Original Research Paper

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Geology

"HYDROGEMORPHIC INVESTIGATION IN THE BHULESHWARI RIVER BASIN WITH EMPHASIS ON HYDROCHEMISTRY, AMRAVATI DISTRICT, MAHARASHTRA."

Sumit D Ingle Asst. Prof., Department of Geology, G.S. Tompe Arts, Commerce & Science College, Chandur Bazar

KEYWORDS :

Introduction:

Groundwater potential of any region can be revealed through geological, geo morphological, hydro geological, geophysical and hydro geochemical investigations. The Bhuleshwari river basin flows over varied geological formations right from the Deccan trap to Alluvium of recent age. Hence it gives the opportunities to study the interrelationship of geology, lithology and geomorphology on the occurrence of groundwater and its hydrochemistry.

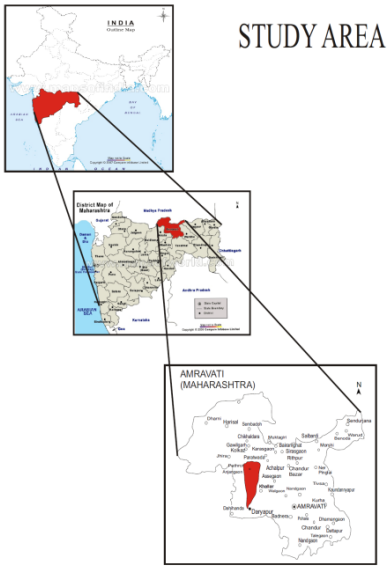

Fig. No. 1 Location of study area

The basin covers an area of about 380 sq kms from (Fig.No.1) Bhatkuli Taluka and Achalpur Taluka of Amravati District, Maharashtra. The basin is bounded by longititude 78^0 17'E to 78^0 28'E and latitudes 20^0 55'N to 21^0 20' N falling in the Survey of India toposheets No. 55 H/5, 55 G/7 and 55 G/8.

Different geological formations have different hydrogeological conditions from groundwater occurrences, development and potential point of view, therefore, the present investigation have been undertaken to apply an integrated approach using geological, geomorphological including remote sensing, hydro geological, geophysical and hydrogeochemical properties were studied in the basin.

Aims and Objectives:

1. Study geomorphic and morphometric characteristics of the basin and evaluate the impact of geomorphology on groundwater occurrence.
2. Study the dynamics of groundwater flow in the basin.
3. Study the hydrogeochemical characteristics of groundwater in the basin and understand evolution of groundwater.

Methodology:

1. Preparation of drainage map from Survey of India toposheets on 1:50,000 scale and determine linear, aerial and relief parameters.
2. Field mapping and preparation of geological map of the study area.
3. Monitoring of depth to water levels in 40 observation wells for summer 2010 and winter 2010 season to understand flow system and hydrodynamic conditions in the basin.
4. Collection of groundwater samples, analysis them with standard techniques to determine the variations in the chemical constituents to understand geologic, hydrogeologic, hydrochemical and geochemical characteristics, lithologic controls, facies and groundwater evolution.
5. Integrate geologic, hydrogeologic, hydrochemical and geochemical data for rational development and management of the groundwater resources.

Observations and Discussion:

Bhuleshwari river is a fifth order river basin with 5 fourth order streams, 15 third order streams, 63 second order and 285 first order streams. The total stream length 413.55 km with mean stream length 1.12. The average bifurcation ratio is 4.18. Drainage density is 1.41; length of overland flow is 0.35 while slope is 6.84 m/km

The number of streams in third order varies from 7 to 30. The total stream length among third order stream varies from 6 to 35.25 km with mean stream length from 0.38 to 2.62. The average bifurcation ratio varies from 2 to 4.90. Drainage density ranges from 1.02 to 3.38, length of overland flow ranges from 0.15 to 0.49, while slope varies from 2.69 to 56.73 m/km.

