



Physico-chemical assessment of ground water quality of some areas of Imphal east and Imphal west districts of Manipur during pre-monsoon-2nd phase

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ABSTRACT

Twelve (12) ground water samples were collected from hand pumps of different locations of Imphal East and Imphal West districts during pre-monsoon of 2014 and they were analysed for various physico-chemical parameters – temperature, pH, electrical conductivity (EC), TDS (total dissolved solids), total alkalinity (TA), CO_3^{2-} , HCO_3^- , total hardness (TH), Ca^{2+} , Mg^{2+} , Na^+ and Cl^- . Only the ground waters represented by S-4 (Khonghampat Mantri Leikai), S-7 (Maharabi Loushaang) and S-11 (Neikanlong Cheirao Chingkhong, Thangmeiband) of Imphal West district are found to be fit for drinking from physico-chemical analyses point of view. But remaining ground waters represented by S-1 to S-3, S-5 to S-6, S-8 to S-10 and S-12 are unfit for drinking purpose as some of their parameters like TDS (total dissolved solids), total alkalinity (TA) and Mg^{2+} are present beyond corresponding desirable limits of BIS standards for drinking water. So, some suitable treatments are necessary so as to keep the values of these parameters within the desirable limits of BIS standards so as to make fit the above mentioned ground waters for drinking purpose. However all the ground waters (S-1 to S-12) are fit for other domestic and irrigation purposes. Further, strong positive correlations exist among the parameters such as TDS, electrical conductivity, total alkalinity, total hardness, Mg^{2+} , Ca^{2+} , Na^+ and HCO_3^- .

Keywords: Ground water, physico-chemical parameters, drinking, domestic and irrigation.

INTRODUCTION

There is rapid urbanization and industrialization all over the globe because of increasing population growth day by day. As a result of it, quantity of surface water is decreasing and people starts exploitation of ground water not only for drinking and other domestic purposes but also for irrigation and industrial purposes all over the world.

Out of total global water resources, fresh water (which includes ground water) is 1% while the economically extractable ground water is 0.3% [1-2]. But such ground water may not always be safe for drinking, other domestic and irrigation purposes and it is necessary to monitor the quality of such ground water from time to time. With a view to this objective, many researchers all over the world including our country India, had carried out extensive investigations about the suitability of such ground waters for drinking, other domestic and irrigation purposes mainly [3-13].

The present aim of the research work is to assess the ground water quality of some areas of Imphal East and Imphal West districts during pre-monsoon (middle of April to middle of May, 2014) so as to examine whether such ground waters from different locations, are fit for drinking, other domestic and irrigation purposes mainly and also to find out correlations among various parameters. This research is in continuation of my former research work on ground water analysis of some other different areas of Imphal East and Imphal West districts [14].

EXPERIMENTAL SECTION

All the chemicals used for this research work, were of AR grade and were used as received. The twelve (12) ground water samples (S-1 to S-12) were collected from hand pumps of different locations (sampling sites) of Imphal East and Imphal West districts during pre-monsoon period (middle of April to middle of May) of 2014. These ground water samples were collected in well sterilized polythene bottles of one litre capacity each following strict guidelines of sampling.

The twelve (12) ground water samples were analysed for physico-chemical parameters such as temperature, pH, TDS (total dissolved solids), electrical conductivity (EC), total alkalinity (TA), CO_3^{2-} , HCO_3^- , total hardness (TA), Ca^{2+} , Mg^{2+} , Na^+ and Cl^- .

