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Research Article

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Physico-chemical investigation of ground water quality of some areas of Imphal east district of Manipur during post-monsoon-2nd phase

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ABSTRACT

Ten (10) ground water samples were collected from hand pumps of different locations of Imphal East district during post-monsoon of 2013 and they were analysed for physico-chemical parameters such as temperature, pH, electrical conductivity (EC), TDS (total dissolved solids), total hardness (TH), Ca^{2+}, Mg^{2+}, Na^{+}, K^{+} and Cl^{-}. All the ten samples (S-1 to S-10) are found to be fit for drinking purpose from physico-chemical analyses point of view as the values of different physico-chemical parameters are within the desirable limits of BIS standards for drinking water as well as that of WHO. But this does not guarantee that such ground waters are totally safe for drinking purpose. Further some investigations are necessary to examine whether toxic/carcinogenic metals such as As, Pb, Hg, Cd etc. are present beyond desirable limit or not. However, such ground waters are found to be fit for other domestic purpose as their TDS values are less than 1000mg/L and also fit for irrigation purpose as are evident from their values of electrical conductivity and SAR (sodium adsorption ratio). Further, correlation co-efficient data also show that the values of TDS, electrical conductivity and total hardness are mainly attributed to the concentrations of Ca^{2+}, Mg^{2+} and Na^{+}.

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

INTRODUCTION

The population growth all over the world, is increasing day by day. Due to rapid urbanization and industrialization, quantity of surface water is decreasing in urban areas and consequently people starts exploitation of ground water to meet their demand for drinking, other domestic, irrigation and industrial purposes.

Of the total global water resources which includes 1% as freshwater, ground water is about 0.6% and out of this only 0.3% is extractable economically [1-2]. It is necessary to examine such ground waters for drinking, other domestic and irrigation purposes mainly. 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. [3-12].

The present aim of the research work is to carry out physico-chemical investigation of ground water quality of some areas of Imphal east district during post-monsoon season (November) of 2013. This is in continuation of my former research work on ground water quality of some areas of Imphal east district [13].

EXPERIMENTAL SECTION

All the chemicals were of AR grade and were used as received. The ten ground water samples (S-1 to S-10) were collected in well sterilized polythene bottles (1 litre capacity each) in the month of November, 2013 (Post-monsoon) and they were analysed for parameters like temperature, pH, TDS (total dissolved solids), electrical conductivity

(EC), total hardness (TH), Ca^{+2}, Mg^{2+}, Na^{+}, K^{+} and Cl^{-}. Geographical locations of different sampling sites of the ten ground water samples, were recorded with the help of a GPS instrument and they are shown in table-1:

Table – 1 : Locations of different ground water sampling sites with their sources

Sample code no.	Ground water source	Sampling sites	District	Longitude	Latitude
S-1	Hand pump	Kontha Ahallup Mayai Leikai (1)	Imphal East	$93^0 56' 50.32'' E$	$24^0 51' 07.42'' N$
S-2	Hand pump	Kontha Ahallup Mayai Leikai (2)	Imphal East	$93^0 56' 50.46'' E$	$24^0 51' 11.22'' N$
S-3	Hand pump	Heingang Makha Leikai(1) (Near Heingang High School)	Imphal East	$93^0 57' 07.02'' E$	$24^0 51' 20.19'' N$
S-4	Hand pump	Near foothill of Heingang Hannajing Hill	Imphal East	$93^0 57' 24.54'' E$	$24^0 51' 20.02'' N$
S-5	Hand pump	Near Heingang Panthoibi Lampak	Imphal East	$93^0 56' 46.39'' E$	$24^0 51' 23.23'' N$
S-6	Hand pump	Heingang Mayai Leikai (Bamon Leirak)	Imphal East	$93^0 56' 45.92'' E$	$24^0 51' 31.37'' N$
S-7	Hand pump	Heingang Chingakham Leikai	Imphal East	$93^0 56' 47.99'' E$	$24^0 51' 35.38'' N$
S-8	Hand pump	Heingang Makha Leikai (2)	Imphal East	$93^0 57' 07.02'' E$	$24^0 51' 13.69'' N$
S-9	Hand pump	Kairang Awang Leikai (1) (Near L.P. School)	Imphal East	$93^0 57' 13.83'' E$	$24^0 51' 00.89'' N$
S-10	Hand pump	Kairang Awang Leikai (2)	Imphal East	$93^0 57' 15.94'' E$	$24^0 50' 55.89'' N$

Parameters like temperature, pH, TDS and electrical conductivity (EC) were measured at the different sampling sites while remaining parameters such as total hardness (TH), Ca^{2+}, Mg^{2+} and Cl^{-} were determined in departmental research laboratory using standard methods [14]. Na^{+} and K^{+} were determined by Flame photometer 128(Systronics).

