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RESEARCH ARTICLE

HYDROGEOLOGICAL VARIATIONS IN SAHYADRI GROUP AND SATPURA GROUP OF DECCAN TRAPS: COMPARATIVE STUDY OF REPRESENTATIVE WATERSHEDS FROM THE NANDURBAR DISTRICT OF MAHARASHTRA, INDIA

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Abstract

Water is an elixir of the life and groundwater is the main source of drinking, irrigation, and industrial water uses. Occurrence and movement of the groundwater is mainly depending on the hydrogeological characteristics of the rocks. About 80% of the Maharashtra state is occupied by Deccan basalt exhibiting diversity in the groundwater development. In present study, an attempt has been made to do comparative study of Gomai watershed and Amaravati watershed for analyzing the hydrogeological behavior of basalts of Sahyadri Group and Satpura Group of Deccan Traps.

Introduction:-

Groundwater occurrence and movementis mainly controlled by lithological characteristics, geomorphic landforms, and rainfall pattern of the area. Porosity and permeability of the earth material is expressed by means of depth of weathering, consolidated or unconsolidated sediments, lineament density and well performance. Therefore, for groundwater evaluation, it is very necessary to undertake integrated study in the area. In this chapter hydrogeological investigations and hydrogeological characteristics of different lithological units and groundwater quality of the area are discussed. Discussion on depth of weathering, hydrogeological characteristics, lineament density, well monitoring, groundwater levels and rainfall, hydrogeomorphic landforms, groundwater provinces, influence of dykes on groundwater development and groundwater quality of the area are discussed hereunder.

Study Area

In present study an attempt has been made to carry out an integrated hydrogeological study of watersheds situated on both Northern and Southern side of the Tapi river. Gomai watershed is north to the Tapi river, whereas Amaravati river is to the south of the Tapi river. Major part of the study area is administered by Nandurbar District administration and small part is by Dhule District administration and Khargone District of the Madhya Pradesh. State highways and district highwayspasses through the study area.Gomai watershed and Amaravati watershed are two watersheds studied in the present research work. Gomai river and its tributaries forming Gomai watershed andmeets to Tapi basin at Prakasha. In Gomai watershed, major rivers viz. Umri river, Subri river and Khapri river are flowing South western direction and supplying water to Gomai river. Gomai watershed collects rainfall from Satpura hills. In case of Amaravati watershed, Amaravati river and major drainage like Nandan river and Gusardi river, Nai river are forming Amaravati watershed. Confluence of Amaravati river and Tapi river is near Shenvade village.Gomai watershed is located in the North-Eastern part of the Nandurbar district and is bounded by Latitudes of 21°25′49″ N to 21°51′57″ and Longitudes of 74°16′54″ E to 74°54′48″ E. Amaravati watershed is located in the

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Eastern part of the Nandurbar district and North western part of the Dhule district bounded by Latitudes of 21º09′44″ N to 21º24′43″ N and Longitudes of 74º12′54″ E to 74º43′09″ E. Area is mapped by Survey of India on 1:50,000 scale. Survey of India old Series toposheet Nos. 46K/6, 46K/7, 46K/8, 46K/9, 46K/10, 46K/14 covers the study area. Gomai watershed is covering 1365.08 km^2 area encompassing 95 villages of Shahada Taluka of