The number of streams in fourth order varies from 28 to 52, while average bifurcation ratio from 3.08 to 3.69. The length of fourth order stream varies from 21.10 to 62.50 km with mean stream length from 0.48 to 1.99. Drainage density ranges from 1.09 to 2.40, length of overland flow ranges from 0.21 to 0.46, while slope varies from 3.33 to 31.29 m/km. the drainage map is represented in (Fig. No.2), while the details are given in Table No.1.

The relief aspect for Bhuleshwari river basin have been determined and given in Table No.2. The form factor for third order varies from 0.08 to 0.43, while hypsometric integral ranges from 20.46 to 63.41. The ratio drainage density and drainage frequency varies from 0.38 to 2.62.

The form factor for fourth order varies from 0.11 to 0.38, while hypsometric integral varies from 14.46 to 54.61. The ratio drainage density and drainage frequency varies from 0.48 to 1.99.

Based on hypsometric integral the stage of development of basin has been determined and data presented in Table no.2. All the orders of stream are coming under equilibrium stage or old stage except two third order stream which are in youth stage.

Based on number of field traverses, in the geological map eight lavaflows has been identified mostly in northern region and alluvium in southern region can be divided into younger and older alluvium. The Deccan trap is separated by alluvium with fault, boulder alluvium is seen to occur in this zone. The geological map of Bhuleshwari River is modified from geological survey of India map, represented on (Fig.No.3)

Groundwater flow gradient on northern region is higher as compared to southern region. The hydraulic head increases from basin boundary to basin mouth, while hydraulic gradient decreases from north to south, thereby increasing length of residence time of groundwater.

The depth to water level has been monitored for summer 2010 & winter 2010 and the data is presented in Table No.3. Based on this data spatial variation in depth to water level amsl map has been prepared for summer 2010 & winter 2010 and represented in (Fig.No.4.) Groundwater flow direction has been determined from amsl map, it indicates the groundwater flows in general from north towards south with slight deviation towards east at the centre and a groundwater lowers at north of Saidapur.

The water sample from observation well has been collected during summer 2010 and analysed for major constituent using standard techniques and the data is presented in Table no.4. Based on the concentration of varies cations and anions, four hydrochemical facies have been found to range from $MgHCO_3$ in the northern recharge area followed by $CaCO_3$, $CaSO_4$ and CaCl in southern most portion of Bhuleshwari river basin. (Fig.No.5) This indicated evolution of groundwater from fresh water $MgHCO_3$ type in northern region to brackish type in middle and saline CaCl in southern region due to long residence time and increased reaction of groundwater with lithology.

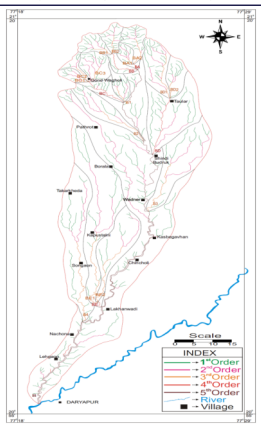

Fig. No. 2. Drainage map of Bhuleshwari River

Table No.1. Drainage Characteristics of the III / IV / and V Order basins of the Bhuleshwari River

