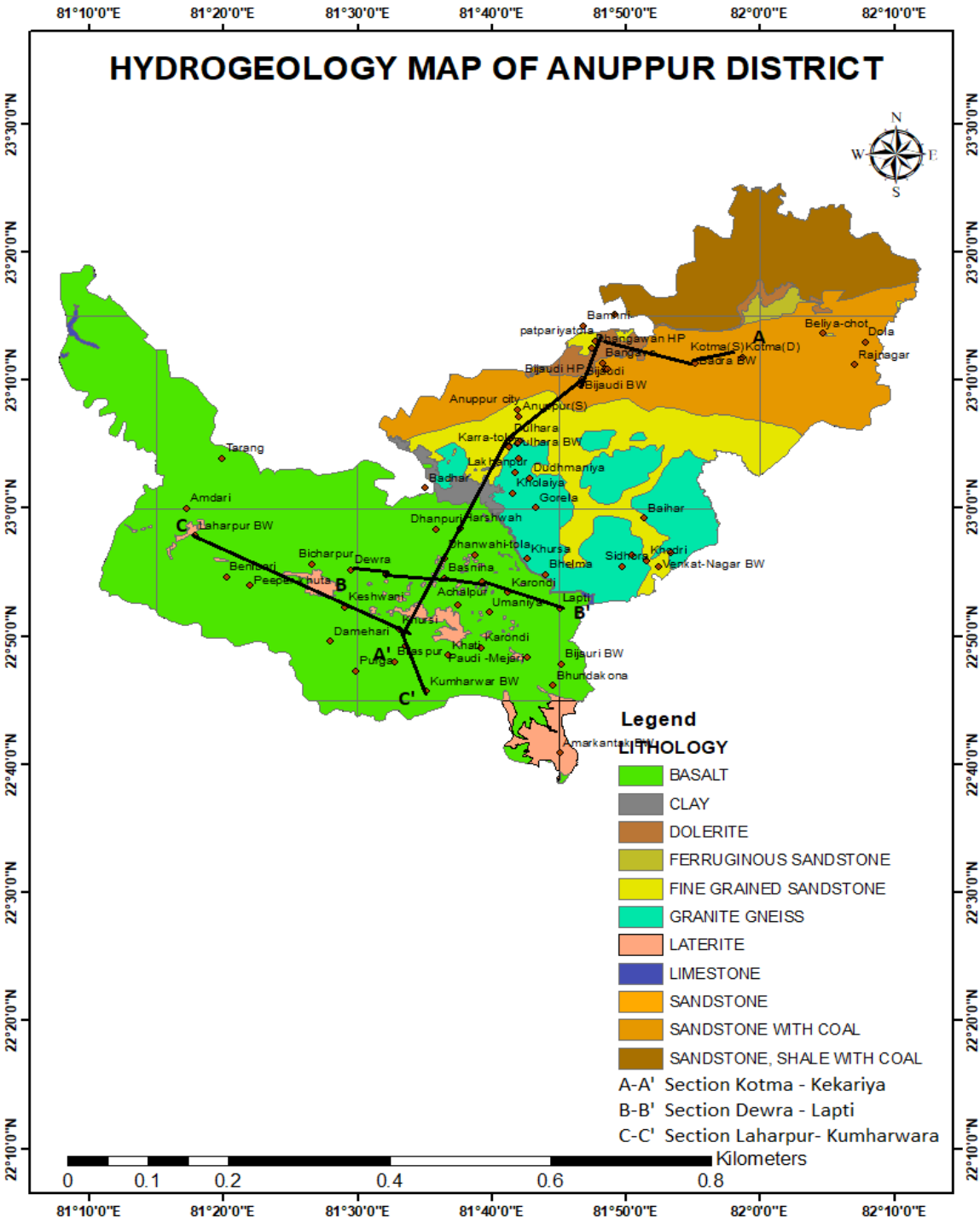


Figure 23 : Geology Map showing the location of the cross sections along A-A'(Kotma - Kekariya), B-B'(Dewara - Lapti), C-C'(Laharpur - Kumharwara) of Anuppur district