The geographical locations (longitudes and latitudes) of the different ground water samples (S-1 to S-12) were measured with the help of a GPS instrument and they are shown in table-1 give below :

Table – 1 : Locations of different ground water sampling sites

Sample code no. (with source)	Sampling sites	District	Longitude	Latitude
S-1(Hand pump)	Mantripukhri (Mr. Subol's residence)	Imphal East	93°56'15.63"E	24°50'57.65"N
S-2(Hand pump)	Luwangsangbam Awang Leikai(near rented quarters)	Imphal East	93°55'01.80"E	24°52'37.00"N
S-3(Hand pump)	Aenon village, Luwangsangbam(northern side)	Imphal East	93°54'51.25"E	24°52'29.13"N
S-4(Hand pump)	Khonghampat Mantri Leikai	Imphal West	93°54'22.34"E	24°52'50.17"N
S-5(Hand pump)	Garden near Pheidingga bazar	Imphal West	93°53'12.13"E	24°53'58.40"N
S-6(Hand pump)	Tendongyan Mamang Leikai (near foothill)	Imphal West	93°52'55.85"E	24°54'48.18"N
S-7(Hand pump)	Maharabi Loushaang(near foothill)	Imphal West	93°52'55.07"E	24°55'53.47"N
S-8(Hand pump)	Nagaram D-block	Imphal East	93°56'59.71"E	24°49'38.92"N
S-9(Hand pump)	Laipham Khunou Mayai Leikai	Imphal East	93°57'09.03"E	24°49'59.85"N
S-10(Hand pump)	Sagolband Sayang Kurao Makhong(Samballei Sekpil)	Imphal West	93°55'19.99"E	24°47'36.56"N
S-11(Hand pump)	Neikanlong Cheirao Chingkhong, Thangmeiband	Imphal West	93°56'01.65"E	24°49'54.13"N
S-12(Hand pump)	Langol Tarung Village, Thangmeiband	Imphal West	93°55'58.47"E	24°50'13.64"N

Parameters such as temperature, pH, TDS (total dissolve solids) and electrical conductivity (EC) were measured at the corresponding sampling sites of the twelve (12) ground water samples (S-1 to S-12). However, other remaining parameters such as total alkalinity (TA) (and hence CO_3^{2-} and HCO_3^-), total hardness (TH), Ca^{2+} , Mg^{2+} (by calculation method) and Cl^- were determined in departmental research laboratory using standard methods [15]. The values of sodium (Na^+) were found out by calculation method [16]. The instruments and brief methods used for the measurements/determination of different physico-chemical parameters, are shown in table-2 given below:

Table-2: Instruments and methods used for measurements/determination of physico-chemical parameters of ground water samples

Physico-chemical parameters measured/determined	Instruments and methods used
Temperature	TDS Meter (TDS-3)(TDS/Temp.) (HIMEDIA, India)
pH	pHep® Pocket-sized pH Meter (HI 98107) (HANNA Instruments, Romania)
TDS (total dissolved solids)	TDS Meter (TDS-3)(TDS/Temp.) (HIMEDIA, India)
Electrical conductivity (EC)	Conductivity Tester (Dist 3: HI 98303) (HANNA Instruments, Romania)
Total alkalinity (TA)	By titrimetric method with standard HCl solution using phenolphthalein and methyl orange indicators
CO_3^{2-} and HCO_3^-	By calculation method from total alkalinity values
Total hardness (TH)	EDTA titrimetric method (using Eriochrome Black T indicator)
Calcium (Ca^{2+})	EDTA titrimetric method (using Murexide indicator)
Magnesium (Mg^{2+})	Calculation method
Sodium (Na^+)	By calculation method
Chloride (Cl^-)	Argentometric titrimetric method (Using K_2CrO_4 indicator solution)

Values of parameters such as RSC (residual sodium carbonate) and SAR (sodium adsorption ratio) for the different ground water samples, were calculated using the following relationships [16-17]:

$$\text{RSC (Residual sodium carbonate)} = (\text{CO}_3^{2-} + \text{HCO}_3^-) - (\text{Ca}^{2+} + \text{Mg}^{2+})$$

$$\text{and SAR (Sodium adsorption ratio)} = \frac{\text{Na}^+}{\sqrt{\frac{\text{Ca}^{2+} + \text{Mg}^{2+}}{2}}}$$

where ionic concentrations were expressed in milli-equivalents/litre (meq/L).