Order of stream	No. of stream (N)	Avg. Bifurcation ratio (Rb)	Length of stream (L)	Mean stream length (L/N)	Avg. length ratio (RL)	Total area of Basin (A)	Mean Area	Drainage Density (DD)	Constant of channel maintenance	Drainage Frequency (DF)	Length of overland flow (Lg)	Basin Length	Height of difference	Slope in meters/km
BA1	13	3.00	6.75	0.52	1.18	2.56	0.20	2.64	0.38	5.08	0.19	2.75	156.00	56.73
BA2	30	4.90	13.35	0.45	3.34	5.64	0.19	2.37	0.42	5.32	0.21	4.50	160.00	35.56
BB1	16	3.50	8.25	0.52	1.99	4.44	0.28	1.86	0.54	3.61	0.27	3.25	116.00	35.69
BB2	23	4.25	8.85	0.38	2.38	3.78	0.16	2.34	0.43	6.09	0.21	3.60	100.00	27.78
BC1	12	2.83	6.50	0.54	1.63	2.44	0.20	2.67	0.38	4.92	0.19	2.75	120.00	43.64
BC2	7	2.00	6.00	0.86	1.80	4.88	0.70	1.23	0.81	1.44	0.41	3.35	120.00	35.82
BC3	21	4.00	17.00	0.81	1.91	5.06	0.24	3.36	0.30	4.15	0.15	3.70	120.00	32.43
BD1	24	4.30	19.50	0.81	2.82	9.56	0.40	2.04	0.49	2.51	0.25	7.15	210.00	29.37
BD2	9	2.50	9.50	1.06	1.35	6.38	0.71	1.49	0.67	1.41	0.34	4.90	41.00	8.37
BE1	16	4.25	35.25	2.20	2.95	34.64	2.16	1.02	0.98	0.46	0.49	20.80	70.00	3.37
BE2	11	3.00	20.00	1.82	2.56	16.13	1.47	1.24	0.81	0.68	0.40	11.15	30.00	2.69
B1	13	3.00	11.50	0.88	1.69	3.40	0.26	3.38	0.30	3.83	0.15	3.80	56.00	14.74
B2	13	3.00	18.50	1.42	2.45	10.09	0.78	1.83	0.55	1.29	0.27	8.40	75.00	8.93
B3	15	3.33	26.75	1.78	2.74	23.42	1.56	1.14	0.88	0.64	0.44	11.55	36.00	3.12
B4	13	3.50	34.00	2.62	2.25	29.43	2.26	1.16	0.87	0.44	0.43	18.75	61.00	3.25
BA	44	3.38	21.10	0.48	1.60	8.80	0.20	2.40	0.42	5.00	0.21	5.05	158.00	31.29
BB	44	3.45	21.70	0.49	2.11	11.28	0.26	1.92	0.52	3.90	0.26	6.55	158.00	24.12
BC	49	3.25	38.25	0.78	2.06	17.40	0.36	2.20	0.45	2.82	0.23	6.80	155.00	22.79
BD	52	3.69	62.50	1.20	1.89	35.64	0.69	1.75	0.57	1.46	0.29	13.15	235.00	17.87
BE	28	3.08	55.75	1.99	1.80	51.26	1.83	1.09	0.92	0.55	0.46	21.30	71.00	3.33
B	369	4.18	413.55	1.12	4.53	292.72	0.79	1.41	0.71	1.26	0.35	44.75	306.00	6.84

Table No.2. Relief aspects of Bhuleshwari river basin

Basin Name	Basin Order	Total area of Basin (A)	Form factor	DD/ DF	Hypsometric Integral	Stage of basin development
BA1	3	2.56	0.34	0.52	29.86	Old
BA2	3	5.64	0.28	0.45	48.07	Equilibrium
BB1	3	4.44	0.42	0.52	60.92	Youthful
BB2	3	3.78	0.29	0.38	59.25	Equilibrium
BC1	3	2.44	0.32	0.54	29.33	Old
BC2	3	4.88	0.43	0.86	30.52	Old
BC3	3	5.06	0.37	0.81	41.94	Equilibrium
BD1	3	9.56	0.19	0.81	20.46	Old
BD2	3	6.38	0.27	1.06	42.42	Equilibrium
BE1	3	34.64	0.08	2.20	45.27	Equilibrium
BE2	3	16.13	0.13	1.82	59.07	Equilibrium
B1	3	3.40	0.24	0.88	42.18	Equilibrium
B2	3	10.09	0.14	1.42	30.28	Old
B3	3	23.42	0.18	1.78	63.41	Youthful
B4	3	29.43	0.08	2.62	50.45	Equilibrium
BA	4	8.80	0.34	0.48	44.79	Equilibrium
BB	4	11.28	0.26	0.50	54.61	Equilibrium
BC	4	17.40	0.38	0.78	51.34	Equilibrium
BD	4	35.64	0.21	1.20	14.46	Old
BE	4	51.26	0.11	1.99	38.67	Equilibrium
B	5	292.72	0.15	1.13	24.69	Old