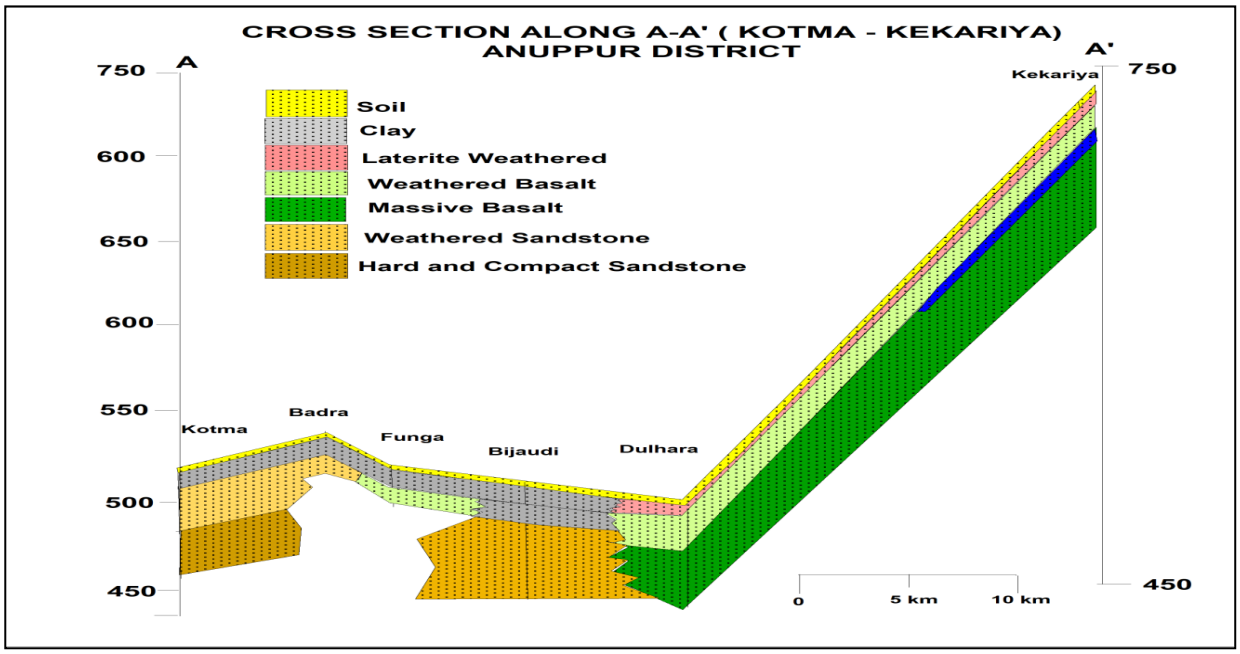


Figure 24 : 2-D Cross sections A-A'(Kotma - Kekariya) of Anuppur district

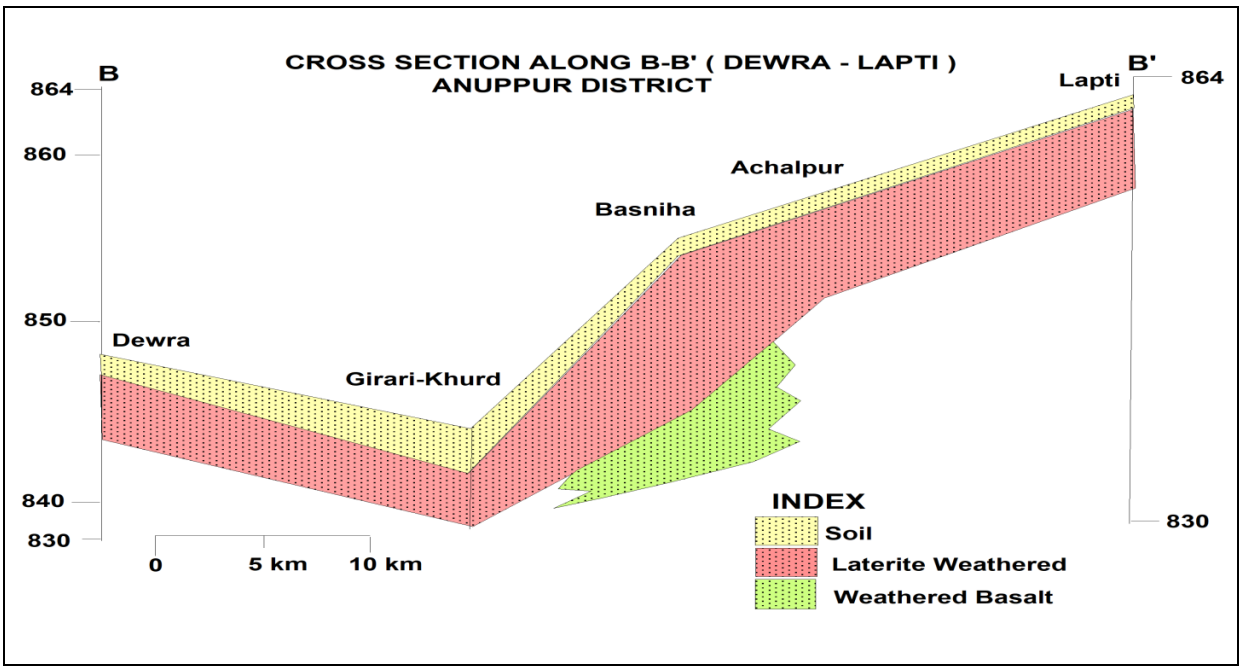


Figure 25 : 2-D Cross sections B-B'(Dewara - Lapti) of Anuppur district

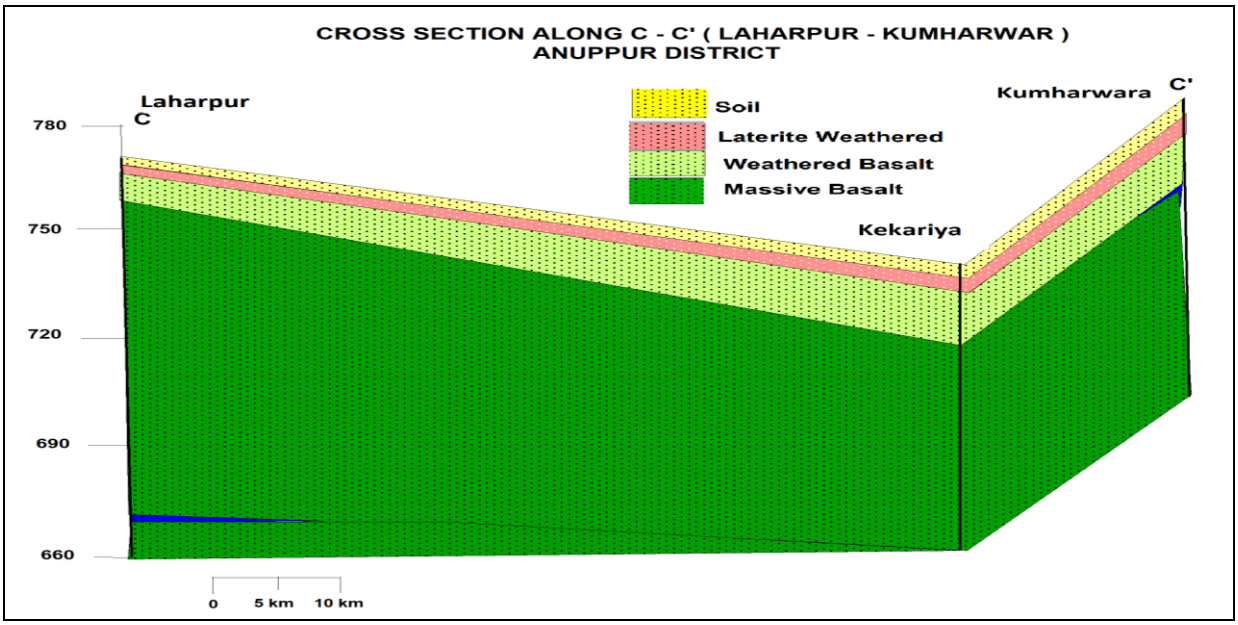


Figure 26: 2-D Cross sections C-C'(Laharpur - Kumharwara) of Anuppur district

CHAPTER 4

GROUND WATER RESOURCES

4.1 Dynamic Ground Water Resources:

The dynamic ground water resources of the Madhya Pradesh state assessed jointly by the CGWB and State Ground Water Departments under the supervision of the State Level Committees and have been estimated for the Anuppur district for the year **2020 block wise** basis. There are 4 assessment units (blocks) in the district namely Anuppur, Jaithari, Kotma and Pushprajgarh. Out of 3724 sq. km of geographical area 2942 sq km is ground water recharge worthy area and 782 sq km is forest and hilly area.

There are four assessment units (block) in the district and all blocks falls under safe category.

Ground water resources have been computed including two components i.e. 1) Groundwater recharge during the monsoon season and 2) Groundwater recharge during non-monsoon season.

The resource assessment during the monsoon season is estimated as the sum total of the change in storage and gross ground water draft. The change in storage is computed by using the water level fluctuation method. The other sources of ground water recharge during monsoon season include recharge from rainfall, seepage from canals, surface water irrigation, tanks and ponds, ground water irrigation, water conservation structures. The rainfall recharge during monsoon season computed by Water Level Fluctation (WLF) method is compared with recharge figures from RainFall Infiltration Factor (RIF) method. In case the difference between the two sets of data are more than 20%, then RIF method is considered otherwise monsoon recharge from WLF is adopted.**The resource assessment during non - monsoon season** is computed by using Rainfall Infiltation Factor (RIF) method. Recharge from other sources is then added to get the total non-monsoon recharge. In case of areas receiving less than 10% of the annual rainfall during non-monsoon season, the rainfall recharge is ignored.**The total annual ground water recharge** of the district is the sum of monsoon and non-monsoon recharge. An allowance is kept for ecological flow the rivers by deducting 5% of the total annual ground water recharge, if WLF method is employed to compute rainfall recharge during monsoon season and 10 % of the total annual ground water recharge if RIF method is employed. **Recharge from rainfall and other**

sources during rainfall monsoon season in the Anuppur district is 36011.33 hec and 319.95 hec respectively. **Recharge from rainfall and other sources during non-monsoon season** are 2853.65 hec and 1245.99 hec respectively.The Annual Extractable Ground Water Resource in the district is 377.34 MCM and ground water draft for all uses is 75.51 MCM, making stage of ground water extraction to 20.01 % as a whole for the district.Table 6 shows the Dynamic Ground Water Resource Assessment 2020 estimated by CGWB.

