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Groundwater Quality Assessment for Drinking Purposes in Budgam Tehsil, Jammu and Kashmir, India

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Abstract

This study aims to determine the quality of the Groundwater in Budgam Tehsil by using physicochemical parameters. To achieve this objective, groundwater samples were collected from 15 different locations within the study area using a random sampling method from tube wells. The study area was analyzed for various physicochemical parameters, including temperature, electrical conductivity (EC), pH, turbidity, total dissolved solids (TDS), total alkalinity (TA), total hardness (TH), calcium, magnesium, iron, chloride, nitrate, and fluoride concentration. Groundwater suitability was examined by using WHO, BIS, and ICMR standards, which indicates that the quality of groundwater was suitable for drinking purposes. According to this study, all places are within the admissible limit and acceptable for drinking purposes, except for W1, W3, W4, W7, W11, and W15, which require treatment with an oxidizing filter, green-sand filter, or mechanical filter. The higher concentration of Fe may be the result of water's interaction with the ferromagnesian minerals of the Panjal Trap in the deeper aquifer. Iron can change the taste and color of water, yet in minor amounts, it is not usually damaging to human health. However, high iron levels may encourage the development of particular bacteria in water, which can be detrimental to human health. Based on the findings, the water quality of the analyzed tube wells is fairly good in terms of the monitored elements and physicochemical properties which is safe for drinking purposes and is not expected to pose any substantial health risks to consumers.

Keywords: Budgam, physicochemical, parameters, groundwater, WHO, ICMR, BIS.

1. Introduction

The world's surface has abundant water, which is a naturally circulating resource. Saline water makes up around 97% of the water, and freshwater makes up 3% [1]. Less than 1% of fresh water is stored below in aquifers that receive rainfall-recharged aquifers [2]. Confined aquifers are under pressure because they are sandwiched between impermeable layers of rock or soil. Unconfined aquifers, also known as water table aquifers, are under atmospheric pressure because they are in direct contact with the atmosphere. These unconfined aquifers are impacted by drought conditions more quickly than confined aquifers because they are refilled by water from direct rainfall. Climate change modifies the patterns of rainfall, which speeds up floods even while recent increases in global temperature speed up the hydrological cycle. Historically, groundwater has been regarded as having lower levels of pollution compared to surface waters, primarily because it is less exposed to external environmental factors [3]. Nevertheless, factors such as modern civilization, urbanization, population growth, industrialization, and inadequate

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waste management contribute to the deterioration of groundwater quality [4]. However, water causes 80% of all diseases in humans [5]. The contamination of both groundwater and surface waters can be observed as either a natural alteration in water quality or as a result of numerous human activities, rendering the water unsuitable for industrial, agricultural, food production, or human health purposes [6]. The biggest danger to the safety of water (drinking) is toxic substances in the environment, which have devastating impacts on crops, and human health. Detergents and nutrients may be present in runoff from residential homes, solid waste disposal sites, and commercial buildings. This promotes algae blooms in water bodies, which results in eutrophication. Most surface water bodies in Ghana are now polluted as a result of these phenomena [7][8][9]. The most important natural source of drinking water is groundwater. Although the chemical and biological aspects of groundwater are suitable for the majority of purposes, human activities have altered the quality of groundwater [10][11]. The overall natural quality of groundwater changes as it moves from rivers, springs, and recharge regions. The majority of common dissolved mineral elements, including calcium, magnesium, sodium, potassium, chloride, sulfate, and bicarbonates are present in groundwater [12]. Numerous elements, including the quantities of dissolved minerals and organic compounds in the groundwater, affect the acceptability of groundwater for particular uses. Certain constituents found in groundwater are considered harmless, whereas others can be harmful, and a small number may even exhibit high levels of toxicity [13][14]. Population growth stands out as a prominent driver behind the surge in solid waste generation. Additionally, in regions where intensive agricultural practices are employed, agriculture has a noteworthy influence on groundwater quality [15]. Groundwater quality is significantly impacted by urbanization and industrialization. The quality of the groundwater is affected by atmospheric conditions in various places of the world. If the amount of dissolved minerals exceeds the allowed limit outlined in BIS 10500 [16], then groundwater is not considered desirable for drinking [17][18]. The presence of dissolved minerals in groundwater leads to its salinity. When these minerals are present in high concentrations, they can have toxic effects on animals and plants. High concentration of calcium and magnesium in the groundwater is commonly referred to as hard water. The amount of calcium carbonate in water has been studied and reported by Verma et al. and Majumdar and Gupta, [19][20]. The expansion of population, businesses, and technology in recent years has put further stresses on water resources due to which the groundwater quality has deteriorated. The quality of drinking water in developing countries, particularly India, has deteriorated to the point where it is difficult to find excellent-quality drinking water.