RESULTS AND DISCUSSION

All the ground water samples (except S-10 which has very light yellow colour) are found to be colourless and odourless. The values of various physico-chemical parameters for the twelve ground water samples (S-1 to S-12) are shown in table-3 below :

Table – 3 : Values of physico-chemical parameters of ground water samples

Sample code no.	Temperature (°C)	pH	TDS (mg/L)	Electrical conductivity (EC) (µS/cm)	Total alkalinity (TA) (as CaCO ₃) (mg/L)	HCO ₃ ⁻ (mg/L)	Total hardness (TA) (as CaCO ₃) (mg/L)	Ca ²⁺ (mg/L)	Mg ²⁺ (mg/L)	Na ⁺ (mg/L)	Cl ⁻ (mg/L)
S-1	23.4	6.8	229	491	265	323.3	80	15.2	10.2	76.2	4.3
S-2	23.2	7.5	195	411	235	286.7	128	22.4	17.5	35.7	4.3
S-3	23.3	7.3	177	399	225	274.5	132	23.2	18	31.1	5.7
S-4	22.3	7.5	175	363	185	225.7	118	20.8	16	29.4	5.7
S-5	21.2	7.3	194	400	230	280.6	166	32.9	20.4	15.7	5.7
S-6	22.8	7.4	191	399	205	250.1	150	31.3	17.5	22.7	7.1
S-7	22.2	7.4	172	354	185	225.7	122	24.8	14.6	25.3	8.5
S-8	22.7	7.2	401	812	440	536.8	156	20.8	25.3	115	21.3
S-9	22.3	7.1	363	743	415	506.3	146	18.4	24.3	103.8	7.1
S-10	23	6.9	590	1195	715	872.3	262	27.3	47.1	154.4	4.3
S-11	22.9	7.3	211	549	90	109.8	170	25.7	25.8	48	82.4
S-12	23.9	7.5	209	511	285	347.7	230	46.5	27.7	11.8	5.7

Temperature :

The temperatures of the twelve ground water samples (S-1 to S-12) range from 21.2 – 23.9⁰ (table-3). S-5 has the lowest temperature (21.2⁰C) while S-12 has the highest temperature (23.9⁰C).

pH values:

The pH values of the twelve ground water samples (S-1 to S-12) are in the range 6.8 – 7.5 (table-3). S-1 has the lowest value of pH (6.8) while that of S-2, S-4 and S-12 are highest (7.5 each) as shown in table-3. S-1 and S-10 are vary slightly acidic while S-2 to S-9 and S-11 to S-12 are very slightly alkaline. However, all the pH values of these twelve samples are within the desirable limit (6.5 – 8.5) of BIS standards for drinking water as well as that of WHO [18-19].

TDS (Total dissolved solids):

The TDS values of the twelve ground water samples range from 172-590 mg/L (table-3). Sample represented by S-7 has the lowest value (172 mg/L) while that of S-10 is the highest (590 mg/L). The TDS values of S-1 to S-9 and S-11 to S-12 are within the desirable limit (500 mg/L) of BIS standards for drinking water while that of S-10 is beyond the desirable limit [18].

However, the TDS value of each of ground water sample is less than 1000 mg/L; all these ground waters (S-1 to S-12) may be used for other domestic purposes [20].

Electrical conductivity (EC):

The electrical conductivity values of the twelve (12) ground water samples are in the range 354 – 1195 µS/cm (table-3). Ground water represented by S-10 has the highest value while that of ground water represented by S-7 has the lowest value.