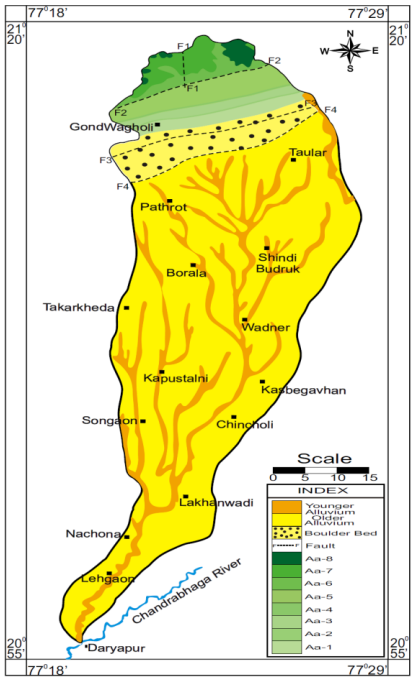

Fig.No.3. Geological map of Bhuleshwari basin (Modified after GSI)

Table No.3. Depth to groundwater monitored wells in the Bhuleshwari river basin

Well No.	R.L.(in m)	Total Depth (in m)	Depth to water level (in m)		Depth to water level amsl (in m)	
			Summer 2010	Winter 2010	Summer 2010	Winter 2010
BH-1	270	9.54	2.71	3.96	267.3	266
BH-2	281	14.63	14.63	14.63	266.4	266.4
BH-3	286	14.1	1	1.8	285	284.2
BH-4	286	11.85	5	5.9	281	280.1
BH-6	285	14.7	1.8	2.1	283.2	282.9
BH-7	292	15	0.5	1.1	291.5	290.9
BH-8	292	13.86	4.44	5.3	287.6	286.7
BH-10	303	21.66	9.86	10.46	293.1	292.5
BH-12	305	18.2	1.1	3	303.9	302
BH-22	323	29.3	0.6	1.2	322.4	321.8
BH-23	326	25.2	25.2	25.2	300.8	300.8
BH-24	331	42.5	10.5	12	320.5	319
BH-25	331	24.72	24.72	24.72	306.3	306.3
BH-26	335	15.8	15.8	15.8	319.2	319.2
BH-27	338	35.05	1.52	3.05	336.5	335
BH-28	340	29.41	29.41	29.41	310.6	310.6
BH-29	340	22.03	22.03	22.03	318	318
BH-30	340	19.7	19.7	19.7	320.3	320.3
BH-32	345	39.11	0.89	7.6	344.1	337.4
BH-33	346	23.27	23.27	23.27	322.7	322.7
BH-34	347	29	1.87	2.45	345.1	344.6
BH-35	348	33.07	33.07	33.07	314.9	314.9
BH-36	355	51	3	20	352	335
BH-37	351	48	10	18.23	341	332.8
BH-38	353	20.08	20.08	20.08	332.9	332.9
BH-39	360	32.42	0.9	2.12	359.1	357.9
BH-40	364	32	32	1.22	332	362.8
BH-41	353	33.5	2.7	2.41	350.3	350.6
BH-42	352	30.5	30.5	0.61	321.5	351.4
BH-43	350	30.5	4.59	8.55	345.4	341.5
BH-47	361	22.5	1.47	6.95	359.5	354.1
BH-50	375	31.85	31.85	2.43	343.2	372.6
BH-51	380	15.33	4.48	9.12	375.5	370.9
BH-52	392	8.89	1.27	7.07	390.7	384.9
BH-53	408	7.72	1.86	6.83	406.1	401.2
BH-54	415	14.63	6.4	12.8	408.6	402.2
BH-55	417	16.86	5.25	10.76	411.8	406.2
BH-56	420	12.62	1.98	6.31	418	413.7
BH-57	435	12.59	5.79	6.19	429.2	428.8
BH-58	490	10.9	6.55	8.81	483.5	481.2