2. Study Area

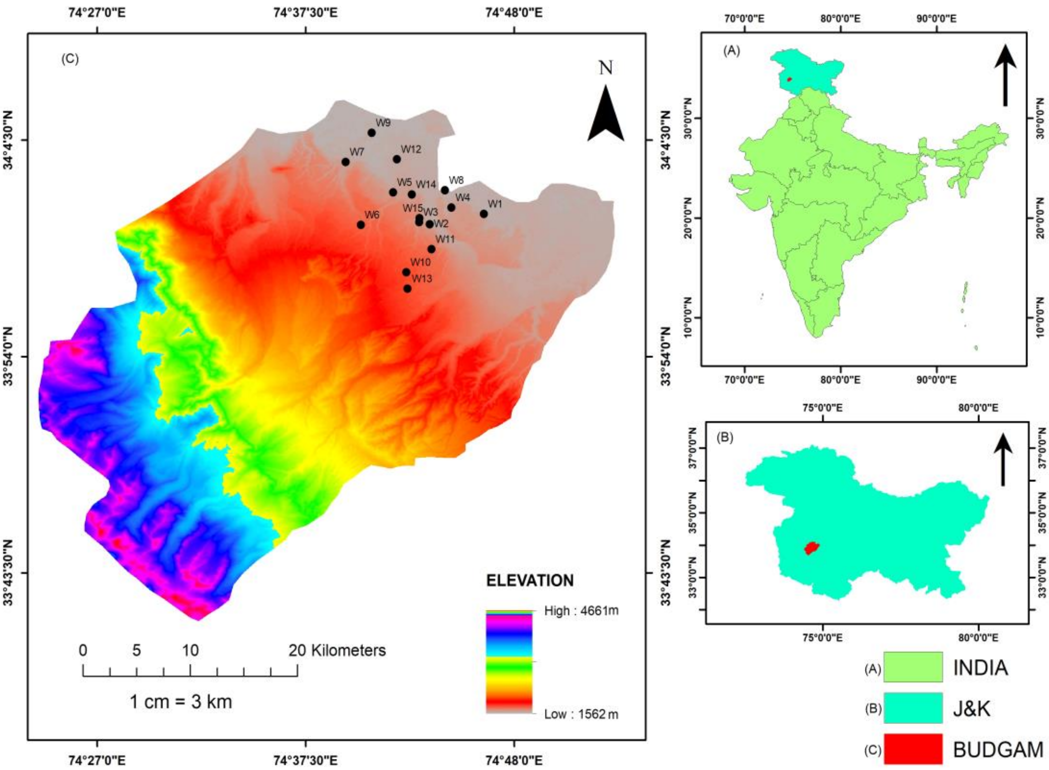

Figure 1: depicts the study area of Budgam**.**

Budgam is one among six districts of Kashmir valley situated between the latitudes of 33° 20' and 34° 54' North and the longitudes of 73° 55' and 75° 35' East at an average elevation of around 1610 meters above mean sea level (Figure1 depicting the study area of Budgam). It is bounded by the districts of Poonch in the west, Srinagar in the north and northeast, Anantnag in the east, Baramulla in the northwest, and Pulwama in the south and southeast. The study area can be geologically classified into three primary groups. The Pre-Karewa compact hard rock, which is exposed on the Pir Panjal hills of the Plio-Pleistocene Karewas formation, is predominantly found in the valley area, and the recent to sub-recent alluvium, which overlays the Karewas [21]. The Karewas Formation, along with the Quaternary and Tertiary alluvium, comprises alternating layers of sand, silt, gravel, and clay, occasionally interspersed with glacial boulder beds at various levels [22]. These formations play a crucial role in the groundwater dynamics of the region and support the local water supply system. The climatic conditions in this region can be described as Temperate-cum-Mediterranean. The average minimum temperature is around -5°C, while the average maximum temperature reaches approximately 33°C, and the annual precipitation in the area is estimated to be around 660 mm.