4.2 Static Ground Water resources:

As an outcome of NAQUIM blockwise Ground Water Resource of Anuppur District has also been calculated in which the **in-storage resource** for the shallow aquifer below zone of fluctuation (upto 30 mbgl) is computed to be around 1055 MCM and **the static resource** for the deeper aquifer (30-200 mbgl) is computed as 244.31 MCM.

4.3 Ground water Draft:

The groundwater draft is the quantity of groundwater withdrawn from the ground reservoirs. The total quantity withdrawn i.e. for irrigation, domestic and industrial purpose is called as gross groundwater draft. Annual groundwater draft is estimated based on the total number of borewell/tubewell/dugwell and unit draft. The draft of dug well and tube well has been calculated separately to assess the ground water draft for irrigation from **shallow and deeper aquifers** that accounts to **75.51 MCM**. The block-wise ground water resources and draft as an outcome of NAQUIM is presented in the Table 7

Table.16 : Dynamic Ground Water Resources of Anuppur district (as on March 2020)

Assessment Unit Name	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization
ANUPPUR							
KOTMA	1062.72	141.439	1204.16	151.8	4057.03	22.84	safe
PUSPRAJGARH	297.0432	539.0006	836.04	578.5	11263.64	6.89	safe
JAITHARI	3450.6	467.6482	3918.25	501.91	7920.09	33.00	safe
ANUPPUR	1228.608	364.1401	1592.75	390.82	6832.23	18.85	safe
DISTRICT TOTAL	**6038.97**	**1512.23**	**7551.2**	**1623.03**	**30072.99**	**20.01**	**safe**

Table. 17: Total Ground Water Resources (Outcome of NAQUIM)

	Anuppur	Jaithari	Kotma	Pushprajgarh	**Total**
First Aquifer					
Dynamic Resources (MCM)	**84.51**	**118.72**	**52.71**	**121.39**	377.33
Static Resources (MCM)	365.838	39.27	145.5441	127.4784	678.131
Total Resources (MCM)	**450.35**	**157.99**	**198.25**	**248.87**	**1055.46**
Second Aquifer					
Static Resources (MCM)	140.08	25.50	43.45	35.28	244.31
Total GW Resources (MCM)	590.43	183.49	241.70	284.15	1299.77
Irrigation GW Draft (MCM)	**12.29**	**34.50**	**10.62**	**2.97**	**60.38**
Domestic+Industries	**3.64**	**4.67**	**1.41**	**5.39**	**15.12**
Gross Ground Water Draft (MCM)	**15.93**	**39.17**	**12.03**	**8.36**	**75.49**
Stage of Ground Water Extraction (%)	**18.85**	**32.99**	**22.83**	**6.89**	**20.01**
Category	**safe**	**safe**	**safe**	**safe**	**safe**

CHAPTER -5

GROUND WATER RELATED ISSUES

5.1 Under Development or Less stage of Ground Water Extraction

As we can see the stage of Ground Water Extraction for the district is only 20.01 % (safe category) as per the resource assement 2020 which implies that the district is not developed fully and has a large scope of development of the district. Agricultural and industrial production can be increased in the district so that district wil become strong economically and agriculturally strong.

5.2 Lack of awareness and involvement of stake holders in decision making

Lack of awareness and involvement of stake holders in decision making related to groundwater is also a very important issue. Stakeholders need to participate because management decision taken by the regulatory agency without social consensus is often impossible to implement. Essential management activities (such as monitoring, inspection, etc) can be carried out more effectively and economically through cooperative efforts and shared burdens. Benefits that arise from the stakeholder's participation are-

1) more informed and transparent decision-making
2) Conflict prevention by development of consensus and information sharing.
3) Economic benefits, because it tends to optimize pumping and reduce energy costs.
4) technical benefits, because it usually involves stakeholders in maintenance and leads to better estimates of water abstraction
5) Management benefits, because the trigger local stakeholder initiatives to implement demand and supply measures and reduce the cost of regulation.

Stakeholder involvement should be seen as on-going, long term process that adapts to the contextual conditions needs and changes therein.

CHAPTER -6

GROUND WATER MANAGEMENT STRATEGIES

India is the largest user of groundwater in the world and therefore highly dependent on it and it will remain the lifeline for years to come. In the current scenario about 70-80 % water supply for agriculture is from groundwater rather than surface water irrigation. Groundwater is the major source of drinking water, agriculture and industry which is increasing day by day because of increased population growth and socio-economic development in the district. But in the Anuppur district there is no problem in the district in terms of groundwater. Anuppur district is not development economically and agriculturally fully. The stage of groundwater extraction for the district is only 20 % which can be increased till 70 %. This implies that more industries and more agricultural practices can be adopte. This trend continuous unchecked because of **lack of awareness**, involvement **of stake holders in decision making, lack of groundwater management** Effective groundwater management is underpinned by sound science that actively engages the wider community and relevant stake holders in the decision making process. Therefore an integrated approach is needed to improve and develop the district.

6.1 District Ground Water Management Plan (Outcome of NAQUIM)

Groundwater management entails both quality and quantity related groundwater resource management. Quantification of groundwater resources and understanding of hydrogeological processes is a basic pre-requisite for efficient and sustainable management of groundwater resource development and For managing the groundwater resource, to develop the district agriculturally and to maintain the sustainability of the aquifer, groundwater management plan is to be prepare for the district. As per the directions of **Ministry of Jal Shakti,** Department of Water Resources, River Development and Ganga Rejuvenation preparation of Aquifer Management Plan and its financial layout for the Anuppur district in the State has been prepared **blockwise.** The ground water management plan for Anuppur district has been made keeping in view the area specific details and includes the strategies like enhancing the agricultural activities, to increase the area under irrigation, increase the net cropping area thereby, augmenting the agricultural economy of the district.

Management Plan of Anuppur district

Anuppur district is divided into 4 blocks namely Anuppur, Jaithairi, Kotma and Pushprajgarh block having stage os groundwater extraction very less i.e. 18.85 %, 33 %, 22.84 % and 6.89 % respectively. In the district annual extractable Ground Water resource is 377.34 mcm which is not utilized and managed properly. With this much amount of groundwater available district can become economically and agriculturally strong. For changing the condition of the district more number of dugwells and borewells can be proposed to extract the groundwater . The water that is extracted from the proposed borewell and dugwell can be used for irrigation in the district. The area that is irrigated once in a year can be used twice or thrice in a year to increase the gross irrigated area and increase the agricultural productivity.

The ground water development is proposed in the view of developing the additional groundwater resources available to bring the stage of groundwater extraction upto 60%. The 152 mcm vloumne of groundwater generated from the proposed borewell and dugwell can bring the 380 sq km additional area under assured ground water irrigation with average crop water requirement 0.4 m by constructing 7700 dugwells and 8200 borewells in the entire district. Blockwise also 34.84 mcm volumne of generated water can bring 87.1 sq km additional area under assured ground water irrigation with average crop water requirement 0.4 m by constructing 2200 dugwells and 1800 borewells in Anuppur block, 32.10 mcm volumne generated can bring area 80.25 sq km additional area under assured ground water irrigation with average crop water requirement 0.4 m by constructing 1200 dugwells and 1500 borewells in Jaithari block, 20.33 mcm volumne of water generated can bring 52.82 sq km additional area under assured ground water irrigation with average crop water requirement 0.4 m by constructing 1100 dugwells and 1200 borewells in Kotma block and 64.74 mcm volumne of water generated can bring 161.35 sq km additional area under assured ground water irrigation with average crop water requirement 0.4 m by constructing 3200 dugwells and 3700 borewells in Pushprajgarh block. The crop land area in the Anuppur block is 129 sq km, in Jaithari block is 435 sq km, Kotma block is 92 sq km and in Pushprajgarh block is 1126 sq km & as a whole district crop land area is 1782 sq km. The area under irrigation onces in a year can irrigate twice or third in a year that will increase the agricultural productivity as well as other activities in the district. The crop land map givem

shows that in that part of the area we can irrigate and developed the district so that the stage of ground water extraction increase and blocks will remain safe.

