International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.04, March 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

ASSESSMENT OF GROUNDWATER QUALITY ALONG THE PERIPHERY OF DAL LAKE

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ABSTRACT

With shrinking of surface water resources along with degradation in their quality, there is a crisis for freshwater to meet the growing demands. The need is to fulfill the demand by way of exploiting other water resources like groundwater, which is considered to be in abundance and fresh. Even though groundwater is present in rich quantities and is underground, its quality assessment is necessary prior to its consumption. It was in this context that the present study was carried out to assess groundwater quality around Dal Lake. A total of seven groundwater samples viz. 1 tube well, 3 bore wells and 3 springs were selected and analyzed for various physico chemical parameters. The results obtained were equated with WHO (2011) and BIS (2009) standards. By and large the quality was found to be good. However, at few sites geology and anthropogenic activities were found to be responsible for the increase in certain physico chemical parameters. Water Quality Index (WQI) also revealed good to excellent quality of water in the study area and it can be concluded that groundwater in the study area is fit for drinking purpose.

Keywords: Bore Well, Geology, Spring, Tube Well, Water Quality Index

I INTRODUCTION

Currently there is a need of good quality of water for drinking, agriculture and industry as a result of increase in population and rise in standard of living (1). This has in turn resulted in increased usage of water resources particularly groundwater (2). In India alone, about 60% of irrigation and 85% of drinking water is from groundwater (3). Being a significant portion of freshwater, this resource is under risk of degradation both qualitatively and quantitatively. Besides, excessive use of fertilizers, discharge of chemicals and excessive pumping are the main activities which result in degradation of groundwater (4).

Kashmir valley has abundant deposits of ground water, both in confined as well as unconfined aquifers, however, it is due to the prevailing geology of the valley that its distribution becomes uneven (5). As estimated by Central Groundwater Board, groundwater potential of the valley is about 2400 million cubic meter per year and the current rate of exploitation is only 2.4 million cubic meter per year. Thus, domestic water supply and other requirements can be met by exploring the groundwater resources of the valley even if there is pressure on surface water sources due to recent advancement in industralisation and urbanisation in Srinagar city.

Until now, few reports are available on the groundwater quality of some of the areas of Srinagar city but no work has been done on the groundwater quality around Dal Lake, a freshwater body located in the heart of the city. Thus, the present study was attempt to obtain a baseline data on groundwater quality around Dal Lake and its suitability for drinking.

II STUDY AREA

Dal Lake is an urban lake, located in the north east of Srinagar city at 34° 03′- 34° 13′ N latitude and 74° 48′-75° 08′ E longitude and at an altitude of 1584m a.s.l. (Fig. 2.1). It is a Himalayan lake probably formed from an enlarged oxbow in the flood plains of river Jhelum (6, 7).

III MATERIALS AND METHODS

3.1 Physico Chemical Parameters

For carrying out the study, seven sites were selected for obtaining groundwater samples around the Lake. These comprised of three springs, three bore wells and one tube well. The details of sampling sites are given in table 3.1. Water samples were collected in a clean and dry polyethylene bottles. In case of tube wells and bore wells water was first allowed to flush for 2-3 minutes. Each groundwater sample was investigated for various physico chemical parameters viz; temperature, pH, conductivity, chloride, alkalinity, total hardness, calcium, magnesium, total dissolved solids, ammonia, nitrate, ortho- phosphorus, total phosphorus, sodium and potassium. The water temperature was determined on the spot. The analysis was done as per standard methods (8).

3.1.2 Water Quality Index

For computing Water Quality Index (WQI), mean of ten parameters such as pH, electrical conductivity, TDS, total hardness, alkalinity, chloride, nitrate, total phosphorus, sodium and potassium were used. WHO standards (9) for drinking water were considered for the calculation of WQI. Following four steps were followed as per the method proposed by Horton (10).

Step 1: Selected parameters were assigned a weight (wi) between 1 and 5 according to their relative importance in the overall quality of water for drinking purposes (Table 3.2). The maximum weight of 5 was assigned to nitrate due to its harmful effect (11) in drinking water.

Step 2: The relative weight (Wi) was computed (Table 3.2) using weighted arithmetic index method (12, 13, 14) using following equation;

International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.04, March 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \quad \text{(i)}$$

Where,

Wi is the relative weight

wi is the weight of each parameter and

n is the number of parameters.