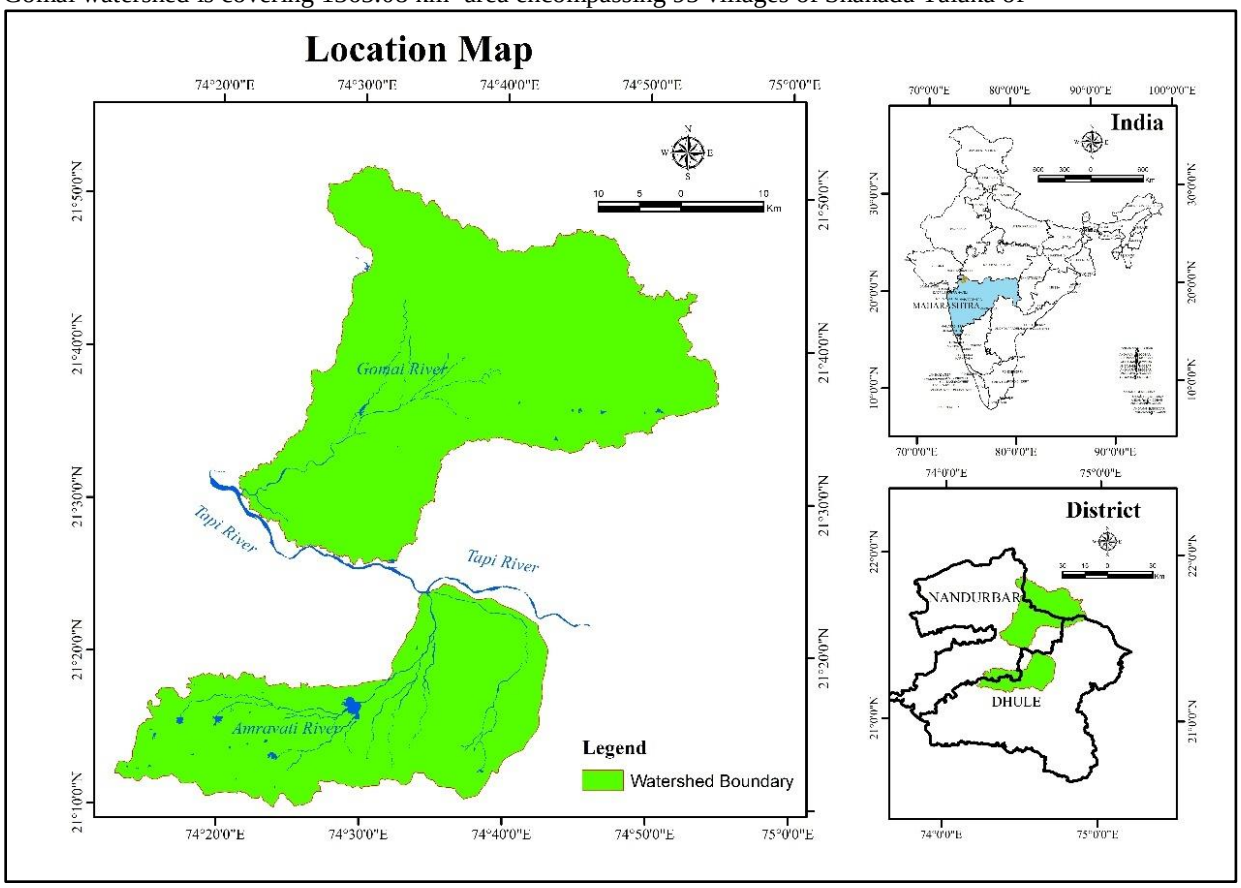

Fig. 1:- Map showing location of the study area.

Nandurbar district of Maharashtra state and 94 villages/habitations of Pansemal Taluka in Barwani district of Madhya Pradesh. Whereas Amaravati watershed is covering 756.57 km^2 area encompassing 65 villages of Shindkheda Taluka of Dhule district and Nandurbar taluka in Nandurbar district. **Fig. 1** shows the location of the study area.

Methodology:-

In present study, well inventory is the main source of groundwater resource mapping. In Gomai watershed, well inventory of 110 wells is carried out, whereas in Amaravati watershed, 56 wells are inventoried. Data on type of well, depth of well, depth of casing, depth to water level, water level fluctuation are collected and correlated with of rainfall, land use/ land cover. Geological units of the study area are classified based on their hydrogeological characteristics. In addition to this, groundwater potential zonation of the study area is carried out by considering rock types, fractures, joints, and other hydrogeological structures. Other factors like geomorphological landforms, Depth of Weathering in the area, Land Use/Land Cover pattern of the area, Slope variations in the area, Drainage Density and Lineament Density are also considered for delineation of groundwater potential zones.

Geological Set-Up Of The Study Area

Geology of the area is studied by referring Toposheets, District Resource Maps (DRM) of Nandurbar Districts, DhuleDistricts and Barwani Districts, GSI Reports published by Geological Survey of India, Groundwater Survey Development Agency (GSDA) reports, GSDA well logs, geological discussion with GSDA officers, Central Ground Water Board reports, interpretation of Sentinel- 2A satellite image and field observations and discussion on well drilling with well owners.Geological set up of the studied area is represented by Tapi Alluvium and Deccan Traps representing by Sahyadri Group and Satpura Group of rocks(**Fig. 2**). In the studied area, Gomai watershed is

northernpart of the Tapi basinand represented by Satpura Group of Deccan Traps, whereas Deccan Traps in Amaravati watershed is situated to the southern part of the Tapi river and basaltic rocks are constituting Sahyadri Group of Deccan traps. In Gomai watershed, Tapi alluvium is spread over 749.57 km^2 area and Satpura Group of rocks are accounted for 610.63 km^2. In case of Amaravati watershed, Sahyadri Group of rocks are prominently covering 688. 66 km^2 area and only 67.91 km^2 area is covered by Tapi Alluvium. Unconsolidated quaternary sediments viz. Tapi alluvium, silt, kankar, grits, conglomerates and calcareous nodules are youngest sediments underlaying dykes and Deccan trap flows in the area. Dark grey coloured doleritic dykes trending EW, NW-SE are intruded in the basalts indicating younger than Deccan traps.

In Gomai watershed, Satpura Group of Deccan traps are exhibiting different varieties of basaltic rocks. On the basis of characteristics of basalts, Satpura Group is sub-divided into 6 litho-units. viz. Basaltic lava flows (Unclassified) coded as II, 4 to 6 compound pahoehoe /Simple basaltic lava flows (5 Flows) coded as III, Group of compound 'Pahoehoe' Basaltic lava flows (4 flows) coded as IV, Group of compound 'Pahoehoe' Basaltic lava flows (5 flows) coded as V, 2 to 3 compound pahoehoe basaltic lava flows coded as VI and 1 Compound Pahoehoe basaltic lava flow coded as VII. In this watershed, Basaltic lava flows (Unclassified)are spreading over 48. 10 km^2 area and4 to 6 compound pahoehoe /Simple basaltic lava flows (5 Flows)are spreading over 2.17 km^2 area.Group of compound 'Pahoehoe' Basaltic lava flows (4 flows)are spreading over 50.68 km^2 area, Group of compound 'Pahoehoe' Basaltic lava flows (5 flows)are spreading over 373.21 km^2 area. 2 to 3 compound pahoehoe basaltic lava flowsare spreading over 70.17 km^2 area and 1 Compound Pahoehoe basaltic lava flowis spreading over 66.30 km^2 area.