The construction of these above dugwells and borewells will increase the stage of groundwater extraction from 18.85 % to 60.07 % in Anuppur block, from 33% to 60.04 % in Jaithari block, from 22.84% to 61.41 % in Kotma block and from 6.89% to 60.22 % in Pushprajgarh block. As a whole district the stage of groundwater extraction will change from 20.01% to 60.30 % and district & blocks will remain in safe category.

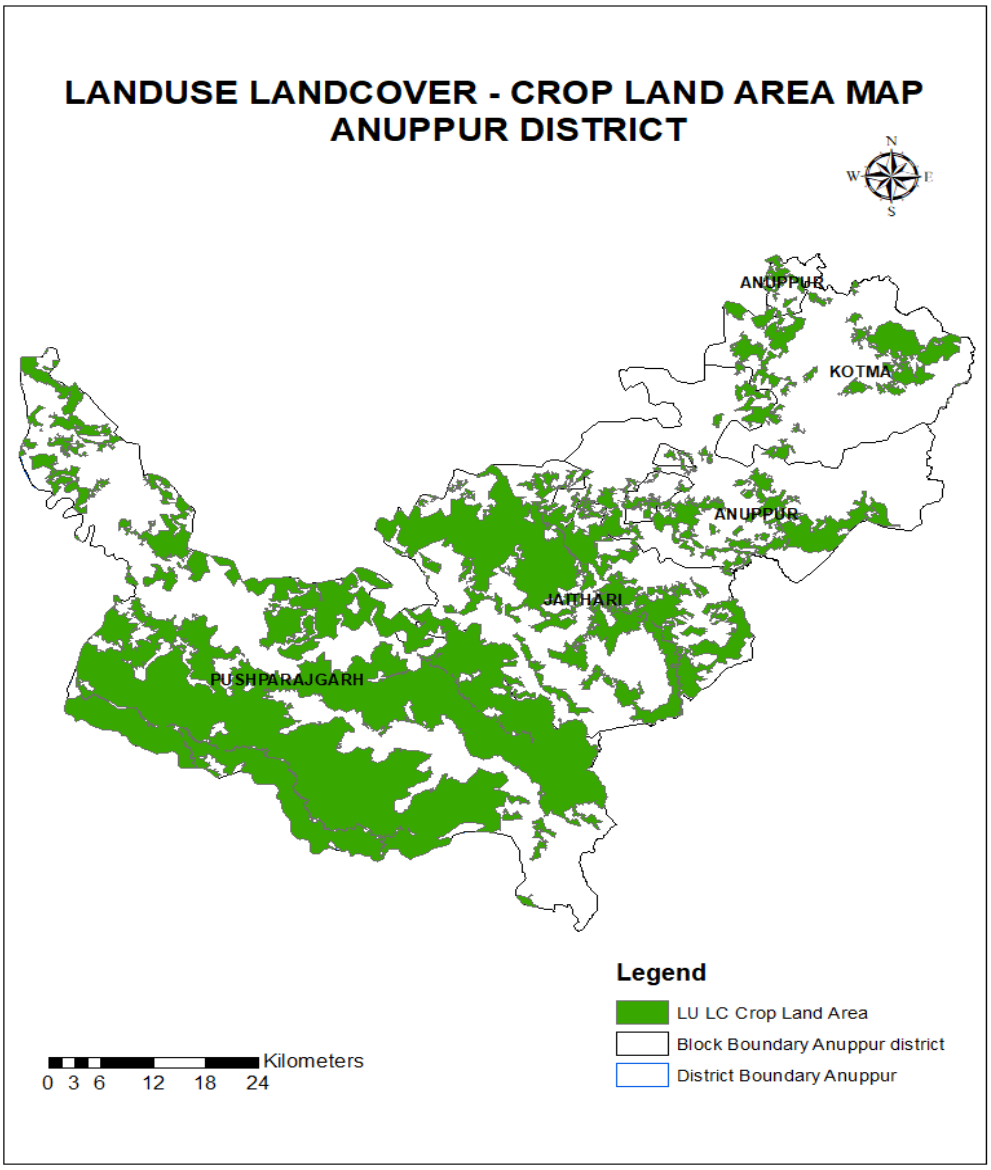


Figure 7 : Crop Land Area of the Anuppur District

Table.18: Management Plan of Anuppur district

Block	Dugwell Unit Draft (mcm)	Borewell Unit Draft	No. Of DW proposed	No. Of BW Proposed	GW Extraction from DW	GW Extraction from BW	Extraction (DW+BW) mcm	Total Draft	Stage of GW Extraction after utilization of additional water extracted from DW and BW	Area irrigate from water extracting from the proposed DW and BW (sq km)	Crop Land area (sq km)
Anuppur	0.0052	0.0130	2200.00	1800.00	11.44	23.40	34.84	50.77	60.07	87.1	129
Jaithari	0.0065	0.0162	1200.00	1500.00	7.80	24.30	32.10	71.28	60.04	80.25	435
Kotma	0.0043	0.0130	1100.00	1200.00	4.73	15.60	20.33	32.37	61.41	50.825	92
Pushprajgarh	0.0052	0.0130	3200.00	3700.00	16.64	48.10	64.74	73.10	60.22	161.85	1126
Total	0.0053	0.0138	7700.00	8200.00	40.61	111.40	152.01	227.51	60.30	380.03	1782.00

CHAPTER-7

CONCLUSIONS AND RECOMMENDATIONS

Based on the study of data gap analysis, data generated, exploration data and data acquired from the State Government an integrated approach was adopted for the preparation of aquifer maps and blockwise aquifer management plan for the Anuppur district.

- Anuppur district occupies an area of sq km out of which the ground water recharge worthy area is 2942 sq. km. and 782 sq. km. is covered by hilly and forest area. It comprises 4 blocks namely – Anuppur, Jaithari, Kotma and Pushprajgarh block.
- The district is drained by the river Narmada, entire Anuppur district forms of the Ganga system. The river Son is an important Tributary of the Ganga basin, drains the major part of the district. In between the river Narmada and Son the great central represented by north western branch of Maikal Range, which separates the river Narmada from the Son river.
- The major part of the district is covered by the Deccan Basalt, sandstone and granite and laterite in patches. The terrain in undulatory overall the district having a high elevation difference. As we move towards north sandstone is encountered at shallow depth.
- Very less development of Groundwater for irrigation in comparision to irrigation from surface water and from rainfed area under cultivation.
- Pre-Monsoon depth to water level in the year 2021 range from **1.55 mbgl at Nagara Bandh site**, Kotma block (minimum) to **15.86 mbgl Venkat Nagar at site**, Jaithari block (maximum).
- During post monsoon period, water level ranges from 1.25 **mbgl at Nagara Bandh site**, Kotma block to **15.86 mbgl at Venkat Nagar site, Jaithari** block**.**
- **Groundwater quality in the entire district is good and no parameters excedding the permissible limits of** BIS recommendation. Therefore groundwater can be used for

drinking, domestic and irrigation purposes without and threat. As per the corrositivity ratio calculated use of groundwater for industrial use is suitable as the corrositivity ratio is less than 1 for the samples. For irrigation purpose ground water is suitable except in some indices the suitability criteria exceeds in 4 samples.

