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HYDROGEOLOGICAL AND GROUNDWATER QUALITY DELINEATION MANASA AREA, NEEMUCH DISTRICT, MADHYA PRADESH, INDIA

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ABSTRACT

Groundwater is one of the major resource of the drinking water in Mansa area, Neemuch District, M.P. In the present study groundwater quality of the 20 groundwater samples collected from entire villages and assessed for their suitability for human consumption. The multiple regression analysis and regression equation indicated that the degraded water quality of Manasa area caused water management plan.

In the present area of investigation, the Physico-chemical of groundwater with respect to the major elements related properties has been determined. The physically related properties such as Total Dissolved Solids (TDS) and Total Hardness (TH) were also determined and chemically the major cations include Ca, Mg, Na, K and anion Cl, So_4, Co_3 and HCo_3 . Integrated overlay technique helped to delineate to prepare spatial distribution of groundwater quality for drinking purposes in the study area.

KEYWORDS: Groundwater, Physco-Chemical, Dissolved Solids, Madhya Pradesh

INTRODUCTION

The groundwater has been considered as a single Physco-chemical equilibrium system. Geochemistry of water involves accurate analysis of different parameters. Palmer, (1911) remarked that 'the earlier phases of hydro-geochemical investigations, the emphasis was placed on the major cations and anions present in groundwater'. The groundwater quality delineation by chemical analysis constitutes theme of the hydrogeochemistry. The concentration of dissolved elements in water is useful to evaluate its suitability for different applications such as domestic, drinking, irrigation, industrial and agricultural. The chemical analyses are to be conducted with a precision to delineate the quality of groundwater. The quality criteria, involve determination methods and specification of chemical, physical, biological and radiological constituents and comparing results of water analysis (Todd 1959, 1980).

Location of Study Area: The present study area is located in Manasa block of Neemuch district, of the Malwa plateau in Madhya Pradesh, within latitudes from 24^0 18' to 24^0 30' N and longitudes from 75^0 5' to 75^0 15' E (Survey of India toposheet no. 45 P/3, Figure 1). The study area covers 371 km^2 in vicinity of Manasa and is located on the Mhow- Neemuch road at a distance of 22 km. from the Neemuch city.

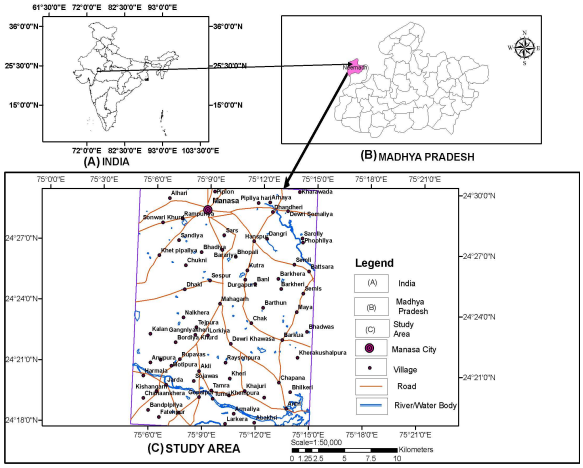


Figure 1: Location Map of Manasa Study Area, Neemuch District, M.P.

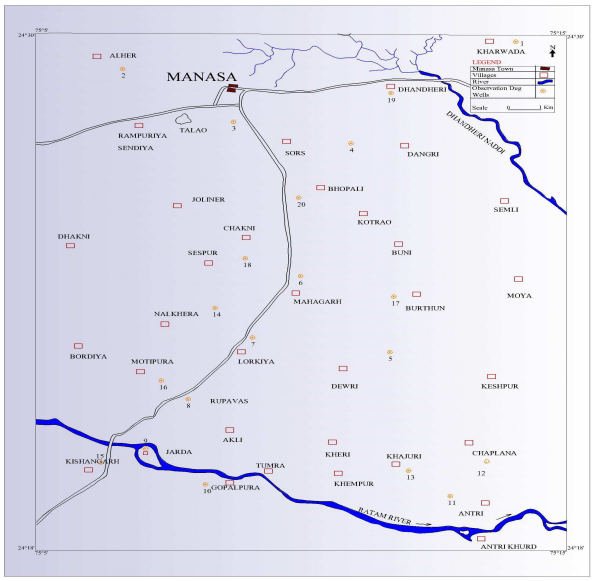


Figure 2: Map Showing Collection Sites of Groundwater Samples of Manasa Area

MATERIAL AND METHODS

Collection of Sample: The groundwater samples have been selected from 20 open dug wells of study area to determine the chemical quality assessment for different applications. The samples were collected from selected dug wells and stored in double capped polyethylene bottles of one liter capacity, and pasted with labels indicating location of sample, type of well and number of sample and date of sample collection. The collected groundwater samples were pleased in a container and brought to the laboratory for the chemical analysis.

The different methods of chemical analysis of water have been proposed and adopted by various workers and organizations for determination of water quality assessments. The standard methods of water analysis have been specified by the American Public Health Association (APHA, 1998), Todd (1959, 1980), Davis and DeWiest, (1966), Nagbhusniah, (2001), Karanth, (2003, 2009) and others. The chemical analysis of groundwater is carried out by determination of physico-chemical parameters in different laboratories by following procedures of standard methods. The physical analysis includes colour, odour, taste, specific conductivity, pH, and total dissolved solids (TDS). The chemical parameters involves

determination of the Ca, Mg, Na, K, Cl, So_4, Co_3, HCo_3, No_3, F and total hardness (TH). The chemical analysis has been conducted in the laboratory of Reference laboratory and scientific Services Indore.

Groundwater Quality Analysis: Groundwater samples collected from 20 dug wells existing in the Manasa study area for delineation of quality assessment. The samples were subjected to chemical treatment in the laboratory by using standard procedure of chemical analysis. The determined values of groundwater samples have been recorded by tabular form and graphic representation techniques.