Various instruments and brief methods used for measurements and determination of different physico-chemical parameters, are shown in table-2 given below:

Table–2: Different instruments/methods used for measurements (or determination) of physico-chemical parameters of ground water samples

Various parameters measured (or determined)	Different instruments/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 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^{+})	Flame photometer 128 (Systronics, India)
Potassium (K^{+})	Flame photometer 128 (Systronics, India)
Chloride (Cl^{-})	Argentometric Titrimetric Method (Using K_2CrO_4 indicator solution).

Parameters like percent sodium (%Na) and SAR (sodium adsorption ratio) were calculated using the relationships [15-16]:

$$\%Na = \frac{Na^+}{Ca^{2+} + Mg^{2+} + Na^+ + K^+} \times 100$$

And $SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$, where ionic concentrations were expressed in milli-equivalents/litre (meq/L).

The values of correlation co-efficient(r) of the different pairs of physico-chemical parameters, were calculated using MS-Excel 2007.

RESULTS AND DISCUSSION

The experimentally found values of different physico-chemical parameters of various ground water samples (S-1 to S-10) are shown in table – 3 given below:

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

Sample code no.	Temp. (^{0}C)	pH	TDS (mg/L)	Electrical conductivity (EC) (μS/cm)	Total hardness (TH) (mg/L, as $CaCO_3$)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^+ (mg/L)	K^+ (mg/L)	Cl^- (mg/L)
S-1	23.1	7.8	421	836	162	24.8	24.4	116.3	1.8	12.8
S-2	22.7	7.8	324	647	122	19.2	18.1	95.1	1.6	14.2
S-3	22.1	7.6	228	472	88	12.8	13.7	64.7	1.4	9.9
S-4	23.4	8.5	380	760	160	28.1	22.0	114.3	1.3	34.0
S-5	22.5	7.9	305	615	118	19.2	17.1	87.7	1.4	11.3
S-6	22.4	7.7	261	532	100	18.4	13.2	71.2	1.4	11.3
S-7	22.1	7.7	257	524	96	16.0	13.7	69.3	1.5	11.3
S-8	22.1	7.3	306	614	114	16.8	17.6	87.2	1.6	9.9
S-9	22.5	7.6	249	512	94	14.4	14.2	69.7	1.3	7.1
S-10	21.8	7.7	332	660	128	14.4	22.4	102.4	1.0	11.3

Based on the values of different physico-chemical parameters (shown in table-3) of the ten ground water samples, the following discussion has been made:

Temperature :
From table-3, it is clearly seen that the temperature of ground water samples (S-1 to S-10) range from 21.8^{0}C to 23.4^{0}C. Ground water represented by S-4 has the highest temperature while that of S-10 has the lowest temperature.

pH values:
The pH values of the ten ground water samples (S-1 to S-10) are in the range 7.3-8.5 (as shown in table-3). All the ground waters represented by S-1 to S-10, are found to be slightly alkaline. All the pH values of the ten ground water samples, are within the desirable limit (6.5-8.5) of BIS standards for drinking water as well as that of WHO [17-18].

TDS (total dissolved solids):
For the ten ground water samples (S-1 to S-10), the TDS values range from 228 mg/L to 421 mg/L (table-3). Ground water (S-1) has the highest value while that of S-3 has the least value. The TDS values of the ten ground water samples, are within the desirable limit of (500mg/L) of BIS standards for drinking water [17]. As the TDS values of the ten ground water samples are less than 1000 mg/L, all of them may be used for other domestic purposes [15].

Electrical conductivity (EC):
The electrical conductivity values of the ten ground water samples (S-1 to S-10) are in the range 472-836 μS/cm (as shown in table-3). Ground water (S-1) has the highest value while ground water (S-3) has the lowest value of electrical conductivity.

Total hardness (TH):
The total hardness values of the ten ground water samples (S-1 to S-10) range from 88 – 162 mg/L (table-3). Ground water represented by S-1 has the highest value of total hardness while that of S-3 is the lowest one. From table-3, it is clearly seen that ground waters represented by S-2 to S-3 and S-5 to S-10 belong to the moderately hard water category (75-150 mg/L) while the total hardness values of S-1 and S-4 are within hard water category (150-300 mg/L) [15].

All the values of total hardness of the ten ground water samples, are within the desirable limit (300 mg/L) of BIS standards for drinking water [17].

Calcium (Ca^{2+}):
The values of calcium of the ten ground water samples (S-1 to S-10) range from 12.8 mg/L to 28.1 mg/L (as shown in table-3). Ground water represented by S-4 has the highest value of calcium while ground water represented by S-3 has the least value of it.

Further, all the values of calcium of the ten ground water samples (S-1 to S-10) are within the desirable limit (75 mg/L) of BIS standards for drinking water [17].