- On the basis of the 47 dugwells, 17 borewells established and 5 piezometer drilled by CGWB, NCR, it has been observed that wells are having yield of the wells having variable discharge and sustainabilty.
- As per the Dynamic Ground Water Resource Assessment Report (2020), the annual extractable ground water availability in the district is 377.34 MCM and ground water draft for all uses is 75.51 MCM, resulting the stage of ground water extraction to be 20.01 % as a whole for district. The Anuppur district falls under safe category.
- There are 4 blocks namely Anuppur, Jaithari, Kotma and Pushprajgarh having stage of groundwater extraction 18.25 %, 33 %, 22.84 %, and 6.89 % respectively and falls in safe category.
- As per the Management plan prepared under NAQUIM of all the Block of Anuppur district 152 mcm vloumne of groundwater generated from the proposed borewell and dugwell can bring the 380 sq km additional area under assured ground water irrigation with average crop water requirement 0.4 m by constructing 7700 dugwells and 8200 borewells in the entire district.
- The construction of these above dugwells and borewells will increase the stage of groundwater extraction from 18.85 % to 60.07 % in Anuppur block, from 33% to 60.04 % in Jaithari block, from 22.84% to 61.41 % in Kotma block and from 6.89% to 60.22 % in Pushprajgarh block. As a whole district the stage of groundwater extraction will change from 20.01% to 60.30 % and district & blocks will remain in safe category.

Table 16: Quantitative Impact After Implementation of Supply Side and Demand Side Management Plan

Block	Stage of Development (%)	Stage of GW extraction after intervention (%)	Additional area irrigated by GW after intervention (Ha)
Anuppur	18.85	60.07	87.1
Jaithari	33.00	60.04	80.25
Kotma	22.84	61.41	50.825
Pushprajgarh	6.89	60.22	161.85
Total	20.01	60.30	380.03

ACKNOWLEDGMENTS

I would like to expressmy sincere gratitude to Sh P K Jain, Retierd Member South (Former Regional Director, CGWB, NCR, Bhopal) for giving the assignment to prepare and write this report.

I would like to thank to Sh Rana Chatterjee, Regional Director, CGWB, NCR, Bhopal and, for their guidance, valuable comments and suggestions.

I would like to thank Smt Rose Anita Kujur, Scientist-E for their guidance, valuable comments and suggestions.

I would like to thank to Dr K.Paramasivam, AHG for their support and unparalled assistance.

I would like to thank to Sh Tej Singh, ACH and other officers for providing the water quality data from time to time.

I am also grateful to all the officers and officials for cooperating, sharing their academic and technical knowledge, valuable suggestions and filed experiences which helped in the successful completion of the this report.

LastlyI would like to thank to young professional and officials of CGWB, NCR, Bhopal for their support and cooperation.

Annexure I

Litholog Key well established and piezometer

Umaniya			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1	1	Top soil
1	2	1	Laterite Weathered
2	9.4	7.4	Weathered Basalt
Karondi			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1	1	Top soil
1	2.6	1.6	Laterite Weathered
2.6	12.19	9.59	Weathered Basalt
Lapti			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	0.75	0.75	Top soil
0.75	2	1.25	Laterite Weathered
2	6	4	Weathered Basalt
Achalpur			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	0.5	0.5	Top soil
0.5	6	5.5	Weathered Basalt
Basniha			
Depth range		Thickness (m)	Lithology

(m)			
From	To		
0	1	1	Top soil
1	9	8	Laterite Weathered
9	12.19	3.19	Weathered Basalt
Khati			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1	1	Top soil
1	12.19	11.19	Weathered Basalt
Dhanwahi Tola			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1.5	1.5	Top soil
1.5	10.66	9.16	Weathered Basalt
Harshwah			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1.1	1.1	Top soil
1.1	10.66	9.56	Weathered Basalt
Girari Khurd			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	2.4	2.4	Top soil
2.4	5.7	3.3	Laterite Weathered
Purga			

Depth range (m)		Thickness (m)	Lithology
From	To		
0	1	1	Top soil
1	2.5	1.5	Laterite Weathered
2.5	13.7	2.5	Weathered Basalt
Bilaspur			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1.5	1.5	Top soil
1.5	10.66	9.16	Weathered Basalt
Khursi			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1	1	Top soil
1	1.5	0.5	Laterite Weathered
1.5	10	2.5	Weathered Basalt
Tarang			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1.5	1.5	Top soil
1.5	10.66	9.16	Weathered Basalt
Dewra			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1	1	Top soil
1	4.5	3.5	Laterite Weathered

4.5	10	5.5	Weathered Basalt
		Funga	
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1	1	Top soil
1	10.66	9.66	Weathered Sandstone
Dulhara			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1.5	1.5	Top soil
1.5	3	1.5	Clay
3	15.24	12.24	Weathered Sandstone
Karra tola			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	0.5	0.5	Top soil
0.5	5	4.5	Weathered Basalt
5	12.24	7.24	Massive Basalt
Lakhanpur			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	2	2	Top soil
2	10.66	8.66	Weathered Sandstone
Amarkantak			
Depth range (m)		Thickness (m)	Lithology
From	To		

0	3.04	3.04	Top soil
3.04	23	1	Weathered Basalt
23	25.9		Fractured Basalt
25.9	106		Massive Basalt
Bijauri			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	2	2	Top soil
2	20	1	Weathered Basalt
20	35	15	Fractured Basalt
35	109	74	Massive Basalt
Kumharwar			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1	1	Top soil
1	3	2	Laterite Weathered
3	15	12	Weathered Basalt
15	17	2	Fractured Basalt
17	27	10	Massive Basalt
Kekariya			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	2	2	Top soil
2	4	2	Laterite Weathered
4	15	11	Weathered Basalt
15	17	2	Fractured Basalt
17	79	62	Massive Basalt
Laharpur			
Depth range		Thickness (m)	Lithology

(m)			
From	To		
0	1.5	1.5	Top soil
1.5	3	1.5	Laterite Weathered
3	7.5	4.5	Weathered Basalt
7.5	94	86.5	Massive Basalt
94	96	2	Fractured basalt
96	106	10	Massive Basalt
Funga BW			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1	1	Top soil
1	9	2	Clay
9	27	11	Weathered Basalt
Pipariya			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1	1	Top soil
1	12.2	2	Clay
12.2	25	13	Weathered sst
25	45	20	Hard and Compact Sandstone
Karra tola			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1	1	Top soil
1	9	8	Laterite Weathered
9	27	11	Weathered Basalt
27	90		Massive Basalt
Dulhara BW			