Table 1: Physical Parameters of Open Dug Well Water Samples of Manasa Area, Neemuch, District, M.P.

Well No.	Location	Colour	Odour	Taste	Ph	Specific Cond.	Tds	Th
1	Kharawada	Colourless	Odourless	Tasteless	8.9	640	948	730
2	Alher	Colourless	Odourless	Tasteless	8.4	628	950	722
3	Manasa	Colourless	Odourless	Tasteless	8.9	645	965	732
4	Hanspur	Colourless	Odourless	Tasteless	8.7	622	941	726
5	Dewrikhawasa	Colourless	Odourless	Tasteless	7.7	632	918	713
6	Mahagarh	Colourless	Odourless	Tasteless	7.9	670	920	738
7	Lorkiya	Colourless	Odourless	Tasteless	8.6	528	930	650
8	Rupavas	Colourless	Odourless	Tasteless	8.7	534	933	718
9	Jarda	Colourless	Odourless	Tasteless	7.8	544	925	575
10	Gopalpura	Colourless	Odourless	Tasteless	8.5	532	950	590
11	Antri	Colourless	Odourless	Tasteless	8.9	538	915	718
12	Chaplana	Colourless	Odourless	Tasteless	8.3	430	935	700
13	Khajuri	Colourless	Odourless	Tasteless	7.5	598	945	708
14	Nalkhera	Colourless	Odourless	Tasteless	8.5	478	922	725
15	Kishangarh	Colourless	Odourless	Tasteless	8.7	608	925	556
16	Motipura	Colourless	Odourless	Tasteless	8.3	635	947	715
17	Barthun	Colourless	Odourless	Tasteless	7.7	620	928	726
18	Sespur	Colourless	Odourless	Tasteless	8.9	613	955	735
19	Dhandneri	Colourless	Odourless	Tasteless	7.9	595	958	722
20	kotrao	Colourless	Odourless	Tasteless	7.8	592	960	729

Abbreviations: pH = Hydrogen ion concentration, E.C. = Electrical Conductivity,

TDS = Total Dissolved Solids.

Pysical Prameters: Physical analysis includes determination of the colour, odour, taste, hydrogen ion (pH), specific conductivity, total dissolved solids (TDS) and total hardness in respect of groundwater samples of the Manasa study area. Table 1

Colour, Oduor and Taste: All the groundwater samples are colourless, oduorless and tasteless.

Hydrogen Ion Concentration (pH): In the study area pH values of groundwater samples range from 7.5 to 8.9. The minimum pH of groundwater samples have been noted as 7.5 at Khajuri village, (Table 1; sample no 13) and maximum pH of groundwater samples have been recorded as 8.9 at Kharwada, Manasa, Antri and Sespur villages, (Table 1; sample no 1, 3, 11, 18)

Specific Conductivity: In the study area, specific conductivity of groundwater samples ranges from 430 to 670. The minimum EC of groundwater sample has been recorded as 430 at Chaplana village (Table 1; sample no. 12) and maximum EC of groundwater sample have been recorded as 670 at Mahagarh, village (Table 1; sample no 6).

Total Dissolved Solids: In the study area TDS of groundwater samples range from 915 to 965 . The minimum TDS of groundwater sample has been recorded as 915 at Antri village (Table 1; sample no. 11) and maximum TDS of

groundwater sample has been recorded as 965 at Manasa village (Table 1; sample no. 3).

Total Hardness: In the study area total hardness values range from 556 to 738 mg/l in groundwater samples. The minimum total hardness of groundwater samples has been recorded as 556 at Kishangarh village (Table 1; sample no. 15) and maximum total hardness groundwater sample has been recorded as 738 at Mahagarh village, (Table 1; sample no. 6).

(B) Chemical Prametes: Chemical analysis forms the basis for interpretations of the quality of water such as cataions (Calcium, Magnesium, Sodium and Potassium,) and anions (Chloride, Sulphate, Carbonate, Bicarbonate and Nitrate) of groundwater samples have been determined (Table 2).

Calcium: In the study area, calcium concentration has been recorded within range from 89 to 170 ppm. The minimum calcium has been recorded as 89 ppm at Barthun village (Table 2; sample no. 17) and maximum calcium has been noted as 170 ppm at Jarda village (Table 2; sample no. 9).

Magnesium: In the present study area, magnesium concentration has been recorded ranging from 29 to 83 ppm. The minimum magnesium has been recorded as 29 ppm at Barthun village, sample no. 17 and maximum magnesium has been recorded as 83 ppm at Kishangarh village, sample no. 15.

Sodium: In the study area, sodium concentration in groundwater ranges from 68 to 152 ppm. The minimum sodium has been recorded as 68 ppm at Kotrao village (Table 2; sample no. 20) and maximum sodium has been observed as 152 ppm at Rupavas village (Table 2; sample no. 8).

Potassium: In the study area, Potassium content reveals a range from 1 to 4 ppm in groundwater samples. The minimum Potassium has been noted as 1 ppm at Manasa village (Table 2; sample no. 3) and maximum Potassium has been recorded as 4 ppm at Alher, Han spur villages (Table 2; sample no. 2, 4).