In Amaravati watershed, Deccan traps are represented by Sahyadri Group of rocks. On the basis of variationsin basaltic rocks, Deccan traps are sub-divided into Upper Ratangarh Formation and Lower Ratangarh Formation. In this watershed, Upper Ratangarh Formation is accounting for 247.16 km^2 area of the watershed. In case of Lower Ratangarh Formation, 441.5 km^2 area of the watershed is constituted by 3 'Aa' and 5 compound Pahoehoe basaltic lava flows. In Gomai watershed, small patch of Deccan basalt is surrounded by Tapi alluvium forming an inlier covering villages north of Sarangakheda viz. Pusand, Kalmadetc.

Depth Of Weathering

Depth of weathering are responsible for diverting surface flow to the subsurface flow. In study area, based on depth of weathering both watershedsare divided into Shallow depth of weathering (0-3 m), Moderate depth of weathering (3-7 m), Deep depth of weathering (7-10 m) and Very deep depth of weathering (more than 10 m). In case of alluvium areas of the Gomai watershed, maximum depth of 100 m is observed at Prakasha village and minimum depth of 10 m is observed at Rakhi Khurd village. Satpura group of Deccan trap constitutes the Deccan geology of the Gomai watershed, in this area, maximum depth of 7 m is observed at Lohare village and un-weathered basaltsare observed at Tilikhet village.In alluvium areas of Amaravati watershed, maximum depth of 100 m is observed at Tavkhede Nava village and minimum depth of 5m is observed at Varhihadi village. In Amaravati watershed, Sahyadri group of Deccan trap is divided in to Lower Ratangarh formation and Upper Ratangarh formation. Maximum depth of weathering in Lower Ratangarh formation is 3 m observed at Shani Mandal village and un-weathered section is observed at Hatti village. Rocks of Upper Ratangarh formations are exhibiting maximum depth weathering of 7m observed at Dondaicha village and massive un-weathered basalts are observed at Korde village. In study area, 36.64 % area of the Gomai watershed is characterised shallow depth of weathering zone, 7.50 % area is moderate weathered zone, 18.96 % area is under deep weathering zone and 37.31 % area is covered by very deep weathering zone. In case of Amaravati watershed, shallow depth of weathering zone, moderate weathered zone, deep weathering zone and very deep weathering zone are characterised by 24.58 %, 28.79 %, 22.92 % and 23.62 % area of the watershed respectively.