Step 3: A quality rating scale (Qi) for each parameter is assigned by dividing its mean concentration in each water sample by its respective standard according to the guidelines of WHO (2011) and then multiplied by 100

Qi (ii)

Where,

Qi is the quality rating

Ci is the concentration of each chemical parameter in each water sample in mg/L and

Si is the WHO drinking water standard for each chemical parameter in mg/L according to the guidelines of WHO (2011).

Step 4: The SIi is first determined for each chemical parameter, which is then used to determine the WQI as per the following equation;

(iii)

Where,

SIi is the sub index of ith parameter and

Qi is the rating based on concentration of ith parameter.

The overall water quality index (WQI) was calculated by adding together each sub index values of each groundwater samples as;

(iv)

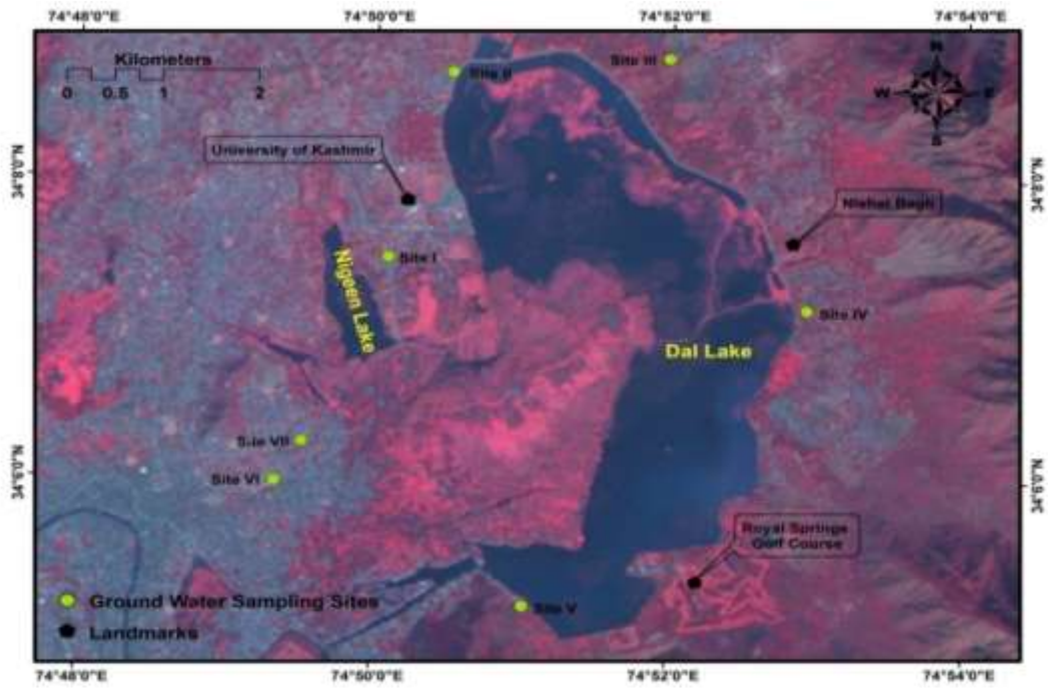

Fig. 2.1. Satellite image of Dal Lake showing study sites

Table 3.1. Summary of study sites

Sr. No	SAMPLE TYPE	LOCATION	LATITUDE	LONGITUDE	ELEVATION (m)	DEPTH (ft)	USAGE	DISTANCE FROM DAL LAKE (m)
1	Bore well	Hazratbal	34^{0}07‘28.3“	074^{0}50‘05.4“	1594	60	Domestic	≈ 80m
2	Spring	Habbak	34^{0}08‘42.2“	074^{0}50‘30.6“	1580	3.58	Domestic	≈ 30m
3	Spring	Foreshore road	34^{0}08‘48.0“	074^{0}51‘58.4“	1595	2.93	Domestic & irrigation	≈ 95m
4	Spring	Nishat	34^{0}07‘08.3“	074^{0}52‘55.5“	1600	4.60	Domestic	≈ 40m
5	Bore well	Nehru park	34^{0}05‘09.3“	074^{0}51‘01.8“	1597	12	Domestic	33m
6	Bore well	Rainawari	34^{0}05‘58.7“	074^{0}49‘20.5“	1595	55	Commercial	≈ 1500m
7	Tube well	Saida kadal	34^{0}06‘14.4“	074^{0}49‘31.3“	1607	250	Supplied for drinking	≈ 40m