Table 2: The Chemical Parameter of Open Dug Well Water Samples of Manasa Area, Neemuch District, M.P. (In ppm)

Well No.	Location	Ca	Mg	Na	K	Cl	So_4	Co_3	Hco_3	No_3
1	Kharawada	153	82	92	3.50	660	345	-	39.47	35
2	Alher	151	65	100	4.00	650	370	-	40.09	37
3	Manasa	159	72	130	1.00	850	390	-	23.04	25
4	Hanspur	142	62	128	4.00	780	310	-	23.07	22
5	Dewri khawasa	128	42	148	3.50	715	280	-	29.38	13
6	Mahagarh	95	32	118	2.10	650	220	-	21.58	14
7	Lorkiya	140	65	80	2.00	570	350	-	17.18	39
8	Rupavas	131	48	152	1.95	718	295	-	27.35	20
9	Jarda	170	69	73	1.50	565	355	-	20.12	32
10	Gopalpura	180	72	78	3.00	580	370	-	19.91	35
11	Antri	160	78	87	2.75	627	335	-	16.09	49
12	Chaplana	155	72	85	3.50	620	330	-	22.50	42
13	Khajuri	158	75	90	3.61	635	328	-	28.20	44
14	Nalkhera	146	68	94	2.71	639	332	-	28.75	47
15	Kishangarh	158	83	90	2.15	715	298	-	24.08	15
16	Motipura	168	79	102	1.35	675	339		18.09	54
17	Barthun	89	29	107	1.85	630	213	-	25.34	13
18	Sespur	169	82	142	2.50	790	385	-	17.84	27
19	Dhandheri	147	76	82	2.10	640	335	-	24.68	31
20	kotrao	155	68	68	2.30	830	365	-	19.85	19

Chloride: In the study area, chloride concentration in groundwater ranges from 565 to 850 ppm in groundwater

samples. The minimum chloride has been recorded as 565 ppm at Jarda village (Table 2; sample no. 9) and maximum chloride has been determined as 850 ppm at Manasa village (Table 2; sample no. 3).

Sulphate: In the study area sulphate concentration in groundwater ranges from 213 to 390 ppm in groundwater samples. The minimum sulphate has been recorded as 213 ppm at Barthun village (Table 2; sample no. 17) and maximum sulphate has been noted as 390 ppm at Manasa village (Table 2; sample no. 3)

Carbonate and Bi-Carbonate: In the study area, bi-carbonate in groundwater ranges from 16.09 to 40.09 ppm. The minimum bi-carbonate has been recorded as 16.09 ppm at Antri village (Table 2; sample no. 11) and maximum bi-carbonate has been observed as 40.09 ppm at Alher village (Table 2; sample no. 2).

Nitrate: In the study area, nitrate concentration in groundwater samples is recorded within the range of 13 to 54 ppm. The minimum nitrate has been recorded as 13 ppm at Dewari Khawasa and Barthun villages (Table 2; sample no. 5, 17) and maximum nitrate has been noted as 54 ppm at Motipura village (Table 2; sample no. 16).

(C) Data Representation of Analysis: The data of chemical analysis have been displayed both in the tabular and graphic forms of data representation. The chemical analytical data of Manasa area have been graphically displayed by pie diagram (Table 3). The data measurement are recorded in different units such as milligrams per liter (mg/liter) or ppm and milliequvialents per liter (emg/liter) or epm. Thes data have been used for assessment chemical quality of groundwater suitability for domestic, drinking, irrigation and industrial application. The analytical data are.

Table 3: Chemical Parameter of Open Dug Well Water Samples of Manasa Area, Neemuch District, M.P. (Values Are Expressed in epm)

Well No.	Location	Ca	Mg	Na	K	Cl	So_4	Co_3	Hco_3	No_3
1	Kharawada	7.634	6.745	4.002	0.089	18.618	7.182	-	0.646	0.564
2	Alher	7.534	5.346	4.35	0.102	18.336	7.702	-	0.567	0.596
3	Manasa	7.934	5.922	5.655	0.025	23.978	8.119	-	0.377	0.403
4	Hanspur	7.085	5.100	5.568	0.102	22.003	6.454	-	0.378	0.354
5	Dewri khawasa	6.387	3.454	6.438	0.089	20.170	5.829	-	0.481	0.209
6	Mahagarh	4.740	2.632	5.133	0.053	18.336	4.580	-	0.353	0.225
7	Lorkiya	6.986	5.346	3.48	0.051	16.079	7.287	-	0.281	0.629
8	Rupavas	6.536	3.948	6.612	0.049	20.254	6.149	-	0.448	0.322
9	Jarda	8.483	5.675	3.175	0.038	15.938	7.391	-	0.329	0.516
10	Gopalpura	8.982	5.922	3.393	0.076	16.361	7.703	-	0.326	0.564
11	Antri	7.984	6.416	3.784	0.095	17.687	6.974	-	0.263	0.790
12	Chaplana	7.734	5.922	3.697	0.089	7.490	6.870	-	0.368	0.677
13	Khajuri	7.884	6.169	3.915	0.092	17.913	6.828	-	0.462	0.709
14	Nalkhera	7.285	5.593	4.089	0.069	18.026	6.912	-	0.471	0.758
15	Kishangarh	7.884	6.827	3.915	0.054	20.170	6.204	-	0.394	0.241
16	Motipura	8.383	6.498	4.437	0.034	19.041	7.057	-	0.296	0.871
17	Barthun	4.441	2.385	4.654	0.047	17.772	4.434	-	0.415	0.209
18	Sespur	8.433	6.745	6.177	0.063	22.285	8.015	-	0.292	0.435
19	Dhandheri	7.335	6.251	3.567	0.053	18.054	6.974	-	0.404	0.500
20	Kotrao	7.734	5.593	5.133	0.058	23.414	7.599	-	0.325	0.306

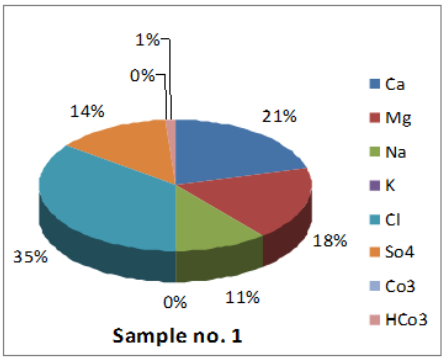
Table 4: Chemical Parameters of Open Dug Well Water Samples of Manasa Area, Neemuch District, M.P. (Values Expressed In Percentage of epm)