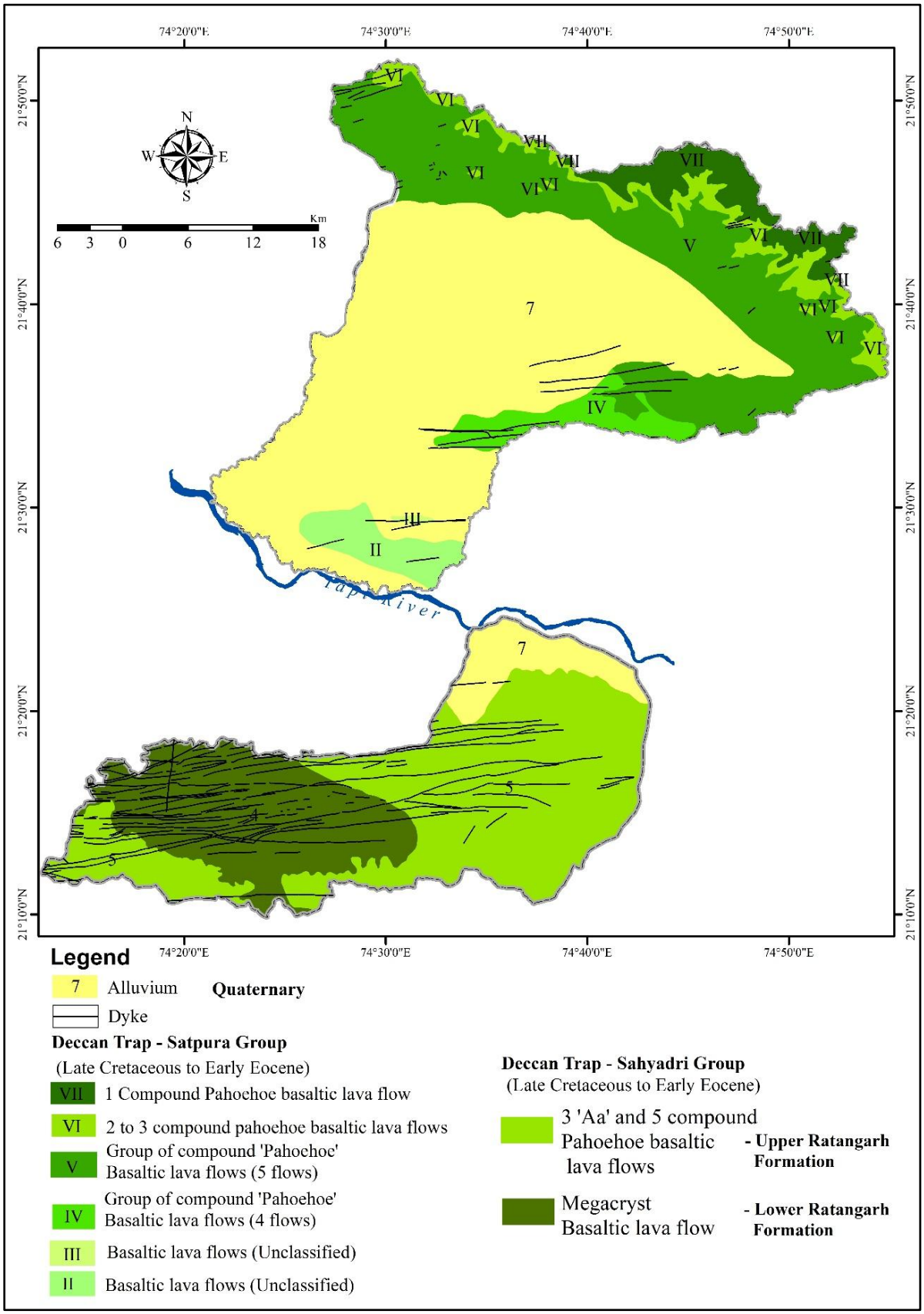

Fig. 2:- Geological map of the study area (After, GSI, 2001).

Hydrogeological Characteristics

The geological formation in the study area ranges in ages from Lower Cretaceous to Recent. 55.10 % area of the Gomai watershed constitutes of Alluvium followed by Deccan Basalts of Satpura group covering 44.89% of the total area. In case of Amaravati watershed, 8.97 % of the area is covered by alluvium, 32.66% of the area is covered by rocks of Lower Ratangarh formation and 58.35 % of the area is covered by rocks of Upper Ratangarh formation. Doleritic dykes are occupied 0.092% of the area in Gomai watershed and 0.75% of the area in Amaravati watershed. Hydrogeological characteristics of different litho-units are grouped as Consolidated formations and Unconsolidated formations (**Fig.3**).

Consolidated Formations:

Consolidated formations in the study area are represented by doleritic dykes, Deccan basalts ofSahyadri group and basalts of Satpura group. 0.092% area of the Gomai watershed and 0.75%area of the Amaravati watershed is under this class. Consolidated formation behaves as good aquifer due to secondary porosity and permeability. In Consolidated zone of Gomai watershed, Depth of weathering is in the range of 0 m to 7 m. Lineament density is considerably high trending in West-East direction. Drainage density is high, depicting rate of infiltration in the area. 47 numbers of monitoring wells are drilled in consolidated formation anddepth ranges of wells are 11.0 m -19.4 m.Diameter of Dug wells is in the range of 2 m – 5m. Depth of water level is 2.9 m -14 m. Post-monsoon and Pre-monsoon water level fluctuation is in the range of 2.1 m – 11.0 m.Surface waterbodies like Amaravati dam, Gomai dam, Susri dam and other lakes are present on consolidated formation playing an important role in fulfilling the need of nearby villages.In Consolidated zone of Amaravati watershed, Depth of weathering is in the range of more than 10m. Lineament density is considerably high trending in East direction. Drainage density is high, depicting rate of infiltration in the area. 56 numbers of monitoring wells are drilled in consolidated formation. Depth of wells are in the range of 8m to 20.4m. Diameter of Dug wells are in the range of 2 m -5.5m. Depth of water level is in the range of 1.1 m -20.4m. Post-monsoon and Pre-monsoon water level fluctuation is in the range of 0.9 m -10.5 m. Surface water bodies on Consolidated formation of Amaravati watershed are present at Vaindane and Nava Dongrala villages.

Unconsolidated Formations:

Unconsolidated sediments in the study area are represented by Tapi Alluvium, gravels, pebbles, Kankar and foot hill boulders. 55.10% area of the Gomai watershed and 8.94 % area of the Amaravati watershed is under this class. In Gomai watershed, Unconsolidated sediments formed the potential aquifer occurs in south western part of the watershed. Lineament density is considerably high trending in east-west direction. Drainage density is high depicting rate of infiltration in the area. 62 numbers of monitoring wells are drilled in unconsolidated sediments. Depths of wells are in the range of 7.3 m to 23.0 m. Diameter of Dug wells are in the range of 3 m – 7 m. Depth of water level is in the range of 1.1 m to 19.5m. Post-monsoon and Pre-monsoon water level fluctuation is in the range of 1.2 – 10.8 m. Surface water bodies on unconsolidated sediment areas are present at Shahada villages of Gomai watershed.

Amaravati watershed, Unconsolidated sediments formed the potential aquifer occurs in northern part of the watershed. Lineament density is considerably high trending in East direction. Drainage density is high depicting rate of infiltration in the area. 6 numbers of monitoring wells are drilled in Unconsolidated sediments. Depth of wells are in the range of 9.8 m - 15.1m. Diameter of Dug wells are in the range of 3 m – 4 m. Depth of water level is 2.0 m - 7.4m. Post-monsoon and Pre-monsoon water level fluctuation is in the range of 1.0 m -5.2m.

Fig. 3: - Hydrogeological units demarcated in the study area.

Lineament Density

In study area, overall trends of Lineaments are E-W, NE-SW, NW-SE and N-S directions. Lineament density map prepared for the area to demarcate the zones of no lineament, very low lineament (0.1 – 0.5 km/km^2), low lineament (0.6 – 1.0 km/km^2), moderate lineament (1.1 – 2.0 km/km^2), high lineament (2.1 – 3.0 km/km^2), and very high lineament (3.1 – 4.0 km/km^2). Basaltic areas of the area show moderate to very high lineament density. In case of Amaravati watershed, basalts of both Lower Ratangarh and Upper Ratangarh formation shows high lineament density ranging 2.1 – 3.0 km/km^2, and very high lineament density ranging 3.1 – 4.0 km/km^2. Lineament plays an important role in an occurrence and movement of groundwater and same is reflected in hydrogeological behavior of basaltic rocks of the study area.Depth of dug wells in these areas are in the range of 12.3 m to 15.0 m. Pre-monsoon

water levels are in the range of 10.7 m to 13.5 m. In case of Post-monsoon water levels are ranging from 7.22 m to 9.6 m.