Table 3.2. WHO standards, weight (wi) and calculated relative weight (Wi) for each parameter

Parameters	Standards (WHO 2011)	Weight (wi)	Relative weight (Wi)
pH	6.5-8.5	4	0.142
Conductivity	1500 μScm^{-1}	2	0.071
Chloride	250mg/l	3	0.107
Alkalinity	200mg/l	2	0.071
T. Hardness	500mg/l	4	0.142
TDS	1000mg/l	4	0.142
Nitrate	10mg/l	5	0.178
T. Phosphorus	5mg/l	2	0.071
Sodium	250mg/l	1	0.035
Potassium	12mg/l	1	0.035
Total		**28**	**0.994**

IV. RESULTS AND DISCUSSIONS

4.1. Physico Chemical Parameters

Various factors like Urbanization and industrialization are responsible for the entry of pollutants into the groundwater, resulting from industries, municipal sewers and agricultural activities. As a result of this groundwater becomes a mixture of harmful pollutants like nitrates, chlorides and pesticides. Apart from this, substances like dissolved ions are also influenced by many natural factors like lithology, groundwater flow, geochemical reactions and soluble salts (15, 16). Thus, groundwater quality can be assessed by analysis of various physico-chemical parameters and their comparison with standards meant for the purpose (Table 4.1.1 and 4.1.2).

The temperature of the studied samples remained relatively constant throughout the study period. The mean groundwater temperature showed narrow range of fluctuation between 14^{0} C (site III and IV) to 17^{0} C (site I) among the study period. In the present study pH values were found to be ranging from a mean value of 6.8 (site II) to 7.2 (site I) in comparison to the 6.5 to 8.5 standard set by WHO 2011, thus indicating its suitability for drinking. Overall the pH shows circum-neutral behavior.

Conductivity at the sites varied from a mean value of 303μScm^{-1} (site III) to 1161μScm^{-1} (site VI). However, slightly high value at site II (982 μScm^{-1}), V (776 μScm^{-1}) and VI (1161 μScm^{-1}) can be attributed to longer rock water interaction time and geology of the region (17), besides, some anthropogenic activities at site V and VI can also responsible for this increase (18). As per guidelines set by WHO (2011) a limit of 1500μScm^{-1} has been established for drinking water quality and none of the sites were found to be exceeding this limit. Total Dissolved Solids (TDS) were following the same trend as that of conductivity. Values of TDS were found to be ranging from mean of 204mg/l (site III) to 746mg/l (site VI). Across the study sites TDS values were much below the prescribed limit of 1000mg/l set by WHO (2011). However, slightly high values at site II (654mg/l) and VI (746mg/l) can be attributed to the hydrogeological properties of rocks, which tend to influence on the extent of water/rock reaction (19).

In the present study carbonate alkalinity was absent in all samples and bicarbonate alkalinity ranged from 25 to 313mg/l at site I and II. All the sites had alkalinity values below the WHO limit (200mg/l) except at site II (313mg/l) where high values can be attributed to the dissolution of carbonates due to carbonic acid formed as a result of infiltrating carbon dioxide (20, 21).

Chloride ions in excess impart a salty taste to water and its concentration serves as an indicator of sewage pollution (22). In the present study chloride was found to be ranging from a mean value of 12mg/l (site IV) to 107mg/l (site V). Chloride is present in natural waters in many ways, as the water dissolves chloride from top soil and deeper as ions (23). As per the standard given by WHO for chloride a limit of 250mg/l is permissible and was not exceeded by any of the sites.