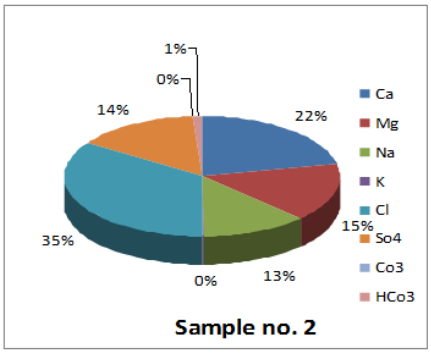
Well No.	Ca	Mg	Na	K	Cl	So_4	Co_3	Hco_3
1	41.331	36.518	21.667	0.004	70.400	27.157	-	2.442
2	43.468	30.844	25.098	0.588	68.921	28.954	-	2.131
3	40.61 2	30.313	28.946	0.127	73.837	25.001	-	1.160

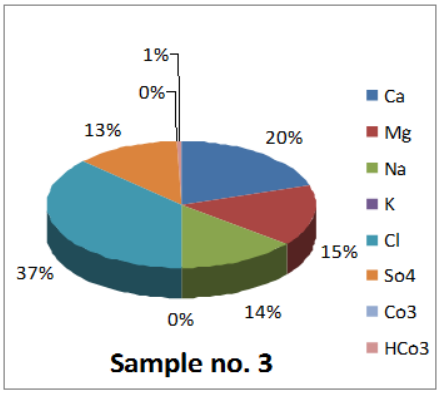
Table 4: Contd.,

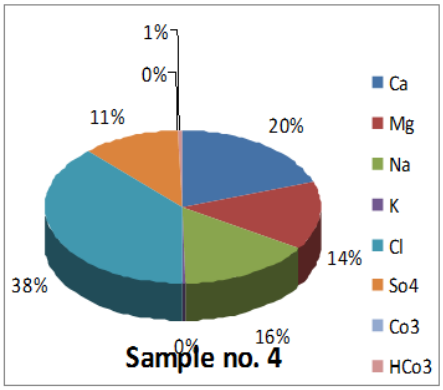
4	39.680	28.563	31.184	0.571	76.306	22.382	-	1.310
5	39.021	21.102	39.332	0.543	76.170	22.012	-	1.816
6	37.744	20.958	40.874	0.422	78.800	19.682	-	1.517
7	44.039	33.701	21.937	0.321	67.995	30.815	-	1.188
8	38.121	23.027	38.565	0.285	75.431	22.900	-	1.668
9	48.834	32.669	18.277	0.218	67.368	31.241	-	1.390
10	48.886	32.232	18.467	0.413	67.080	31.582	-	1.336
11	43.678	35.100	20.701	0.519	70.963	27.981	-	1.055
12	44.341	33.952	21.195	0.510	70.729	27.782	-	1.488
13	43.65	34.158	21.677	0.509	71.074	27.092	-	1.833
14	42.762	32.830	24.002	0.405	70.943	27.202	-	1.853
15	42.205	36.547	20.958	0.589	75.351	23.176	-	1.471
16	43.318	33.577	22.927	0.175	72.152	26.741	-	1.121
17	38.526	20.690	40.374	0.407	78.564	19.594	-	1.834
18	39.378	31.492	28.840	0.294	72.845	26.199	-	0.954
19	42.630	36.330	20.731	0.308	70.983	27.422	-	1.588
20	41.764	30.203	27.718	0.313	74.714	24.248	-	1.037

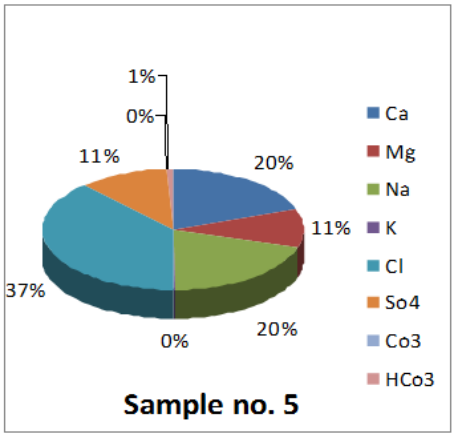
Pie Diagram: The pie diagram (circular diagram) has been used to represent the data of chemical analysis of groundwater samples of Manasa area (Figure 3). Pie diagram method described by Todd (1959, 1980) has been adopted in the study. The ionic concentrations have been exhibited with the help of radii scale so that the area of a circle is proportional to the total of the analysis. Sectors with a circle represent the fractions of the different ions exposed in milli equivalents per ions expressed in milli equivalents per ions expressed in milli equivalents per liter (epm).