Well Monitoring

Well monitoring helps to monitor hydrogeological performance of the litho-units and to estimate the seasonal variation in water levels. In study area, total 171 wells are established for monitoring water levels. In Gomai watershed, total 109 wells are established considering varied hydrogeological behaviour of deccan basalt and alluvium. 62 wells are on Alluvium and 47 wells are on Deccan Basalts of Satpura group. In Amaravati watershed, 6 tube wells are on alluvium and 9 wells are on Deccan Basalts of Lower Ratangarh formation 47 wells are on Deccan Basalts of Upper Ratangarh formation Sahyadri group.In Gomai watershed, out of 109 wells, 43 wells are dug wells, 46 are bore wells and 20 are Tube wells. In case of Amaravati watershed, out of 62 wells, 43 wells are dug wells, 13 are bore wells and 6 are Tube wells. Dug wells and bore wells are common in basaltic areas and Tube wells are more common in alluvium areas. These wells are monitored for two consecutive years 2018 and 2019. Post-monsoon water levels are recorded from October month and Pre--monsoon water levels are recorded from month of March.

Monitoring wells are under domestic as well as under agriculture use. In Gomai watershed, Depth of dug wells is in the range of11.0 - 15.4m. Bore wells are more common in basaltic areas having depth range 11.0 m to 19.4m. Tube wells are in Alluvium areas having depth range of 10 m to 15.4m. In Amaravati watershed, Depth of dug wells are in the range of 11.0 m to 17.5 m. Bore wells are more common in basaltic areas having depth range 12.0 m to 20.4m. Tubewells are drilled in alluvium areas having depth range of 10 m to 12 m. In Gomai watershed, Pre-monsoon groundwater level is in the range of 5.9m to 17.6 m and of 1.1m to 9.3m in post-monsoon. Most of the dug wells are having parapet height of 1.5m to 3.0 m.

Diameter of the dug well is in the range of 2.0 m to 5.0 m. Dug wells from eastern areas are converted to Dug-cum-Bore wells due to the considerable depth of the water level. In such dug wells, about 10.0 m of bores are drilled to take out the ground water. Well details of monitored wells are given in **Table 1**.

Table 1:- Lithologic unit-wise well details observed during well monitoring.

Lithology / Performance		Alluvium	Influenced by Dyke	Basalts of Satpura group	Basalts of Lower Ratangarh Formation	Basalts of Upper Ratangarh Formation
Type of Wells		**Tube Well**	**Dug Well**	**Dug Well/ Bore well**	**Dug Well/ Bore well**	**Dug Well/ Bore well**
Depth range of the well (In m)		10.0 -14.7	15.4-20.4	13.4-17.8	14.3-18.6	13.5-19.5
Diameter range of the well		2 - 8 Inch	5.0 - 5.5 m	3.0 – 5.0 m / 2-8 Inch	3.0 – 5.0 m / 2-8 Inch	3.0 – 5.0 m / 2 - 8 Inch
Depth range of water level (In m)	Pre – Monsoon - 2018	16.2 - 11.2	8.2 - 14.1	6.0 – 13.6	7.0 – 14.1	6.7 – 18.2
	Post – Monsoon - 2018	2.2 – 11.1	6.3 - 14	2.1 – 8.6	6.2 – 10.4	7.7 – 15.3
	Pre – Monsoon - 2019	4.1 – 11.0	7.2 - 14.1	3.6 – 6.8	6.8 – 14.1	3.8 – 17.7
	Post – Monsoon - 2019	1.8 – 4.1	0.3 – 6.0	1.2 – 4.4	0.3 – 4.6	0.9 – 11.8
Range of water level fluctuation(Pre-monsoon and Post-monsoon) (In m)		0.8 – 4.4	3.1 - 10.4	1.7 – 7.1	0.9 – 10.1	1.6 – 11.7

In Amaravati watershed, Pre-monsoon groundwater level is in the range of 7.0 m to 19.5 m and of 4.6m to 15.3 m in post-monsoon. Most of the dug wells are having parapet height of 1.0 m to 3.5 m. Diameter of the dug well is in the range of 3.0 m to 5.0 m. Dug wells from southern areas are converted to Dug-cum-Bore wells due to the considerable depth of the water level. In such dug wells, about 12.0 m of boresare drilled to take out the ground water.