Depth range (m)		Thickness (m)	Lithology
From	To		
0	1	1	Top soil
1	9	8	Laterite Weathered
9	27	11	Weathered Basalt
27	90		Massive Basalt
Lakhanpur			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1	1	Top soil
1	9	8	Laterite Weathered
9	27	11	Weathered Basalt
27	90		Massive Basalt
Bhalumada			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1	1	Top soil
1	12	2	Caly
12	25	13	Weathered sst
25	91	20	Hard and Compact Sandstone
Venkat Nagar			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1	1	Top soil
1	9	8	Clay
9	27	11	Hard & compact granite
Kotma(S)			

Depth range (m)		Thickness (m)	Lithology
From	To		
0.00	1.30	1.3	Top soil
1.30	7.00		Clay
7.00	27.50		Weathered sst
27.50	30.99		Hard and Compact Sandstone
Kotma(D)			
Depth range (m)		Thickness (m)	Lithology
From	To		
0.00	1.15		Top soil
1.15	7.20		Clay
7.20	27.50		Weathered sst
27.50	60.50		Hard and Compact Sandstone
Anuppur(S)			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1	1	Top soil
1	9.3	8	Clay
9.3	17.5		Weathered sst
17.5	32.5		Hard and Compact Sandstone
Rajendragram(D)			
Depth range (m)		Thickness (m)	Lithology
From	To		
0.00	0.70		Top soil
0.70	2.40		Laterite weathered
2.4	15.3		Weathered Basalt
15.3	15.6		Fractured Basalt

15.6	37.5		Massive Basalt
37.5	38		Fractured Basalt
Rajendragram(S)			
Depth range (m)		Thickness (m)	Lithology
From	To		
0	1	1	Top soil
1	2.5	8	Laterite weathered
2.5	15.5	11	Weathered Basalt
15.5	16		Fractured Basalt

Annexure II : Pre-monsoon Water Level Data 2021

Block Name	Site Name	Latitude	Longitude	Site type	Depth	Date	Water Level mbgl
Anuppur	Anuppur	23°7'10" N	81°42'2" E	DW	7.7	25-05-2021	5
Anuppur	Anuppur(S)	23°7'10" N	81°42'2" E	Pz	37.43	25-05-2021	8.25
Anuppur	Barbaspur	23°5'57" N	81°56'35" E	DW	10.97	25-05-2021	5.6
Anuppur	Jhiriyatola	23°12'52" N	82°6'15" E	DW	12.35	25-05-2021	7.2
Anuppur	Muddhoba	23°15'6" N	81°53'4" E	DW	12	25-05-2021	3.8
Jaithari	Deohara	23°8'35" N	81°35'50" E	DW	14.55	25-05-2021	8.4
Jaithari	Dhangaon	23°1'50" N	81°50'20" E	DW	10	25-05-2021	8.98
Jaithari	Jamudi	23°3'59" N	81°37'58" E	DW	15	25-05-2021	8.6
Jaithari	Kerar	23°0'35" N	81°36'37" E	DW	11	25-05-2021	4.3
Jaithari	Lapta	22°59'1" N	81°53'22" E	DW	7	25-05-2021	4.82
Jaithari	Murra Tola	23°3'22" N	81°47'36" E	DW	6.3	25-05-2021	2.4
Jaithari	Venkat nagar	22°55'22" N	81°52'22" E	DW	16.49	25-05-2021	15.86
Kotma	Banshi Tola	23°11'53" N	81°53'20" E	DW	9.38	25-05-2021	8.3
Kotma	Kotma	23°11'45" N	81°58'43" E	DW	10.1	25-05-2021	7.35
Kotma	Kotma(S)	23°11'45" N	81°58'43" E	Pz	30.99	25-05-2021	5.9
Kotma	Nagara Bandh	23°12'34" N	81°59'6" E	DW	7.46	25-05-2021	1.55
Pushprajgarh	Amarkantak	22°40'28" N	81°45'40" E	DW	22.49	25-05-2021	14.1
Pushprajgarh	Basaniha	22°55'50" N	81°36'30" E	DW	10.4	25-05-2021	4.9
Pushprajgarh	Bhejari	22°49'24" N	81°41'52" E	DW	10	25-05-2021	2.6
Pushprajgarh	Piparaha	22°51'30" N	81°38'45" E	DW	8.5	25-05-2021	4.53
Pushprajgarh	Podki	22°47'2" N	81°43'45" E	DW	9.34	25-05-2021	3.7
Pushprajgarh	Rajendra gram	22°56'0" N	81°36'30" E	DW	11.72	25-05-2021	7.52
Pushprajgarh	Rajendragram -S	22°56'0" N	81°36'30" E	Pz	27.92	25-05-2021	9.92

Annexure III : Post-Monsoon Water Level Data 2021

Block Name	Site Name	Latitude	Longitude	Site type	Depth	Date	Water Level mbgl
Anuppur	Anuppur	23°7'10" N	81°42'2" E	Dug Well	7.7	10-11-2021	2
Anuppur	Anuppur(S)	23°7'10" N	81°42'2" E	Piezometer	37.43	10-11-2021	5.2
Kotma	Banshi Tola	23°11'53" N	81°53'20" E	Dug Well	9.38	10-11-2021	2.8
Pushprajgarh	Bhejari	22°49'24" N	81°41'52" E	Dug Well	10	10-11-2021	1.7
Jaithari	Dhangaon	23°1'50" N	81°50'20" E	Dug Well	10	10-11-2021	3.58
Jaithari	Jamudi	23°3'59" N	81°37'58" E	Dug Well	15	10-11-2021	6
Jaithari	Kerar	23°0'35" N	81°36'37" E	Dug Well	11	10-11-2021	2.6
Kotma	Kotma	23°11'45" N	81°58'43" E	Dug Well	10.1	10-11-2021	5.15
Kotma	Kotma(D)	23°11'45" N	81°58'43" E	Piezometer	61.75	10-11-2021	4.2
Kotma	Kotma(S)	23°11'45" N	81°58'43" E	Piezometer	30.99	10-11-2021	4.2
Jaithari	Lapta	22°59'1" N	81°53'22" E	Dug Well	7	10-11-2021	3.02
Anuppur	Muddhoba	23°15'6" N	81°53'4" E	Dug Well	12	10-11-2021	2.2
Jaithari	Murra Tola	23°3'22" N	81°47'36" E	Dug Well	6.3	10-11-2021	2.7
Kotma	Nagara Bandh	23°12'34" N	81°59'6" E	Dug Well	7.46	10-11-2021	1.25
Pushprajgarh	Piparaha	22°51'30" N	81°38'45" E	Dug Well	8.5	10-11-2021	1.93
Pushprajgarh	Podki	22°47'2" N	81°43'45" E	Dug Well	9.34	10-11-2021	3.4
Pushprajgarh	Rajendra gram	22°56'0" N	81°36'30" E	Dug Well	11.72	10-11-2021	5.17
Pushprajgarh	Rajendragra m-D	22°56'0" N	81°36'30" E	Piezometer	52.47	10-11-2021	8.5
Pushprajgarh	Rajendragra m-S	22°56'0" N	81°36'30" E	Piezometer	27.92	10-11-2021	6.7
Jaithari	Venkat nagar	22°55'22" N	81°52'22" E	Dug Well	16.49	10-11-2021	15.86