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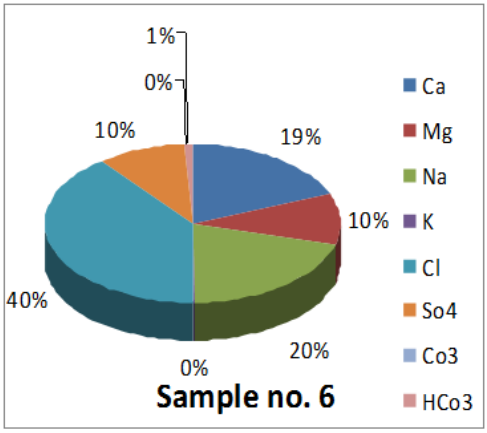
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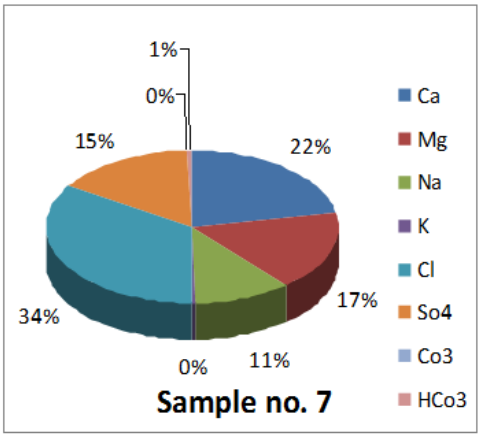
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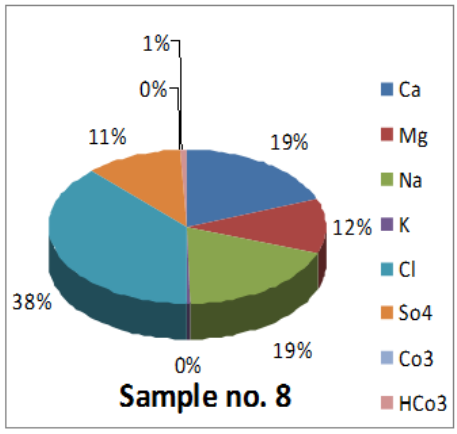
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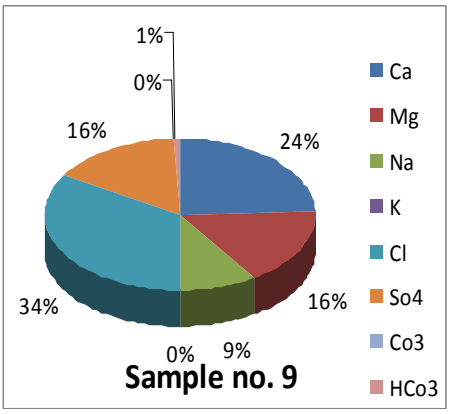
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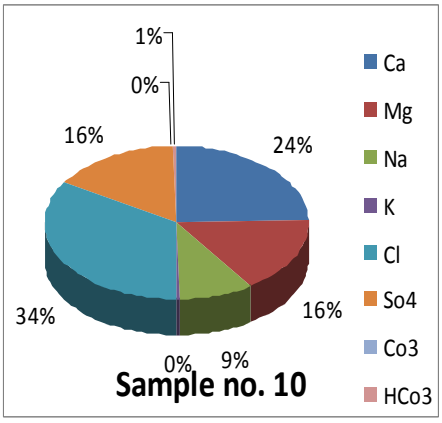
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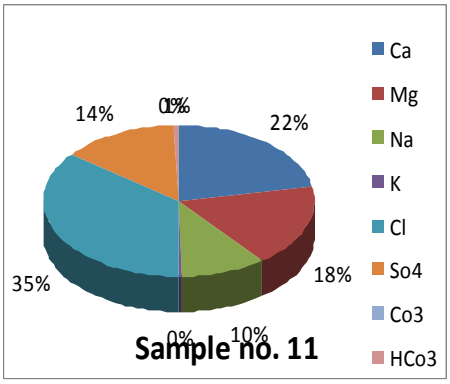
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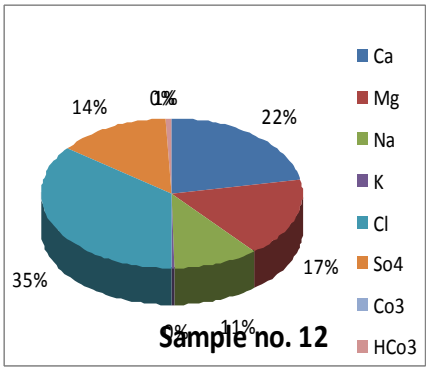
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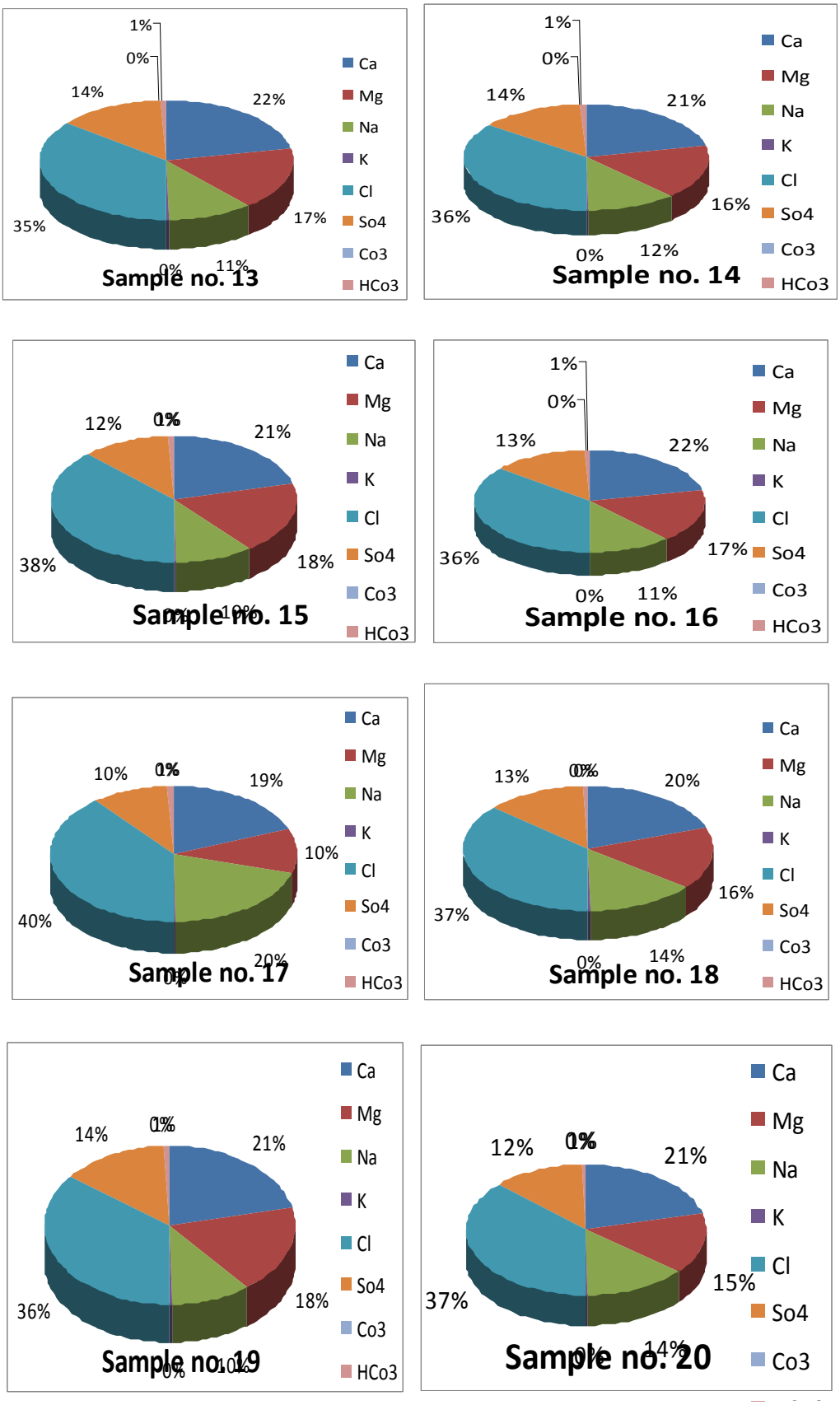