Groundwater Levels

In the study area, total 171 wells are monitored. In Gomai watershed, total 109wells and in Amaravati watershed, total 62 wells are monitored during Pre-monsoon and Post-monsoon period of year 2018 and 2019. Recorded depth to water table in Pre-monsoon and Post-monsoon period of the year 2018 and 2019 are plotted on the map as shown in **Fig.4.**

In study area, Alluvium is comprising of sand, gravel and pebbles forms a good aquifer, Pre-monsoon depth to groundwater levels in alluvium areas of Gomai watershed are 6.4 m to 12.2 m recorded in the year 2018 and 3.8 m to 12.0 m recorded in year 2019.Ranges of 2.1 mto 7.6 m and 1.4 m to 5.6 m are Post-monsoon depth to groundwater levels in alluvium areas of Gomai watershed recorded in the year 2018 and 2019, respectively. In alluvium areas of Gomai watershed, maximum depth of groundwater level of 14.8 m is recorded in Dongargaon village and minimum level of 1.3 m is recorded in Prakasha village.In case of Amaravati watershed, Pre-monsoon depth to groundwater levels in alluvium areas are in the ranges of 6.2 m – 12.2 m and 3.8 m– 12.0 m recorded in the year 2018 and 2019, respectively. Ranges of 6.2 m – 12.2 m and 1.7 m – 4.1 m are Post-monsoon depth to groundwater levels in alluvium areas of Amaravati watershed recorded in the year 2018 and 2019, respectively. In alluvium areas of Amaravati watershed, maximum depth of groundwater level of12.2 m is recorded in DaulMandane village and minimum depth level of 1.7 m is recorded in Shendwade village.Deccan Basalt is hydrogeologically inhomogeneous. In Gomai watershed, Deccan basalt is of Satpura Group comprising varied basaltic flows. In some areas, it is highly fractured and weathered up to 3 m depth. Due to secondary porosity and permeability basalts also behave as good aquifer in north-eastern part of the watershed comprising Kevli, Bhadhhada, Ghatiya, Raykhed, Mankul and adjacentvillages.Pre-monsoon depth to groundwater levelsin Deccan basalts of Satpura Group are in the ranges of 6.9 m – 17.6 m and 5.4 m – 12.9 m recorded in the year 2018 and 2019respectively. Depth to groundwater levelsare in the ranges of 4.2 m – 9.3 m and 1.2 m – 5.4 recorded in the post-monsoon seasons of year 2018 and 2019 respectively.

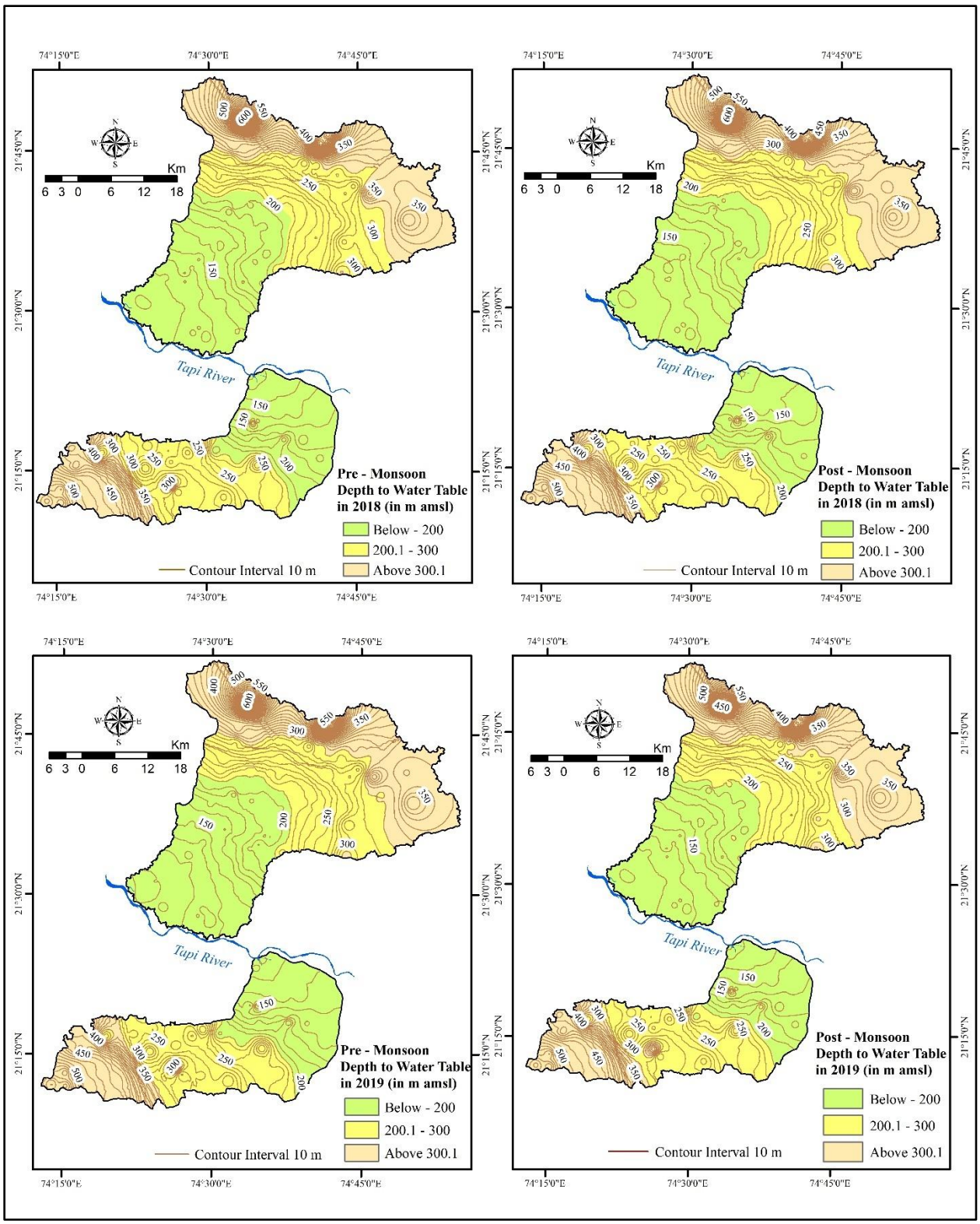

Fig. 4:- Depth to water table recorded in Pre-monsoon and Post-monsoon seasons of year 2018 and 2019.