3. Methodology and analysis

A total of fifteen groundwater samples were taken from fifteen differently-located tube wells in the Budgam district with depths ranging between 10-15 meters. All these samples were collected in the dry season in sterile plastic bottles and then carefully sealed, labeled, and transferred to the laboratory for analysis. All the collected samples underwent analysis for several physicochemical parameters, including temperature, electrical conductivity (EC), pH level, total alkalinity (TA), turbidity, total dissolved solids (TDS), total hardness (TH), calcium, magnesium, chloride, nitrate, fluoride, and iron concentration. The water sample analysis was conducted following standard analytical methods outlined in [23]. This analysis involved the use of high-grade analytical reagents and double-distilled water bottles which were employed for the preparation of solutions.

3.1 Sample Collection

To ensure the integrity of the groundwater samples, clean and sterile plastic bottles were utilized for collection. Before sample collection, all the bore wells were pumped for more than 10 minutes using the existing infrastructure. This procedure was carried out to ensure representative sampling and minimize any potential contamination. The bottles were washed well and then tightly capped and labeled before being transferred to the laboratory for analysis. The temperature of the water samples was recorded instantly after they were collected.

3.2 Chemical Analysis

Standard methods were used in this study to analyze the dissolved chemical components [24]. In situ, measurements of temperature, electrical conductivity (EC), pH, and alkalinity were conducted using a digital water analysis kit. Digital thermometers, standard pH meters, and conductivity meters were used to measure water temperature, pH, and conductivity, respectively. Total dissolved solids (TDS) were determined by calculating the combined concentrations of total cations and total anions in the samples (TZ concentration). Alkalinity was measured using HCl titration. Total hardness was analyzed through titration using standard EDTA (Ethylenediamine tetra acetic acid). Magnesium (Mg^{++}) content was calculated based on the total hardness and calcium (Ca^{++}) levels. Chloride (Cl^-) concentration was determined using standard AgNO3(Silver Nitrate) titration.

4. Results and discussion

Table 1 presents the recorded water quality parameters for the groundwater samples in the study area. The temperature of these tube wells fluctuated between 9.8°C to 21.7°C, with a mean temperature of 14.86°C. To assess their compliance with regulations, these results have been compared against the standard permissible limits established by reputable organizations such as the WHO (World Health Organization), ICMR (Indian Council of Medical Research), and BIS (Bureau of Indian Standards). Below (Table 1) is a detailed summary of the various physio-chemical parameters of the groundwater samples evaluated from this study area:

Table1: Physicochemical parameters of different well sampling sites in Budgam.

Serial No.	Location	Turbidity (NTU)	Electric conductivity (µmhos/cm)	TDS (mg/L)	PH	Temp. (°C)	Total Hardness	Total Alkalinity (mg/L)	Chloride (mg/L)	Ca (mg/L)	Mg (mg/L)	Nitrate (mg/L)	Fluoride (mg/L)	Fe (mg/L)
W1	Humhama	3.79	631	441.7	6.7	15.6	310	113	60	97.6	16.1	10	0.3	2
W2	Horu	2.15	668	467.6	6.7	16.2	350	125	70	180	22.3	15	0.1	0.5
W3	Sholipora	1.9	448	338.4	6.7	14.4	288	110	60	78	15.13	5	0.2	2
W4	DPS Humhama	3.2	528	369.6	6.9	21.7	402	110	50	118	26.35	25	0.3	1
W5	Watermans	3.35	636	445.2	6.6	9.8	500	117	50	170	24.4	15	0.2	0.2
W6	Sholipora	4.98	495	346.5	6.7	10.7	288	108	40	188	18.6	15	0.2	0.5
W7	Whabpora	4.72	855	598.5	6.8	16.2	675	125	50	190	26.15	10	0.2	2
W8	Ompora	2.6	557	389.9	7	14.8	400	145	60	140	17.01	35	0.1	0.1
W9	Wadwan	2.75	478	334.6	6.9	16.1	275	106	100	115	14.75	15	0.1	0.1
W10	Kathwar	1.31	282	197.4	7	15.3	250	127	40	132	19.26	8	0.1	0.1
W11	Choon	2.58	607	424.9	7	10.4	450	120	40	155	21.03	15	0.4	2.5
W12	Warsangam	0.82	139.7	97.89	6.4	17.7	125	101	50	40	7.81	8	0.2	0.5
W13	Parnew	4.13	255	178.5	7.2	16.1	225	114	40	130	15.07	15	0.1	0.1
W14	Palar	2.15	690	483	6.9	13.2	475	130	40	162	22.1	8	0.2	0.1
W15	Haknipora Budgam	2.96	696	487.2	6.6	14.7	342	130	80	118	26.35	18	0.2	1.2