Annexure IV : Pre-monsoon Trend 2012-2021, Anuppur district

Block Name	Site Name	Latitude	Longitude	Site Type	Premonsoon trend 2012-21(m/yr)
Anuppur	Anuppur	23°7'10" N	81°42'2" E	Dug Well	-0.08054
Anuppur	Anuppur(S)	23°7'10" N	81°42'2" E	Piezometer	0.080184
Anuppur	Funga	23°10'58" N	81°49'23" E	Dug Well	-1.08841
Anuppur	Jhiriyatola	23°12'52" N	82°6'15" E	Dug Well	-0.05414
Anuppur	Muddhoba	23°15'6" N	81°53'4" E	Dug Well	-0.00088
Jaithari	Deohara	23°8'35" N	81°35'50" E	Dug Well	-0.5174
Jaithari	Dhangaon	23°1'50" N	81°50'20" E	Dug Well	0.108504
Jaithari	Jamudi	23°3'59" N	81°37'58" E	Dug Well	0.168588
Jaithari	Kerar	23°0'35" N	81°36'37" E	Dug Well	0.064884
Jaithari	Lapta	22°59'1" N	81°53'22" E	Dug Well	-0.03413
Jaithari	Venkat Nagar	22°55'22" N	81°52'22" E	Dug Well	-0.27302
Kotma	Kotma	23°11'45" N	81°58'43" E	Dug Well	-0.04931
Kotma	Kotma(D)	23°11'45" N	81°58'43" E	Piezometer	1.349616
Kotma	Kotma(S)	23°11'45" N	81°58'43" E	Piezometer	-0.77611
Kotma	Nagara Bandh	23°12'34" N	81°59'6" E	Dug Well	0.642048
Pushprajgarh	Amarkantak	22°40'28" N	81°45'40" E	Dug Well	-0.55172
Pushprajgarh	Basaniha	22°55'50" N	81°36'30" E	Dug Well	0.079584
Pushprajgarh	Bhejari	22°49'24" N	81°41'52" E	Dug Well	0.296004
Pushprajgarh	Piparaha	22°51'30" N	81°38'45" E	Dug Well	0.141132
Pushprajgarh	Rajendra Gram	22°56'0" N	81°36'30" E	Dug Well	0.3477
Pushprajgarh	Rajendragram-D	22°56'0" N	81°36'30" E	Piezometer	-0.15268
Pushprajgarh	Rajendragram-S	22°56'0" N	81°36'30" E	Piezometer	-0.18619

Annexure V : Post-monsoon Trend 2012-2021, Anuppur district

Block Name	Site Name	Latitude	Longitude	Site Type	Postmonsoon trend (m/year) 2012-21
Anuppur	Anuppur	23°7'10" N	81°42'2" E	Dug Well	0.007968
Anuppur	Anuppur(S)	23°7'10" N	81°42'2" E	Piezometer	0.058332
Anuppur	Funga	23°10'58" N	81°49'23" E	Dug Well	0.086328
Anuppur	Jhiriyatola	23°12'52" N	82°6'15" E	Dug Well	-0.0166
Anuppur	Muddhoba	23°15'6" N	81°53'4" E	Dug Well	0.029844
Jaithari	Deohara	23°8'35" N	81°35'50" E	Dug Well	-0.65012
Jaithari	Dhangaon	23°1'50" N	81°50'20" E	Dug Well	0.19302
Jaithari	Jamudi	23°3'59" N	81°37'58" E	Dug Well	0.17418
Jaithari	Kerar	23°0'35" N	81°36'37" E	Dug Well	0.221124
Jaithari	Lapta	22°59'1" N	81°53'22" E	Dug Well	0.029688
Jaithari	Venkat nagar	22°55'22" N	81°52'22" E	Dug Well	-0.01214
Kotma	Kotma	23°11'45" N	81°58'43" E	Dug Well	-0.04812
Kotma	Kotma(D)	23°11'45" N	81°58'43" E	Piezometer	-0.08755
Kotma	Kotma(S)	23°11'45" N	81°58'43" E	Piezometer	-0.06125
Kotma	Nagara Bandh	23°12'34" N	81°59'6" E	Dug Well	0.22878
Pushprajgarh	Amarkantak	22°40'28" N	81°45'40" E	Dug Well	-0.3501
Pushprajgarh	Basaniha	22°55'50" N	81°36'30" E	Dug Well	-0.25589
Pushprajgarh	Bhejari	22°49'24" N	81°41'52" E	Dug Well	-0.01045
Pushprajgarh	Piparaha	22°51'30" N	81°38'45" E	Dug Well	-0.00136
Pushprajgarh	Rajendra gram	22°56'0" N	81°36'30" E	Dug Well	-0.06788
Pushprajgarh	Rajendragram-D	22°56'0" N	81°36'30" E	Piezometer	0.098004
Pushprajgarh	Rajendragram-S	22°56'0" N	81°36'30" E	Piezometer	0.009528

Annexure VI : Ground Water Quality for Irrigation Purpose, Anuppur district

		Majour ion chemistry of ground water														Suitability of water for irrigation pourposes						
Sl.	Village	pH	EC	TH	Ca2+	Mg2+	Na+	K+	CO32-	HCO3-	Cl-	SO42-	NO3-	F-	TDS (EC* 0.64)	S S P%	SAR	%Na	RSC	K I	Mg2+ Ratio	P I
.			µ S/cm	mg/l	meq/l											Na*100/ Ca+ Mg+ Na	Na / √ (Ca+ Mg) / 2	((Na+ K) / (Ca+ Mg+ Na+ K))*100	(HCO3 + CO3) – (Ca + Mg)	Na/Ca+Mg	(Mg) / (Ca+ Mg)* 100	((Na+ (√HCO3) / (Ca+Mg+Na))* 100
1	Amarkantak	6.75	130.00	30.00	0.40	0.20	0.43	0.24	0.00	0.90	0.28	0.02	0.02	0.00	83.20	42.01	0.79	52.75	0.30	0.72	33.35	133.50
2	Anuppur	7.53	987.00	425.00	5.00	3.50	1.22	0.03	0.00	6.08	2.72	0.31	0.13	0.03	631.68	12.52	0.59	12.78	-2.43	0.14	41.19	37.88
3	Banshi Tola	6.54	282.00	110.00	1.20	1.00	0.61	0.04	0.00	1.29	1.05	0.17	0.37	0.02	180.48	21.67	0.58	22.79	-0.91	0.28	45.47	62.17
4	Bhejari	7.55	469.00	70.00	1.30	0.10	3.04	0.14	0.00	2.89	1.33	0.10	0.18	0.02	300.16	68.49	3.64	69.44	1.49	2.17	7.15	106.74
5	Deohara	7.36	1431.00	580.00	9.30	2.30	2.43	0.10	0.00	7.17	7.47	0.17	0.13	0.02	915.84	17.35	1.01	17.96	-4.43	0.21	19.84	36.42
6	Dhangaon	7.23	305.00	90.00	1.30	0.50	0.96	0.09	0.00	1.79	0.56	0.46	0.03	0.02	195.20	34.70	1.01	36.81	-0.01	0.53	27.79	83.26
7	Jamudi	7.18	578.00	185.00	2.90	0.80	1.65	0.29	0.00	4.58	0.63	0.19	0.02	0.06	369.92	30.87	1.21	34.44	0.88	0.45	21.63	70.85
8	Jhiriyatola	7.25	895.00	275.00	4.60	0.90	3.26	0.07	0.00	7.17	1.33	0.25	0.08	0.03	572.80	37.22	1.97	37.73	1.67	0.59	16.37	67.78
9	Kerar	7.46	1140.00	410.00	5.70	2.50	2.83	0.22	0.00	9.16	1.26	0.52	0.03	0.02	729.60	25.63	1.40	27.10	0.96	0.34	30.50	53.08
10	Kotma	6.70	596.00	225.00	3.30	1.20	1.22	0.12	0.00	1.59	2.93	0.35	0.52	0.01	381.44	21.29	0.81	22.84	-2.91	0.27	26.68	43.37
11	Lapta	6.80	388.00	130.00	2.00	0.60	1.09	0.04	0.00	2.19	1.05	0.40	0.03	0.03	248.32	29.48	0.95	30.25	-0.41	0.42	23.09	69.62