In basaltic areas of Gomai watershed, maximum depth of groundwater level of 17.6 m is recorded in Piplod village and minimum level of 1.2 m is recorded in Chandsali. In Amaravati watershed, Sahyadri Group comprising basalts of lower Ratangarh formation and Upper Ratangarh Formation. In areas of lower Ratangarh formation, basalt is

highly fractured in some areas and weathered up to 3.0 m depth. Due to secondary porosity and permeability basalts lower Ratangarh formation also behaves as good aquifer in Thanepada areas. Pre-monsoon depth to groundwater levels in basalts of lower Ratangarh formation recorded the ranges of 8.2 m – 14.1 m and 7.2 m – 14.1 m in year 2018 and 2019 respectively. 6.3 m – 14.0 m and 1.3 m – 6.0m are Post-monsoon depth to groundwater levels ranges recorded in the year 2018 and 2019 respectively. In basaltic areas lower Ratangarh formation, maximum depth of groundwater level of 14.1 m is recorded in Aichale village and minimum level of 0.3 m is recorded in Thanepadavillages of Amaravati watershed.In areas of Upper Ratangarh formation, basalt is highly fractured in some areas and weathered up to 3.0 – 6.0 m depth. Due to secondary porosity and permeability basalts Upper Ratangarh formation also behaves as good aquifer in Anjanvihar and Vikharan village areas. Pre-monsoon depth to groundwater level ranges in basalts of Upper Ratangarh formation are 7.0 m – 19.5 m and 5.6 m – 16.9 m recorded in the year 2018 and 2019 respectively. Post-monsoon depth to groundwater level ranges of 4.6 m – 15.3 m and 0.1 m – 10.64m are recorded in post-monsoon season of year 2018 and 2019 respectively. In basaltic areas Upper Ratangarh formation, maximum depth of groundwater level of 19.5 m is recorded in Chilane village and minimum level of 0.1 m is recorded in Anjanvihar villages of Amaravati watershed.

Groundwater Levels And Annual Rainfall Analysis

Groundwater recharge is due to annual rainfall, responsible to replenish the groundwater level. In present study, an attempt has been made to correlate the variations in precipitation with the Pre-monsoon and Post-monsoon groundwater levels of both the watersheds. **Table 2** depicts actual annual rainfall, average groundwater levels (Pre-monsoon and Post-monsoon) and average groundwater level fluctuation data for years of 2018 and 2019. In Gomai watershed, actual annual rainfall in the year 2018 is 812.20mm, showing average recharge in groundwater levels by 4.21 m, whereas annual rainfall in the year 2019 is 860.96 mm, showing recharge in groundwater levels by 4.92 m. In Amaravati watershed, actual annual rainfall in the year 2018 is 839.0 mm, showing average recharge in groundwater levels by 3.10 m, whereas annual rainfall in the year 2019 is 880.0 mm, showing average recharge in groundwater levels by 7.89 m. As per GSDA well monitoring water level data, average groundwater level fluctuation in Gomai watershed is observed 4.98 m in the year 2011, 4.86 m in the year 2012, 5.08 m in the year 2013, 4.5 m in the year 2014, 4.28 m in the year 2015, 4.1 m in the year 2016 and 4. 85 m in the year 2017. These groundwater level fluctuation for all years shows the positive correlation with rainfall. In case of Amaravati watershed, average groundwater level fluctuation recorded by GSDA is 3.8 m in the year 2011, 4.5 m in the year 2012, 4.9 m in the year 2013, 3.2 m in the year 2014, 3.6 m in the year 2015, 4.8 m in the year 2016 and 5.6 m in the year 2017. This groundwater level fluctuation for all years shows the positive corelation with annual rainfall.

Table 2:- Actual rainfall and groundwater levels (pre-monsoon and Post-monsoon) and average groundwater fluctuation.

Sr. No.	Year	Gomai watershed				Amaravati watershed			
		Actual Annual Rainfall (In mm)	**Average ground water level** (In m)		**Average ground water level Fluctuation**(In m)	**Actual Annual Rainfall** (In mm)	**Average ground water level**(In m)		**Average ground water level Fluctuation**(In m)
			Pre-Monsoon	**Post-Monsoon**			**Pre-Monsoon**	**Post-Monsoon**	
1.	2018	812.20	10.13	5.91	4.21	839.00	12.11	9.01	3.10
2.	2019	860.96	7.97	3.05	4.92	880.00	10.84	2.94	7.89

Hydrogeomorphology

Different geomorphic landforms give different responses to the surface run-off and therefore it plays an important role in groundwater studies. Interaction of surface runoff and geomorphic landforms is studied. In present study, landforms of fluvial origin, denudational origin and structural origin are segregated and analysed the groundwater levels.

In Gomai watershed, 56.21 % area of the watershed is covered by fluvial origin, 27.05 % is represented by structural origin, 15.71 % is of denudational origin and 1.01 is covered by water bodies. In case of Amaravati watershed, majority of the area is covered by denudational origin accounting for 74.30 % area of the watershed, 11.75 % is represented by structural origin, 2.44 % area of the watershed is covered by water bodies and only 11.49 % area of the watershed is covered by landforms of fluvial origin. Surface and subsurface water movements are controlled by

these hydrogeomorphic zones. Zone of fluvial origin landform is most suitable for groundwater development and management also. Zone of structural origin landform supports to high surface runoff. Zone of denudational landform shows moderate to good groundwater prospecting depending on the other factors like land use/ land cover, rock types, lineaments, and slope.