Total alkalinity (TA):

The total alkalinity values of S-1 to S-12 are in the range 90 – 715 mg/L (table-3). S-11 has the lowest value of alkalinity (90 mg/L) while S-10 has the highest value of alkalinity (715 mg/L). Only the ground waters represented by S-4, S-7 and S-11 have their total alkalinity values within the desirable limit (200 mg/L) of BIS standards for drinking water while remaining nine ground waters (S-1 to S-3, S-5 to S-6, S-8 to S-10 and S-12) have their total alkalinity values beyond this desirable limit (200 mg/L) but within the permissible limit (600 mg/L) except S-10 which has the value, 715 mg/L [18].

Carbonate (CO₃²⁻) and bicarbonate (HCO₃⁻):

The carbonate (CO₃²⁻) values of all the twelve ground water sample (S-1 to S-12) are found to be zero as the phenolphthalein alkalinity (P-alkalinity) of these water samples, are zero. However, the bicarbonate (HCO₃⁻) values (calculated from total alkalinity values) of these twelve ground water samples are found to be in the range 109.8 – 872.3 mg/L (table-3). S-11 has the lowest value (109.8 mg/L) while that of S-10 is the highest (872.3 mg/L).

Total hardness (TH):

The total hardness values of the twelve (12) ground water samples range from 80 – 262 mg/L (table-3). S-1 has the lowest value of total hardness while S-10 has the highest value of it. Ground waters represented by S-1 to S-4, S-6 to S-7 and S-9 belong to moderately hard water category (75-150 mg/L) while S-5, S-8 and S-10 to S-12 belong to hard water category (150-300 mg/L) [20]. All the values of total hardness for the twelve ground water samples (S-1 to S-12) are within the desirable limit (300 mg/L) of BIS standards for drinking water [18].

Calcium (Ca²⁺):

For the twelve ground water samples (S-1 to S-12), the values of calcium are in the range 15.2 – 46.5 mg/L (table-3). The ground water represented by S-1 has the lowest value of calcium while that of S-12 is the highest one. All the values of calcium for the twelve ground water samples (S-1 to S-12) are within the desirable limit (75 mg/L) of BIS standards for drinking water [18].

Magnesium (Mg²⁺):

The values of magnesium for the ground water samples S-1 to S-12, range from 10.2-47.1 mg/L (table-3). S-1 has lowest value of magnesium while S-10 has the highest value of it. Except S-10 (47.1 mg/L), the values of magnesium for the remaining eleven samples (S-1 to S-9 and S-11 to S-12) are within the desirable limit (30 mg/L) of BIS standards for drinking water [18].

Sodium (Na⁺):

Regarding sodium contents of the twelve ground water samples (S-1 to S-12), the values of sodium range from 11.8 – 154.4 mg/L (table-3). S-10 has highest value of sodium while S-12 has the least value. All these values of sodium for the twelve ground water samples are within the threshold limit (200 mg/L) of WHO [19].

Chloride (Cl⁻):

The values of chloride for the twelve ground water samples (S-1 to S-12) are in the range 4.3 – 82.4 mg/L (table-3). All these values of chloride for the twelve ground water samples (S-1 to S-12) are within the desirable limit (250 mg/L) of BIS standards for drinking water [18].

Ground water quality for irrigation:

The values of parameters such as RSC (residual sodium carbonate) and SAR (sodium adsorption ratio) are shown in table – 4 given below:

Table-4 : Values of RSC and SAR for different ground water samples

Sample code no.	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12
RSC (Residual sodium carbonate) (meq/L)	3.7	2.1	1.9	1.3	1.3	1.1	1.3	5.7	5.4	9.1	-1.6	1.1
SAR(Sodium adsorption ratio)	3.7	1.4	1.2	1.2	0.5	0.8	1.0	4.0	3.7	4.1	1.6	0.3

As the RSC values for ground waters – S-6, S-11 and S-12 are less than 1.25 meq/L (as shown in table-4), they are of excellent quality for irrigation purpose but for the ground waters – S-2 to S-5 and S-7, their RSC values are in between 1.25 – 2.5 meq/L and they are of good quality for irrigation purpose [2,16].