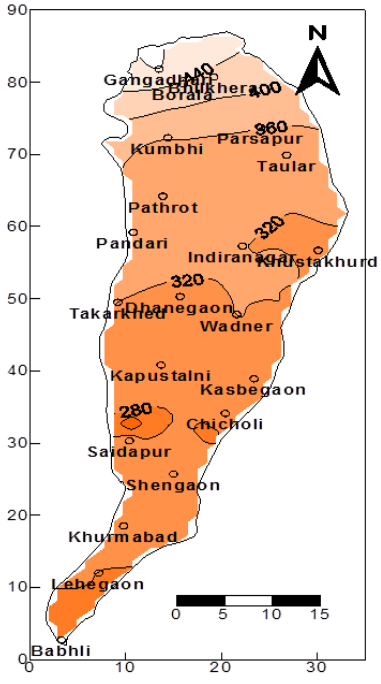

Fig.4 a. Depth to groundwater level (amsl) for the Bhuleshwari basin (Summer 2010)

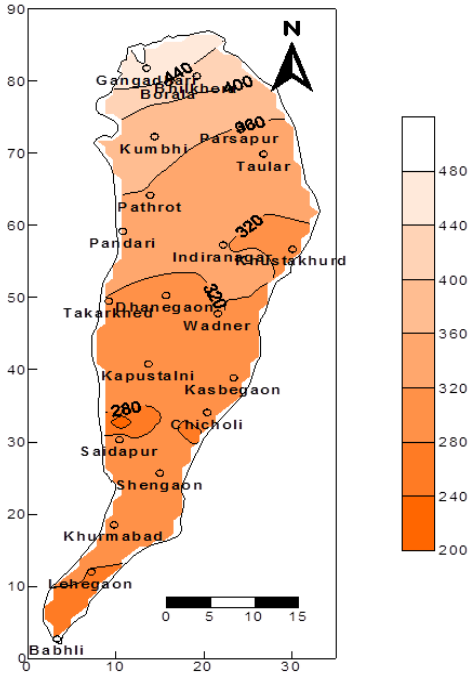

Fig.4 b. Depth to groundwater level (amsl) for the Bhuleshwari basin (Winter 2010)

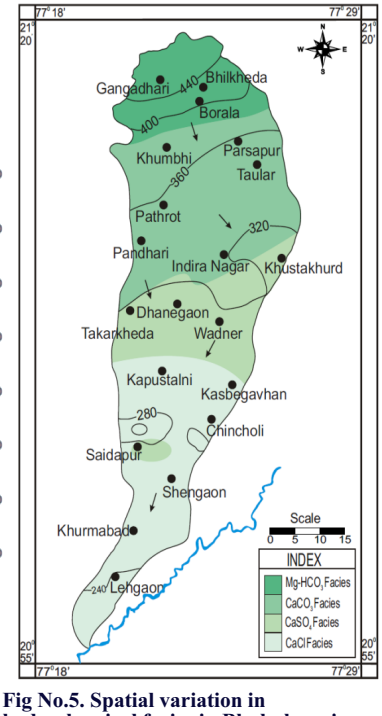

Fig No.5. Spatial variation in hydrochemical facies in Bhuleshwari Basin.

Table No.4. Physio-chemical data from monitoring wells in Bhuleshwari river basin.