Groundwater Provinces Of The Study Area

As per Taylor (1959) classification, study area is grouped into two Groundwater Provinces. Deccan Trap Province of Late Cretaceous to Early Eocene and Tapi alluvium of Pleistocene to recent representing Cenozoic Fault basins. In study are 61.38 % of the area is represented by Deccan Trap Province and 38.62 % of the area is by Cenozoic Fault basins. As concerned to Groundwater development Cenozoic Fault basins are having more scope than Deccan Trap Province. In Deccan Trap Province area depth of wells are in the range of 10.5m to 20.4m. In alluvium of Tapi Cenozoic Fault basin areas depth of wells are in the range of 10m to 15m.

Influence Of Dykes On Groundwater:

In present study, doleritic dykes are criss-cross intruded in both Satpura group and Sahyadri group of Deccan trap. General trend of dykes is ENE-WSW, E- W and N-S running parallel for long distances. Width of dyke is in the range of few meter to 30 m forming prominent ridges in the area. These dykes are resistant to weathering as compared to basalt. Influence of dykes on groundwater movement is studied by observing wells developed in the periphery 100 m, 200 m and 500 m distance from the dykes. In Gomai watershed, wells from Titri village are in 100 m proximity of the dyke. These wells are in the depth range of 13 m to 14 m.

Pre-monsoon and Post-monsoon water levels are in the range of 9.1 m to 10.4 m and 4.1 m to 8.3 m respectively. In Amaravati watershed, wells from Vikharan, Virdel, Setana, Shelti, Vanjara Tanda,Thanepada, Shinbandhpada,Vasantnagar, Petla, Nava Dongraleare in 100 m proximity of the dyke. These wells are in the depth range of 12.6 m to 16.8 m. Pre-monsoon and Post-monsoon water levels are in the range of 7.4 m to 14.8 m and 2.3 m to 14.6 m respectively. In the 200 m proximity of dykes wells from Titri village of Gomai watershed and wells of Vikharan, Virdel, Setana, Shelti, Vanjara TandaThanepada, Shinbandhpada,Vasantnagar, Petla, Nava Dongrale from Amaravati watershed are showing same performance as of 100 m periphery.

In Gomai watershed, wells from Vadchhli, Nava Aslod and Langdi Bhavan village are in 500 m proximity of the dyke. These wells are in the depth range of 12 m to 15 m. Pre-monsoon and Post-monsoon water levels are in the range of 10.0 m to 11.4 m and 4.8 m to 10.3 m respectively. In Amaravati watershed, wells from Malpur, Vaindane, Kherde Khurd, Setana, Balvand, Shelti, Shani Mandal, Anjanvihar, Aichala, Talwade Khurd, Vanjara Tanda, Thanepada, Tambapur, Shinbandhpada, Katekpada, Kaorde and Isarde are in 500 m proximity of the dyke. These wells are in the depth range of 11.5 m to 17.8 m. Pre-monsoon and Post-monsoon water levels are in the range of 6.8 m to 15.2 m and 2.5 m to 15.0 m respectively. At some places these dykes are act as underground bandhara restricting groundwater to flow.

Conclusion:-

Hydrogeological study of the area revels that 45 % area of the Gomai watershed and 91 % area of the Amaravati watershed comes consolidated formation and 55 % area of the Gomai watershed and 9 % area of the Amaravati watershed is of un-consolidated nature. Unconsolidated formations are of good efficiency in view of groundwater development and recharge. Weathered and fractured consolidated rocks are also fulfilling the need of water. In Gomai watershed, extent of Cenozoic Fault basins groundwater Province is more whereas in Amaravati Deccan Trap Province is more.Depth to water table in alluvium areas are in the range of 1.8 m amsl to 16.2 m amsl. In upper Ratangarh formation depth to water table are in the range of 0.9 m amsl to 18.2 m amsl, whereas range of 0.3 m amsl to 14.1 m amsl are observed in lower Ratangarh formation.In Satpura group of basaltic areas, variation in pre-monsoon water levels is in the range of 3.6 m to 13.6 m and post-monsoon water levels are in the range of 1.2 m to 8.6 m. Whereas, In Sahyadri group of basaltic areas, variation in pre-monsoon water levels is in the range of 3.8 m to 18.2 m and post-monsoon water levels are in the range of 0.3 m to 15.3 m. weathered and fractured basalt behaves as a good aquifer.In Tapi alluvium, variation in pre-monsoon water levels is in the range of 4.1 m to 16.2 m and post-monsoon water levels are in the range of 1.8 m to 11.1 m. Groundwater level is more fluctuating in alluvium areas due to groundwater-based irrigation.Influence of dykes on groundwater movement is observed in the monitoring wells. If the monitoring wells are in the buffer of 100 m from dyke, it shows 2.3 m to 14.6 m groundwater level. Monitoring wells in the periphery of 200 m from dyke shows 2.3 m to 14.6 m and 500 m buffer

from dyke shows 2.5 m to 17.8 m. Some dykes behave as barrier for sub-surface runoff and works as a underground bandhara.

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