Figure 3: Graphic Representation of the Ionic Concentration in Groundwater Samples of the Study Area

(D) Delineation of Groundwatwr Quality: The delineation of chemical quality of groundwater is one of the most importance aspects in the formulation of a development and management of groundwater resource planning, which requires top priority implementation of a plan for catering the sustained water supply to the every country facing water supply problem. The chemical quality of groundwater suitability of Manasa study area has been discussed for different applications.

(1) Groundwater quality for Domestic Application: Groundwater quality assessment for domestic application has been determined by plotting ionic concentration on Piper's trilinear diagram.

Trilinear Piper's Diagram

The chemical composition of water is represented by Trilinear plotting in two separate triangles one for anions and the other for cations and finally projected in a central diamond shaped diagram by one single point (Palmer 1911, Hill 1940, Piper 1944, 1953, Handa 1965).

The trilinear diagram has been suggested by Piper (1944, 1953) and commonly know as Trilinear Piper's Diagram. This diagram represent the provision of comparing different samples together. Piper's (1944, 1953) diagram of plotting was suggested and represents a Trilinear plotting system. The relative concentration of constitutes is expressed as a percentage of total reacting value and the essential chemical character of water indicated graphically by a single point plotting of cations and anions on Trilinear coordinates. For convenience the sum total of all cation reacting values and anions variable is taken as the 100 percent base for computing percentage reacting values of the several cation and anion variables.

Piper's diagram consists of three distinct fields, two triangular fields at lower left and lower right and intervening diamond shaped field. All the entire three fields have scaled reading in 100 parts. The plots of chemical analysis data on Piper's diagram exhibits that 18 samples belong to the Ca +Mg - Co_3 +HCo_3 facies indicating that groundwater is suitable for domestic use 2 groundwater samples are referable to the Ca +Mg - SO_4+Cl facies reflecting that the groundwater can be used for domestic application.

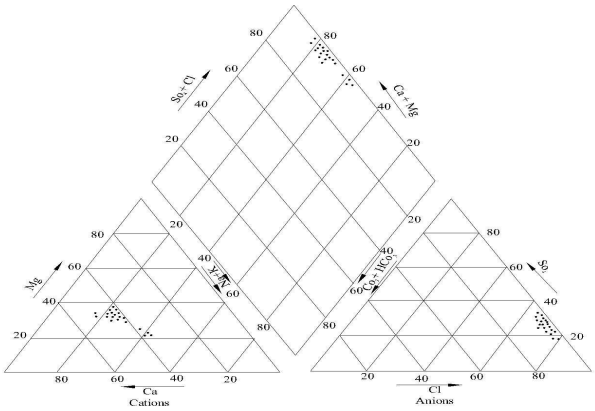

Figure 4: Piper's Diagram Exhibiting Ionic Plots of Manasa Groundwater Samples

(2) Drinking Quality for Groundwater: Quality standard for the drinking water have been proposed by World Health Organization (W.H.O. 1993) (International Standards for Drinking Water) (Cox 1964), National Academy of Sciences 1972, Indian Council of Medical Research (I.C.M.R. 1975), Bouwer (1978), Bureau of Indian Standards (BIS 1983), Karanth 2003 and others (Table 5).

Table 5: Comparison of Physical and Chemical Parameters of Groundwater Samples, in Drinking Water, Manasa Area, Neemuch District, M.P.