Sample No.	pH	EC	Hardness	TDS	Ca	Mg	Fe	Alk	HCO3	Cl	SO4	F	NO3	Na	K
1	6.9	4520	740	2693	32	158	0.38	550	550	1204	283	0.6	40	800	2.9
2	8.1	1150	105	736	12	18	0.25	450	450	116	130	0.8	14	266	0.8
3	7.1	2080	160	1331	10	32	0.42	460	460	308	96	0.9	66	350	1.7
4	7.6	2330	500	1491	40	96	0.34	280	280	602	158	0.7	10	350	1.3
5	7.24	1996	190	1277	16	36	0.4	500	500	315	120	0.8	10	362	1.1
6	7.25	6680	1900	4275	440	192	0.4	390	390	2520	384	0.9	9	1100	3.6
7	6.87	1300	200	823	10	42	0.08	550	550	116	150	0.8	14	220	0.6
8	7.8	2350	660	1504	60	122	0.3	320	320	483	153	0.8	6	230	1.2
9	6.95		3700	7539	600	528	0.08	470	470	2170	922	0.6	750	510	180
10	7.4	1510	210	966	14	42	0.04	290	290	186	144	0.8	57	220	0.4
11	7.4	4990	1150	3194	280	108	0.4	520	520	735	452	0.6	49	380	1.5
12	7.1	1520	235	973	20	44	0.08	750	750	53	53	0.3	9	240	1
13	7.8	4990	240	3194	40	34	0.48	1200	1200	672	415	0.7	6	980	2
14	7.2		7100		1520	792	0.52	150	150	9100	1450	0.6	4	3400	20
15	7.6	3670	800	2349	40	168	0.38	560	560	1092	428	0.8	9	760	5
16	7.6	4740	740	3034	80	130	0.4	500	500	1064	460	0.8	10	760	5
17	7.6	3240	590	2074	64	103	0.67	570	570	476	38	0.6	48	260	0.7
18	1.7	4850	1330	2110	160	223	0.28	190	190	1008	250	0.6	76	260	10
19	7.1	8390	2000	5370	320	288	0.3	85	85	2590	207	0.9	10	900	30
20	7.6	4110	280	2630	40	43	0.6	330	330	637	345	0.8	72	600	5
21	7.8	2380	200	1523	16	38	0.42	310	310	287	192	0.6	35	320	0.7
22	7.7	4670	440	2989	32	86	0.3	310	310	1120	216	0.6	48	760	0.7
23	7.8	1410	160	902	12	31	0.42	250	250	105	115	0.7	12	150	4
24	7.5	4730	960	3027	88	178	0.3	240	240	1085	212	0.5	7.4	480	7
25	7.9	4350	400	2784	16	86	0.32	290	290	707	120	0.8	71	470	1.2
26	8.2	1600	140	1024	12	26	0.4	320	320	308	235	0.8	25	380	2.9
27	8.4	960	160	614	10	32	0.32	160	160	91	150	0.6	34	125	11
28	7.5	2030	175	1299	8	37	0.42	290	290	182	173	0.7	12	234	6
29	8.7	450	125	288	34	10	0.3	85	85	42	10	0.7	8	7.3	0.4
30	7.7	3260	560	2080	32	115	0.28	310	310	511	100	0.6	77	270	1.6
31	8.5	1560	290	998	60	34	0.5	190	190	186	86	0.7	56	170	1.5
32	8.1	1890	245	1210	8	54	0.3	400	400	123	130	0.8	43	200	1.6
33	7.6	1220	205	781	42	24	0.13	140	140	144	91	0.6	32	180	1.8
34	7.8	440	120	282	20	17	108	123	123	18	24	0.7	13	18.2	1.3
35	8.1	510	135	326	30	14	0.4	185	185	39	10	0	6	33.2	0.3
36	8.5	400	75	256	18	7	0.06	110	110	14	5	0.1	3	18.6	0.7
37	9.2	220	80	141	24	5	0	65	65	14	0	0.1	4	0.7	0
38	8.2	312	110	204	30	8	0.08	170	170	28	5	0	1	18	4.5

Conclusions:

Morphometric, geological and geochemical investigations are of great significance in understanding occurrences and evolution of groundwater geochemistry.

Lower drainage density, more the length of overland flow and less drainage frequency indicate better condition of ground water occurrences.

The variation in the groundwater flow was from water level maps indicates the flow from north to south with slight deviation on the eastern side. The ground water gradient on the north was high as compared to southern region. Two significant observations noted are-

1. Hydraulic head increases from basin boundary to basin mouth as groundwater flows from recharge area to discharge area.
2. Hydraulic gradient is decreased from north to south thereby increasing length of residence time of groundwater.

Lithology of the study area varies from Deccan trap in the north to alluvium in the so of groundwater facies from Mg-HCO3 type in recharge areas to Ca-CO3, Ca-SO4 to Ca-Cl in discharge area along groundwater flow direction.

This evolution of groundwater from fresh water in northern region to brackish water type in middle and saline type in southern region is due to longer residence time and increased reaction of groundwater with lithology, thus establishing the morphometric and hydrologic impact on groundwater quality.