Magnesium (Mg^{2+}):
Regarding the magnesium contents of the ten ground water samples (as shown in table-3), the values of magnesium are in the range 13.2 – 24.4 mg/L. Ground water represented by S-6 is found to have the least value of magnesium while that of S-1 is the highest. However, all the values of magnesium for the ten ground water samples (S-1 to S-10) are within the desirable limit (30 mg/L) of BIS standards for drinking water [17].

Sodium (Na^+):
The values of sodium of the ten ground water samples (S-1 to S-10) range from 64.7 mg/L to 116.3 mg/L (as shown in table-3). Ground water represented by S-1 has the highest value of sodium while S-3 has the least value of it. Further, all the values of sodium for the ten ground water samples, are within the threshold limit (200 mg/L) of WHO [18].

Potassium (K^+):
About potassium contents of the ten ground water samples (S-1 to S-10), the values of potassium varies from 1.0 mg/L to 1.8 mg/L. Ground water represented by S-10 has the lowest value of potassium while S-1 has the highest value of it.

Chloride (Cl^-):
As it is clearly seen from ttable-3, the values of chloride of the ten ground water samples (S-1 to S-10), are in the range 7.1 – 34.0 mg/L. Ground water represented by S-4 has the highest value of chloride but S-9 has the least value of it. All the values of chloride of the ground water samples (S-1 to S-10) are within the desirable limit (250 mg/L) of BIS standards for drinking water [17].

Ground water quality for irrigation purpose :
The values of percent sodium (%Na) and SAR (sodium adsorption ratio) for the ten ground water samples (S-1 to S-10) are shown below in table-4 :

Table-4 : Values of percent sodium (%Na) and SAR (sodium adsorption ratio) of 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
Percent sodium (%Na)	60.6	62.4	61.0	60.5	61.4	60.3	60.5	62.0	61.2	63.3
SAR (Sodium adsorption ratio)	4.0	3.7	3.0	3.9	3.5	3.1	3.1	3.5	3.1	3.9

Though the values of %Na for all the ten ground water samples are slightly greater than 60, the SAR values of these ground water samples (S-1 to S-10) are in the range 3.1 – 4.0 and all these values are less than 10, which are within excellent category (SAR upto 10) of water for irrigation purpose [2].

Again from electrical conductivity point of view (as shown in table-3), it is clearly seen that except S-1 (EC = 836 μS/cm), the electrical conductivity (EC) values of S-2 to S-10 are less than 750 μS/cm and hence ground waters represented by S-2 to S-10 are of very good quality for irrigation purpose.

Statistical Analysis (Correlation Co-efficient (r) values):
The correlation co-efficient (r) values of different variable pairs of physico-chemical parameters of the ten ground water samples (S-1 to S-10) are shown in table-5 below:

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

	Temp.	pH	TDS	EC	TH	Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-
Temp.	1									
pH	0.750	1								
TDS	0.653	0.509	1							
EC	0.669	0.520	0.999	1						
TH	0.712	0.630	0.985	0.987	1					
Ca^{2+}	0.910	0.772	0.813	0.824	0.865	1				
Mg^{2+}	0.461	0.431	0.949	0.945	0.936	0.632	1			
Na^+	0.602	0.555	0.980	0.977	0.980	0.770	0.972	1		
K^+	0.375	-0.181	0.274	0.280	0.188	0.341	0.050	0.114	1	
Cl^-	0.711	0.895	0.546	0.554	0.667	0.797	0.472	0.603	-0.106	1

From the above table, it is clearly seen that there is a strong positive correlation (r = 0.999) between TDS and EC (electrical conductivity) showing that the value of EC is directly proportional to TDS. Similarly, strong positive correlation (r=0.987) is there between total hardness (TH) and EC. Further, from table-5, it is clearly seen that there are strong positive correlations between TDS and each of Ca^{2+}, Mg^{2+} and Na^+. Similarly strong positive correlations are there between EC and each of Ca^{2+}, Mg^{2+} and Na^+. Also strong positive correlation exist between TH and each of Ca^{2+}, Mg^{2+} and Na^+.

The above mentioned correlations show that the high or low values of TDS, EC and TH are mainly dependent on the high or low concentrations of Ca^{2+}, Mg^{2+} and Na^+ of these different ground water samples (S-1 to S-10).

CONCLUSION

Based on the experimental results of physico-chemical investigation point of view, it is concluded that all the ground water samples (represented by S-1 to S-10) are found to be fit for drinking, other domestic and irrigation purposes. But this does not guarantee that they are totally safe for drinking purpose as some further investigations are necessary so as to examine whether toxic/carcinogenic metals such as As, Pb, Hg, Cd etc. are present beyond desirable limit for drinking purpose or not.

Further, strong positive correlations of TDS, electrical conductivity (EC) and total hardness (TH) with each of Ca^{2+}, Mg^{2+} and Na^{+} show that the high or low values of TDS, electrical conductivity and total hardness are mainly dependent or high or low concentration respectively of Ca^{2+}, Mg^{2+} and Na^{+}.

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