Quality	NAS 1972	Bureau of Indian Standard 1983		World Health Organization1993		Dug Well Water of Study Area	
	Permissible Limit	Highest Desirable	Maximum Permissible	Highest Desirable	Maximum Permissible	Concentration Range Mg/L	Exceeding Limit Sample No.
Physical Parameter							
Colour	-	-	-	-	-	C.L.	-
Odour	-	UO	-	UO	-	O.L.	-
Taste	-	UO	-	UO	-	T.L.	-
TDS	-	500	1500	500	1500	918-965	-
pH	5-9	6.5-8.5	6.5-9.2	7.0-8.5	6.5-9.2	7.5-8.9	-
TH ($CaCo_3$) mg/l	-	300	600	100	500	556-738	1,2,3,4,5,6, 7,8,11,12,13 ,14,16,17,1 8,19,20
Chemical Ions Concentration							
Ca (mg/l)	-	75	200	75	200	89-180	-
Mg (mg/l)	-	30	100	<30	150	29-83	-
Cl (mg/l)	250	250	1000	200	600	565-850	-
So_4(mg/l)	250	150	400	200	400	213-390	-
F (mg/l)	-	0.6-1.2	1.5	0.6-0.9	0.8-1.8	-	-
No_3 (mg/l)	10	45	-	45	-	13-54	11,14,16

The comparition of determined physico-chemical parameters of study area groundwater samples with the values of international and national standards indicate that the hardness values in sample numbers 1,2,3,4,5,6,7,8,11,12,13,14,16,17,18,19,20 are more than the prescribed limit for drinking purpose. These waters can be used for drinking after treatment for reducing the hardness. The groundwater sample numbers 11,14,16 indicate presence of nitrate more than the recommended maximum limits. It is suggested that the groundwater occurring at Antri, Nalkhera and Motipura villages of the Manasa study area, should be used for agriculture use after minimizing the concentration of nitrate.

(E) Criteria for Irrigation Quality: The suitability delineation of groundwater quality for irrigation is dependent on the effects of the mineral constitutents of the water of both the plant and soil. Soil conditions hazardous to crop development or human and livestock The following parametes have been determined to assess the groundwater suitability for irrigation purpose.

Table 6: Indicates Derived from the Geochemical Parameters

Well No	Sodium Percent	Kelley's Ratio	Sodium Adsorption Ratio	Residual Sodium Carbonate	Mg-Hazards
1	22.149	0.278	1.492	-13.733	46.908
2	23.667	0.337	1.714	-12.313	41.506
3	29.074	0.408	2.148	-13.479	42.739
4	31.755	0.456	2.256	-11.807	41.854
5	39.876	0.654	2.902	-9.36	35.098
6	41.296	0.696	2.674	-7.016	35.702
7	22.259	0.282	1.401	-12.051	50.991
8	38.850	0.630	2.888	-10.036	37.657
9	18.496	0.224	1.193	-13.829	40.083
10	18.880	0.227	1.243	-14.578	39.734

Table 6: Contd.,

11	21.527	0.262	1.410	-14.137	44.555
12	21.706	0.270	1.414	-13.288	43.36
13	22.187	0.278	1.477	-13.591	43.898
14	24.407	0.317	1.611	-12.407	43.430
15	21.247	0.266	1.443	-14.317	46.407
16	23.103	0.298	1.627	-14.585	43.666
17	40.782	0.684	2.525	-6.384	35.078
18	29.134	0.406	2.242	-14.886	44.349
19	21.039	0.262	1.368	-13.182	46.010
20	28.032	0.385	1.988	-13.002	41.967

Sodium Percent: The Sodium concentration is important in classifying irrigation water because sodium reacts with soil to reduce its permeability. Soil containing a large proporagation of sodium with carbonate as the predominant anion is termed alkali soils, those with chloride as sulfates the predominant anions are saline soils. The type of sodium saturated soil will support little or growth of crops (Todd 1959, 1980). Sodium percentage is usually expressed as:

$$Sodium\ percent\ (Na\ \%) = \frac{(Na + K)x\ 100}{Na + Ca + Mg + K}$$

The ionic concentration is expressed in equivalent per million (epm). Sodium percentage in study area are water various from 18.496 to 41.296 (Table 6).

Kelley's Ratio: Kellys (1946 proposed calculation for the ratio of Na and Ca + Mg this ratio is known as the Kelly's ratio. This ratio is a reflection of alkali hazard of the water. It can be expressed as: Kelly's ration = Na / Ca +Mg

Where, the Na, Ca and Mg ionic concentration are expressed in equivalent per million (epm). Kellys ratio of study area water various form 0.224 to 0.696 (Table 6).

Sodium Adsorption Ratio: The U. S. Salinity laboratory (Richard 1954) has proposed a standard on the basis of the sodium adsorption ratio (SAR) of water. The sodium adsorption ratio is defined by the following equation:

$$Sodium\ Adsorption\ Ratio\ (SAR) = \frac{Na}{\frac{\sqrt{Ca + Mg}}{2}}$$

Where, Na, Ca and Mg represents the concentration in equivalent per million (epm). Sodium adsorption ratio in study area are water various from 1.193 to 2.148 (Table 6).

Residual Sodium Carbonate: The Residual sodium carbonate is used to express corbonate and bicarbonate hazards on water quality by symbol 'RSC'. It is can be expresses as: RSC= (Co_3 + HCo_3) – (Ca + Mg)

The representation of ionic concentration is expressed in equivalent per million (epm). The water having excess ions of carbonate and bicarbonate than calcium and magnesium usually contain much greater alkali formation as compared to its sodium adsorption ratio and as a result permeability of soil is decreased. The study area residual sodium carbonate indicate a water varies from -6.384 to -14.886 (Table 6).

Mg- Hazards: Paliwal (1972) examined the impact of magnesium hazards on irrigation water by using the following formula: Mg – Hazard = Mg X 100 / Ca + Mg

The magnesium ratio is the excess amount of magnesium over calcium and magnesium amount, where otherwise

normally the level of calcium and magnesium will be in a state of equilibrium the excess concentration of magnesium affects the quality of soil resulting in poor development of crop. Magnesium Hazard in study area are within the limit from 35.078 to 50.991 (Table 6).

Application of Wilcox Diagram: Wilcox (1955) has proposed a classification of favourable quality assessment of irrigation water, based on the electrical conductivity and sodium percentage. Ground- water has been classified into (i) excellent to good, (ii) good to permissible, (iii) permissible to doubtful, (iv) doubtful to unsuitable and (v) unsuitable.