4.1 pH

In many practical applications, the pH of a solution is the quantitative measure of its acidity or basicity, with a value ranging from 0 to 14. It is defined as the negative logarithm of the concentration of hydrogen ions in the solution. The pH scale ranges from 7 to 14, with 7 being alkaline, 0 being acidic, and 7 being neutral. Drinking water generally exhibits a pH level ranging from 6.5 to 8.5 as it measures its acidity or alkalinity. The pH of the water system has a direct impact on all chemical and biological interactions [25]. The pH of water is a critical factor in geochemical equilibrium and solubility calculations, as it provides information on the concentration of hydrogen ions in the water. The pH values of the groundwater samples in this study ranged from 6.4 to 7.2, which is considered to be the neutral range [26]. Among the sampled wells, the highest pH value was recorded at W13 (Parnew), while the lowest pH value was observed at W12 (Warasangam). Importantly, both values fell within the permissible limits recommended by WHO, ICMR, and BIS. In this study area, the variation of pH across the groundwater samples is visually represented in Figure 2, demonstrating that the majority of the samples exhibit a slightly acidic nature close to neutral.

4.2 Electrical Conductivity

Broadly speaking, electrical conductivity is a measure of a liquid's ability to conduct electricity. This property varies based on the quantity and type of ions present in the solution. The electrical conductivity is influenced by several factors, including the presence of ions, their overall concentration, relative concentration, valence, mobility, and the temperature of the liquid. Distilled water, on the other hand, has a conductivity of less than 1 umhos/cm. Water quality is graded as low, medium, or good based on electrical conductivity measurements [27]. In this study, the maximum conductivity recorded is 855 µmhos/cm W7 (Wahabpora), and the minimum electrical conductivity of 139.7 µmhos/cm at W12 (Warasangam). The electrical conductivity (EC) of drinking water is limited to 1400 micromhos per centimeter (µmhos/cm) by the World Health Organization [28]. As shown in Figure 3, the EC values of the samples in this study are within this permissible limit.

4.3 Total Alkalinity

Alkalinity is the combined presence of certain components in water that tends to raise the pH towards the alkaline end of the scale. It is determined through titration, using calibrated acid until a pH of 4.5 is reached. Alkalinity values are typically expressed in milligrams per liter (mg/L) as CaCO3 (calcium carbonate). Common elements that contribute to alkalinity in water include carbonates, hydroxides, and phosphates. Carbonate buffering is found in limestone bedrock and heavy deposits of glacial till. The total alkalinity of the groundwater samples in our study ranged from 130 mg/l to 103 mg/l. The highest values were observed at W14 (Palar) and W15 (Main Budgam), while the lowest value was recorded at W12 (Warasangam). Figure 4 displays the variation in total alkalinity across the groundwater samples, clearly demonstrating that these values fall within the permissible limits established by WHO, BIS, and ICMR.

4.4Total Hardness

Water hardness is a parameter used to gauge the water's capacity to react with soap, with hard water requiring a greater amount of soap to generate lather. The dominance of calcium (Ca2+) and magnesium (Mg2+), ions in sedimentary rocks and soils contributes to the hardness of groundwater that passes through them. As asserted by Singh et al. [29], the hardness of water is determined by the concentration of calcium or magnesium salts or a combination of both. Total hardness is the crucial factor in assessing the suitability of water for various drinking, domestic, and industrial applications, as highlighted by Mitharwal et al. [26]. Excessively hard water is unsuitable for agricultural and drinking purposes. In our study, the total hardness of the groundwater samples ranged from 125 mg/L to 675 mg/L. Notably, the hardness values obtained in our findings fall within the permissible limits prescribed by WHO, ICMR, and BIS. The minimum hardness value was observed at W12 (Warasangam), while the maximum value was observed at W7 (Wahabpora).

4.4.1 Calcium

In this study, Calcium ranges from 40 -190mg/L. The maximum value was recorded at W7 (Wahabpora) and the minimum value at W12 (Warasangam). It is relatively common to find concentrations of up to 100 mg of calcium per liter in natural water sources. However, sources with calcium concentrations exceeding 200 mg per liter are considered rare occurrences. Variation in calcium hardness is depicted in Figure 5.