On the other hand values of hardness were ranging from a mean value of 159mg/l to 400mg/l at site III and II. This can be attributed to the presence of rich deposits of limestone and evaporates (24, 25, 26). The limit for hardness set by WHO is 500mg/l (2011) and thus was not exceeded by any of the sites. The groundwater in the study area falls between Hard (121-180mg/l) and very Hard (180mg/l) as per Durfor and Becker classification (27). In the present study calcium was ranging from a mean value of 25mg/l (site I) to 147mg/l (site II). The limit for calcium set by WHO (2011) is 75mg/l and site II (147mg/l) and VI (108mg/l) were found to be exceeding the limit. High calcium concentration is a direct attribute of calcium rich rocks. The alkaline nature of Kashmir lakes is due to occurrence of calcium rich rocks (lacustrine deposits) in the catchment areas (28, 29). However, at majority of the sites calcium was dominating over magnesium mostly because of its abundance in the rock types and its solubility. Magnesium was ranging from a mean value of 15mg/l (site III) to 40mg/l (site VII). Magnesium is derived from dissolution of dolomite from source rocks. The WHO limit (2011) for magnesium hardness in case of drinking water is 100mg/l and its value was not exceeded by any of the sites.

Values of Sodium were ranging from mean value of 4mg/l (site I) to 48mg/l (site V) and were much below the prescribed standard of 250mg/l set by WHO, 2011. Low sodium value across all the study sites was due to carbonaceous or lime rich bed rock of the valley (30, 31). Relatively high value at site V (48.2mg/l) and VI (44mg/l) may be due to continuous mineral water interactions (32, 33) or due to anthropogenic stress. Potassium was detected at site II (2.2mg/l), V (1mg/l), VI (48mg/l) and VII (2.2mg/l) only. The values were found to be ranging from a mean of 1mg/l (site V) to 48mg/l (site VI). Low value of Potassium in groundwater is due to highly stable nature of alumino silicate minerals constituting this substance and subsequent fixation in clay minerals if formed due to weathering or use in biological systems (34). However the prescribed limit for potassium in case of drinking water set by WHO is 12mg/l which was exceeded by site VI (48mg/l) only and may be attributed to the anthropogenic stress prevalent on the site.

Ortho phosphorus and total phosphorus concentrations were ranging from a mean value of 0.022mg/l (site VII) to 0.078mg/l (site VI) and 0.090mg/l (site V) to 0.118mg/l (site VII) respectively. Phosphorus concentrations were low because of the fact that aquifers in Kashmir are rich in calcium and thus phosphorus gets precipitated (35) thus decreasing the availability of phosphorus in groundwater.

The amounts of nitrate, nitrite and ammonia present in natural waters in the form of nitrogen are of great interest because of their nutrient values. During the study period, the sites which showed the presence of ammonical nitrogen were as; site II (0.078mg/l), IV (site 0.021mg/l), V (0.061mg/l) and VII (0.051mg/l) and its concentration was much below the prescribed limits of 1.5mg/l set by WHO (2011). The low value was because of its unstable nature of ammonical nitrogen and its conversion to nitrite and subsequently to nitrate. On the other hand Nitrate- nitrogen was ranging from a mean value of 1.023mg/l (site V) to 1.239mg/l (site VII) which is less than the prescribed limit of 10mg/l set by WHO. The potential sources of naturally occurring nitrate are bedrock nitrogen and nitrogen leached from natural soils (36). The various forms of nitrogen does not bear much importance in drinking water standards except for nitrate which is a serious pollutant as its high levels in drinking water can cause health problems like methemoglobinemia (Blue baby syndrome), and it is also considered as a major nutrient for eutrophication of inland water bodies.

4.2. Water Quality Index

WQI is a very efficient method for assessment of water quality and is a reliable tool to provide information about the suitability of water for human consumption (37, 38). On the basis of the calculated values the water quality index (WQI) at different sites was ranging from 24.49 (site I) to 62 (site VI) (Table 4.2.3) and was classified as excellent at site I, III, IV, V, VII and good at site II and VI (Table 4.2.4). High values of WQI at site II and VI were largely because of high value of water quality parameters like pH, conductivity, TDS, alkalinity, hardness, sodium, potassium and chloride thus indicating a decline in water quality. It reveals interference of lithological and anthropogenic factors on the groundwater at these sites. Other sites had low WQI which indicates suitability of water for drinking purposes.