Further, as is evident from table – 3, the electrical conductivity (EC) values of the ground waters – S-1 to S-7, S-9 and S-11 to S-12, are in the category of good quality for irrigation (250-750 $\mu\text{S}/\text{cm}$) while those values of S-8 and S-10 fall in the permissible category (750 – 2000 $\mu\text{S}/\text{cm}$) [17].

However, the values of SAR for the twelve ground water samples (S-1 to S-12) are in the range 0.3 – 4.1 and all of them belong to the excellent category of water for irrigation (SAR upto 10) [2]. Summing up, all the ground waters represented by S-1 to S-12, are fit for irrigation purpose.

Statistical Analysis (Correlation co-efficient (r) values):

The calculated values of correlation co-efficient (r) of different variable pairs of physico-chemical parameters of the twelve ground water samples (S-1 to S-12) are detailed in table-5 below.

As is evident from table-5 above, there are strong positive correlations between TDS and each of EC, TA, HCO₃⁻, Mg²⁺ and Na⁺ showing that the values of EC (electrical conductivity) and TA (total alkalinity) are directly proportional to the values of TDS and also TDS is mainly dependent on the concentrations of HCO₃⁻, Mg²⁺ and Na⁺.

Further, high values of correlation co-efficient (r) between EC and each of HCO_3^- , Mg^{2+} and Na^+ show that the values EC are mainly proportional to the concentrations of these ions. There is a perfect positive correlation between TA (total alkalinity) and HCO_3^- ($r=1$) showing that the total alkalinity of each ground water sample is due to the presence of HCO_3^- ions only.

Table-5 : Correlation co-efficient (r) values between different variable pairs of physico-chemical parameters of ground water samples

	Temp.	pH	TDS	EC	TA	HCO_3^-	TH	Ca^{2+}	Mg^{2+}	Na^+	Cl^-
Temp.	1										
pH	-0.080	1									
TDS	0.054	-0.638	1								
EC	0.129	-0.630	0.989	1							
TA	0.097	-0.596	0.955	0.923	1						
HCO_3^-	0.097	-0.596	0.955	0.923	1	1					
TH	0.165	-0.041	0.598	0.653	0.592	0.592	1				
Ca^{2+}	0.156	0.457	-0.137	-0.082	-0.051	-0.051	0.667	1			
Mg^{2+}	0.127	-0.294	0.832	0.873	0.778	0.778	0.919	0.319	1		
Na^+	0.079	-0.767	0.941	0.927	0.862	0.862	0.322	-0.432	0.637	1	
Cl^-	0.030	0.048	-0.063	0.044	-0.340	-0.340	0.087	-0.035	0.132	0.011	1

The strong positive correlations between Mg^{2+} and HCO_3^- ($r=0.778$) and between Na^+ and HCO_3^- ($r=0.862$) establish the presence of HCO_3^- in the forms of salts such as $\text{Mg}(\text{HCO}_3)_2$ and NaHCO_3 mainly. Strong positive correlations also exist between total hardness (TH) and each of Mg^{2+} , Ca^{2+} and HCO_3^- .

CONCLUSION

From the physico-chemical analyses of the twelve ground water samples (S-1 to S-12), it is concluded that only the ground waters represented by S-4, S-7 and S-11 are found to be fit for drinking from physico-chemical analyses point of view while remaining ground waters represented by S-1 to S-3, S-5 to S-6, S-8 to S-10 and S-12 are found to be unfit for drinking as some of their parameters such as TDS, total alkalinity and Mg^{2+} are present beyond corresponding desirable limits of BIS standards for drinking water. So, some treatments are necessary so as to keep the values of these parameters within corresponding desirable limits. However all these ground waters (S-1 to S-12) are suitable for other domestic purposes as well as fit for irrigation purpose also.

Further, strong positive correlations are shown among the parameters such as TDS, electrical conductivity, total alkalinity, total hardness, Mg^{2+} , Ca^{2+} , Na^+ and HCO_3^- .

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