4.4.2 Magnesium

This study reveals that the Magnesium of groundwater is ranging from 7.81 - 26.35 mg/L. The maximum value was recorded at W4 (DPS Humhama), W15 (Main Budgam), and the minimum value was recorded at W12 (Warasangam). Variation in magnesium hardness is depicted in Figure 6

4.5 Chloride

Evaporation and precipitation have a considerable influence on the chloride concentration of water. Rao [25] states that chloride ions are typically more detrimental to most plants compared to sulfate ions and serve as the primary indicator of pollution. The assessment of chloride concentration in water samples provides information regarding the contamination of water samples by wastewater, soluble chloride salts, and other contaminants. In this study, chloride ranges from 40 - 100 mg/L. The highest value was recorded at W9 (Wadwan) and the lowest value at various locations like W6 (Sholipora), W10 (Kathwar), W11 (Choon), W13 (Parnew), W14 (Palar). The WHO, ICMR, and BIS have established the acceptable limit for chloride in water as 250 mg/L. Chloride salts can make water taste salty, and if they're combined with calcium and magnesium, they can make water more corrosive which is especially true when chloride levels are 100 mg/L or higher [30]. This study found that the chloride levels in the water are safe for drinking and will not pose any health risks.

4.6 Nitrate

Nitrate is a common component found in raw water and predominantly exists in the form of the N2 molecule, representing its oxidized state. Sources of nitrate include chemical and fertilizer factories, animal waste, decaying vegetation, as well as domestic and industrial waste. The UV spectrophotometer is a commonly employed instrument for quantifying the concentration of nitrate in water samples. Drinking water is harmful in the presence of excess nitrate concentrations [31]. Infants younger than six months old suffer from methemoglobinemia, often known as blue baby disease, as a result of increased concentrations of nitrate in water. In our study, the nitrate content in the groundwater samples varied between 5 mg/L and 35 mg/L. The lowest value was found at W3 (Wahadatpora), while the highest value was recorded at W8 (Ompora). Notably, these nitrate concentrations comply with the permissible limits established by WHO, ICMR, and BIS.

4.7 Fluoride

Fluoride is a naturally occurring mineral that can be found in diverse forms like fluorite (fluorspar), triphite, rock phosphate, and phosphorite crystals. The amount of fluoride in groundwater depends on two things: the local climate and the rocks that the water flows through. Notably, these factors influence the observed fluoride concentration levels in groundwater

samples. Fluoride must be added to human nutrition to ensure proper bone development with a concentration typically between 1.0 and 1.5 mg/L.
An elevation in fluoride or accumulation in groundwater can lead to fluorosis, impacting the skeleton, teeth, and other body parts [32]. The concentration of fluoride in the groundwater samples ranged from 0.1 mg/L to 0.4 mg/L. The minimum values were recorded at W2, W8, W9, W10, and W13, while the maximum value was observed at W11 (Choon). Importantly, all the samples had fluoride concentrations within the permissible limit as recommended by relevant standards.

4.8 Total Dissolved Solids

The most crucial factor or parameter in determining the potability of water is total dissolved solids, which, when present more than the recommended level, give water a peculiar taste [26]. The majority of the total dissolved solids comprise calcium, magnesium, potassium, sodium, phosphates, chlorides, nitrates, and manganese, along with salts, organic matter, and other particles [33]. Hard water can cause scale buildup on utensils and in hot water systems, such as boilers and geysers. This is because hard water contains dissolved calcium and magnesium ions, which can precipitate out of the solution and form scale. The primary sources of these ions are soil and aquifer minerals that contain limestone or dolomite. In this study, the total dissolved solids (TDS) values ranged from 97.89 mg/L to 598.5 mg/L. The highest TDS value was recorded at W7 (Wahabpora), while the lowest TDS value was observed at W1 (Warasangam). The Variation in total dissolved solids is depicted in Figure 7.

4.9 Turbidity

Turbidity is the term for the suspension of particles in water that prevents light from passing through. Various suspended particles are the main source of turbidity. Turbidity can be evaluated using either nephelometry, which measures how it affects light scattering, or turbidimetry, which measures how it affects light transmission. The acceptable and allowed limits, according to IS:10500 ranges from 1 to 5 NTU, respectively [34]. In this study Turbidity ranges from 1.31 to 4.72, the minimum turbidity was recorded at W10 (Kathwar) and the maximum at W7 (Wahabpora). Variation in total hardness is depicted in Figure 8.