International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.04, March 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

Table 4.1.1. Mean value of various physico – chemical parameters across study sites

Parameters	Site I	Site II	Site III	Site IV	Site V	Site VI	Site VII
Temperature (°C)	17	15	14	14	15	15	15
pH	7.2	6.8	6.9	6.8	6.9	7	6.8
Conductivity (µScm^{-1}/cm)	306	982	303	399	776	1161	330
T.D.S (mg/l)	205	654	204	270	504	746	217
Alkalinity (mg/l)	25	313	106	143	114	111	54
Chloride (mg/l)	13	47	14	12	107	87	30
Total Hardness (mg/l)	177	400	159	220	227	367	237
Calcium (mg/l)	25	147	39	45	39	108	29
Magnesium (mg/l)	28	26	15	28	33	33	40
Sodium (mg/l)	4	24	8	8	48.2	44	11
Potassium (mg/l)	ND	2.2	ND	ND	1	48	2.2
O-Phosphorus (µg/l)	0.025	0.066	0.028	0.027	0.031	0.078	0.022
T. phosphorus (µg/l)	0.091	0.103	0.117	0.105	0.090	0.104	0.118
Ammonical-nitrogen (µg/l)	ND	0.078	ND	0.021	0.061	ND	0.051
Nitrate-nitrogen (µg/l)	1.053	1.186	1.139	1.18	1.023	1.124	1.239

ND= not detected

International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.04, March 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

Table 4.1.2. Range in values of various physico-chemical parameters and their comparison with WHO and BIS standards

Parameters	Observed range of mean values	BIS :10500 Desirable Limit (2009)	WHO (2011)	Sites exceeding the limit
Temperature (°C)	14 to 17			
pH	6.8 to 7.2	6.5-8.5	6.5-8.5	
Conductivity (μScm^{-1}/cm)	303 to 1161	750μScm^{-1}	1500 μScm^{-1}	
Total Dissolved Solids (mg/l)	204 to 746	500 mg/l	1000mg/l	
Total Alkalinity (mg/l)	54 to 313	200 mg/l	200mg/l	II
Chloride (mg/l)	12 to 107	250 mg/l	250mg/l	
Total Hardness (mg/l)	159 to 400	300 mg/l	500mg/l	
Calcium (mg/l)	25 to 147	75 mg/l	75mg/l	II, VI
Magnesium (mg/l)	15 to 40	30 mg/l	100mg/l	
Sodium (mg/l)	4 to 48.2	200mg/l	250mg/l	
Potassium (mg/l)	1 to 48	200mg/l	12mg/l	VI
Ortho-phosphorus (μg/l)	0.022 to 0.078	NA	NA	
Total phosphorus (μg/l)	0.091 to 0.117	NA	5mg/l	
Ammonical Nitrogen (μg/l)	0.021 to 0.078	0.5 mg/l	1.5mg/l	
Nitrate Nitrogen (μg/l)	1.023 to 1.239	10 mg/l	10mg/l	

Table 4.2.3. Calculated values of water quality index (WQI) of different sites

Sites	WQI
Site I	24.49
Site II	52.24
Site III	26.37
Site IV	30.51
Site V	39.9
Site VI	62
Site VII	28.2

Table 4.2.4. Water Quality Index (WQI) and status of water quality.

Water Quality Index levels	Water Quality Status	Sites
<50	Excellent	I, III, IV, V, VII
50-100	Good water	II, VI
100-200	Poor water	Nil
200-300	Very poor (bad) water	Nil
>300	Unsuitable (unfit) for drinking	Nil

V CONCLUSION

Present study showed that there was high effect of lithology on the groundwater quality at sites II, V and VI whereas at sites V and VI, not only lithology but anthropogenic stress was also responsible for the increase in the concentration of certain physico chemical parameters.

The results were compared with WHO (2011) standards for drinking water and it was concluded that across all the sites (except site II, V and VI) mean values were within the prescribed limits set by WHO (2011) and are thus fit for drinking purposes.

The trend shown by anions across study sites was as follows: HCO_3^- Cl^- and that of cations was as follows: Ca^{2+} Mg^{2+} Na^+ K.

Water Quality Index depicted good quality of water at site II and VI and excellent quality of water at site I, III, IV, V and VII, thereby suggesting that the studied groundwater sources are suitable for drinking purpose.

Thus, from the present study it can be concluded that the groundwater in the study area is fit for consumption and the work can also provide a baseline data for future work regarding consumption and management of groundwater in the area.

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