12	Muddhoba	7.32	410.00	110.00	1.40	0.80	1.96	0.06	0.00	3.69	0.28	0.19	0.05	0.03	262.40	47.07	1.87	47.80	1.48	0.89	36.38	93.24
13	Murra Tola	6.91	487.00	150.00	2.40	0.60	1.57	0.14	0.00	1.79	1.54	1.06	0.10	0.03	311.68	34.28	1.28	36.28	-1.21	0.52	20.01	63.61
14	Nagara Bandh	7.27	1130.00	505.00	9.60	0.50	1.17	0.04	0.00	4.38	5.86	0.27	0.29	0.01	723.20	10.41	0.52	10.74	-5.72	0.12	4.95	28.98
15	Podki	7.53	604.00	225.00	2.70	1.80	1.30	0.07	0.00	3.88	1.12	0.31	0.42	0.01	386.56	22.47	0.87	23.45	-0.62	0.29	40.02	56.42
16	Rajendra Gram	6.95	591.00	265.00	3.80	1.50	0.35	0.14	0.00	2.49	2.79	0.46	0.18	0.00	378.24	6.16	0.21	8.36	-2.81	0.07	28.32	34.09
17	Venkat Nagar	6.81	315.00	80.00	1.50	0.10	1.39	0.04	0.00	1.49	0.63	0.60	0.13	0.04	201.60	46.51	1.56	47.28	-0.11	0.87	6.25	87.37
	Suitability Criteria	**<6.00 to >8.50**	**>3000**												**>1000**	**>50**	**>26**	**>60**	**>2.5**	**>2**	**>50**	**>75**

Annexure VII : Ground Water Quality for Industrial Use, Anuppur district (Corrosivity Ratio) (CR)

Sl	Block	Village	Long	Lat	pH	TH	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Cl/35.50	2(SO4/96)	((Cl/35.50+2(SO4/96))	2(HCO3+CO3/100)	((Cl/35.50+2(SO4/96))/2(HCO3+CO3/100)
No					at 25°C	mg/l									CR
1	Pushprajgarh	Amarkantak	22.674	81.761	6.75	30	0	55	10	1	0.2789	0.0208	0.2997	109.3608	0.0027
2	Anuppur	Anuppur	23.119	81.701	7.53	425	0	371	97	15	2.7189	0.3125	3.0314	741.2232	0.0041
3	Kotma	Banshi Tola	23.198	81.889	6.54	110	0	79	37	8	1.0457	0.1667	1.2124	157.9656	0.0077
4	Pushprajgarh	Bhejari	22.823	81.698	7.55	70	0	176	47	5	1.3246	0.1042	1.4288	352.3848	0.0041
5	Jaithari	Deohara	23.143	81.597	7.36	580	0	437	265	8	7.4597	0.1667	7.6263	874.8864	0.0087
6	Jaithari	Dhangaon	23.031	81.839	7.23	90	0	109	20	22	0.5577	0.4583	1.0161	218.7216	0.0046
7	Jaithari	Jamudi	23.066	81.633	7.18	185	0	279	22	9	0.6274	0.1875	0.8149	558.9552	0.0015
8	Anuppur	Jhiriyatola	23.214	82.104	7.25	275	0	437	47	12	1.3246	0.2500	1.5746	874.8864	0.0018
9	Jaithari	Kerar	23.010	81.610	7.46	410	0	559	45	25	1.2549	0.5208	1.7757	1117.9104	0.0016
10	Kotma	Kotma	23.196	81.979	6.70	225	0	97	104	17	2.9281	0.3542	3.2823	194.4192	0.0169
11	Jaithari	Lapta	22.984	81.889	6.80	130	0	134	37	19	1.0457	0.3958	1.4416	267.3264	0.0054
12	Anuppur	Muddhoba	23.252	81.884	7.32	110	0	225	10	9	0.2789	0.1875	0.4664	449.5944	0.0010
13	Jaithari	Murra Tola	23.056	81.793	6.91	150	0	109	54	51	1.5338	1.0625	2.5963	218.7216	0.0119

14	Kotma	Nagara Bandh	23.209	81.985	7.27	505	0	267	208	13	5.8562	0.2708	6.1270	534.6528	0.0115
15	Pushprajgarh	Podki	22.784	81.729	7.53	225	0	237	40	15	1.1155	0.3125	1.4280	473.8968	0.0030
16	Pushprajgarh	Rajendra Gram	22.933	81.608	6.95	265	0	152	99	22	2.7887	0.4583	3.2470	303.7800	0.0107
17	Jaithari	Venkat Nagar	22.923	81.873	6.81	80	0	91	22	29	0.6274	0.6042	1.2316	182.2680	0.0068

Annexure VIII Ground Water Quality Assessment via Chada Plot

Sl No	District	Block	Village	Long	Lat	%Ca+Mg-Na+K (x)	CO3+HCO3-Cl+SO4 (y)
1	Anuppur	Pushprajgarh	Amarkantak	22.674	81.761	-5.506581536	-64.3561
2	Anuppur	Anuppur	Anuppur	23.119	81.701	74.44509197	-26.1741
3	Anuppur	Kotma	Banshi Tola	23.198	81.889	54.41727991	-36.5868
4	Anuppur	Pushprajgarh	Bhejari	22.823	81.698	-38.88379203	-77.9469
5	Anuppur	Jaithari	Deohara	23.143	81.597	64.08155138	-31.6404
6	Anuppur	Jaithari	Dhangaon	23.031	81.839	26.38667109	-50.1652
7	Anuppur	Jaithari	Jamudi	23.066	81.633	31.12529253	-47.9462
8	Anuppur	Anuppur	Jhiriyatola	23.214	82.104	24.54538301	-51.0194
9	Anuppur	Jaithari	Kerar	23.010	81.610	45.80393707	-40.8776
10	Anuppur	Kotma	Kotma	23.196	81.979	54.31445371	-36.6387
11	Anuppur	Jaithari	Lapta	22.984	81.889	39.49598276	-43.9521
12	Anuppur	Anuppur	Muddhoba	23.252	81.884	4.392481479	-60.085
13	Anuppur	Jaithari	Murra Tola	23.056	81.793	27.43683157	-49.676
14	Anuppur	Kotma	Nagara Bandh	23.209	81.985	78.52733067	-23.9731
15	Anuppur	Pushprajgarh	Podki	22.784	81.729	53.10929994	-37.2454
16	Anuppur	Pushprajgarh	Rajendra Gram	22.933	81.608	83.28680543	-21.372
17	Anuppur	Jaithari	Venkat Nagar	22.923	81.873	5.446177207	-59.6235