In the Manasa study area, the plots of the sodium percentage and electrical conductivity values on the Wilcox diagram (Figure 5), indicate that 2 samples are referable to the category of excellent to good quality for irrigation and 18 samples are represents the category of good to permissible for irrigation purposes. In general, groundwater is suitable for irrigation use.

Application of U. S. Salinity Diagram

The U. S. Salinity laboratory (1954) suggested a classification of water for irrigation quality, based on the electrical conductivity and sodium adsorption ratio (SAR), which provides direct indication of the salinity and alkalinity hazards by locating the point for particular irrigation water describing 16 classes with electrical conductivity and SAR as coordinates. The figure is binomial and C_1, C_2, C_3 and C_4 represent water classes with increasing hazards from total salt concentration and S_1, S_2, S_3 and S_4 represent water classes for increasing hazards of exchangeable and accessible sodium accumulation in irrigated soils. The U. S. Salinity diagram has been adopted for delineation of groundwater quality for irrigation (Figure 6).

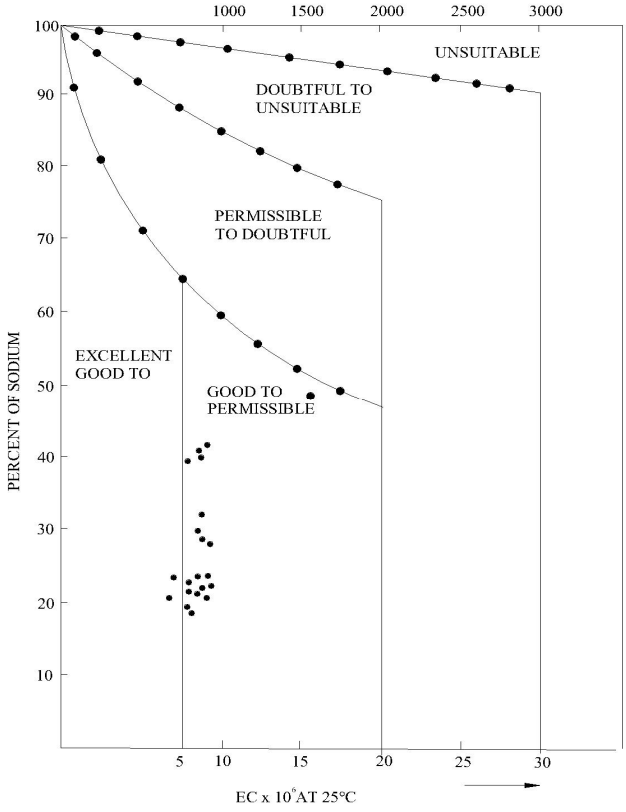

Figure 5: Wilcox Diagram Representing Groundwater Parameter for Irrigation

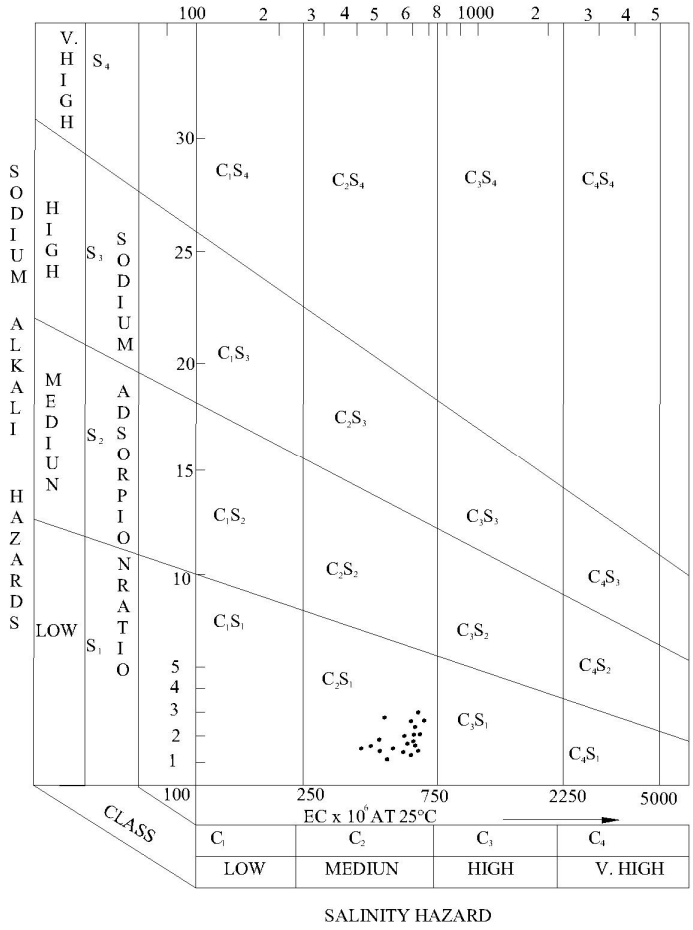

Figure 6: U. S. Salinity Diagram Exhibiting Classification for Groundwater for Irrigation Use

CONCLUSIONS

In the 20 groundwater samples collected for physico-chemical analysis of Manasa area, Neemach District. These sample water cannot be entirely fit for directly drinking. Some critical treatment needed to exchange in drinkable water. In conclusion, from the results of the present study it may be assumed that the public in these rural areas are therefore at higher prospective risk of contacting water-borne or sanitation-related diseases. This area water is not absolutely fit for directly drinking purpose need treatments to minimize the contamination. It is suggested that water analysis should be carried out from time to time to monitor the rate and kind of contamination. In the Manasa study are has been plots of the value electrical conductivity and sodium adsorption ratio on U. S. Salinity diagram reveals that all samples belong class C_2S_1 (medium salinity to low sodium) representing a favorable quality of groundwater for the irrigation purpose in the area. It is need of human to expand awareness among the people to continue the cleanness of water at their highest quality and purity levels to achieve a healthy life.

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