4.10 Iron

Iron bacteria, brown-green stains, bitter or metallic taste, brackish color, rusty sediment, and stained beverages are all signs of iron presence. According to the BIS [16], there is no relaxation in the permissible limit, which is 0.3mg/l. The iron levels in groundwater in the study area ranged from 0.1 to 2.5 milligrams per liter (mg/L), with the highest level recorded at W11 (Choon). This study reveals that all locations except W1, W3, W4, W7, W11, and W15 need some treatment like Oxidizing Filter, Green-sand, or Mechanical Filter. However, even though these locations require treatment, the water quality of the study area remains within the permissible limits and is considered safe for drinking purposes. It is worth noting that shallow groundwater is more susceptible to contamination. The increased concentration of iron (Fe) in the deeper aquifer may be attributed to the interaction of water with ferro-magnesium minerals present in the Panjal Trap formation. The taste and color of the water can be affected by excessive iron levels, yet at low quantities, iron is not always harmful to human health. High iron levels, however, might favor the growth of specific bacteria in water, which can be harmful to human health. Variation in Iron content is depicted in Figure 9

5. Statistical Analysis

Excel was used to calculate the minimum, maximum, average, standard deviation, coefficient of variation, and correlation coefficient (r) for each pair of water quality parameters. The statistical analysis of the water quality parameters estimated experimentally on water samples revealed the range of variation, mean, standard deviation, and coefficient of variation. This information can be used to assess the overall water quality, identify any potential problems and also identify any correlations between the different parameters. The water quality parameters at fifteen different locations were compared. Table 2 shows the minimum, maximum, mean, and standard deviation, coefficient of variation of different parameters, like temperature, pH, TDS, TH, EC, turbidity, alkalinity, chloride, nitrate, calcium, magnesium, fluoride, and iron. Correlation is a statistical measure of the strength and direction of the linear relationship between two variables. When there is a direct correlation, it implies that an increase or decrease in one parameter corresponds to a corresponding increase or decrease in the other parameter. In other words, the variables tend to move together predictably. Water quality parameters exhibit a positive correlation when an increase in one parameter is accompanied by an increase in the other, and a negative correlation when an increase in one parameter leads to a decrease in the other. The correlation coefficient (r) is a numerical measure that falls within the range of +1 to -1. A value of +1 signifies a perfect positive correlation, -1 represents a perfect negative correlation, and 0 indicates no correlation between the variables. The strength of the correlation can be categorized as follows: A strong correlation is evident when the coefficient falls between 0.8 and 1.0, or between -0.8 and -1.0., a moderate correlation is when the coefficient ranges between +0.5 to +0.8 or between -0.5 to -0.8, and weak correlation when the coefficient remains below +0.5 or above -0.5. The computed correlation coefficients (r) for different water quality parameters are provided in Table 3. In this study, strong positive correlations were assessed between TDS and electrical conductivity (0.9988), total hardness and electrical conductivity (0.8532), as well as total hardness and TDS (0.8503). Moderate correlations were found between calcium and turbidity (0.5474), magnesium and electrical conductivity (0.7626), magnesium and TDS (0.7552), magnesium and calcium (0.6611), iron and fluoride (0.7451), magnesium and total hardness (0.76293), and calcium and electrical conductivity (0.6260). On the other hand, alkalinity, pH, chloride, temperature, nitrate, and fluoride displayed weak correlations with the other parameters.

Table 2: Coefficient of variation for water quality parameters.

Parameters	Minimum	Maximum	BIS (2009)	ICMR	WHO (2011)	Mean	Standard Deviation	Coefficient of variation
Turbidity	0.82	4.98	5	5	5	2.8926	1.1781	40.728
Electric conductivity	139.7	855	400	300	400	517.609	191.1463	36.928
TDS	97.89	598.5	500	500	600	368.513	136.039	36.915
PH	6.4	7.2	6.5-8.5	6.5-8.5	6.5-8.5	6.806	0.205	3.012
TEMP.	9.8	21.7	12.0-25.0	12.0-25.0	12.0-25.0	14.193	3.428	24.152
Total Hardness	125	675	300	300	300	357	133.482	37.389
Total Alkalinity	101	145	200	120	300	118.733	11.634	9.798
Chloride	40	100	250	250	200	55.333	17.265	31.201
Ca	40	190	75	75	100	134.24	42.185	31.42
Mg	7.81	26.35	30	30	30	19.494	5.315	27.26
Nitrate	5	35	50	45	50	14.466	7.567	52.308
Fluoride	0.1	0.4	1	1	1.5	0.193	0.088	5.595
Fe	0.1	2.5	0.3	0.3	0.3	0.86	0.863	99.393

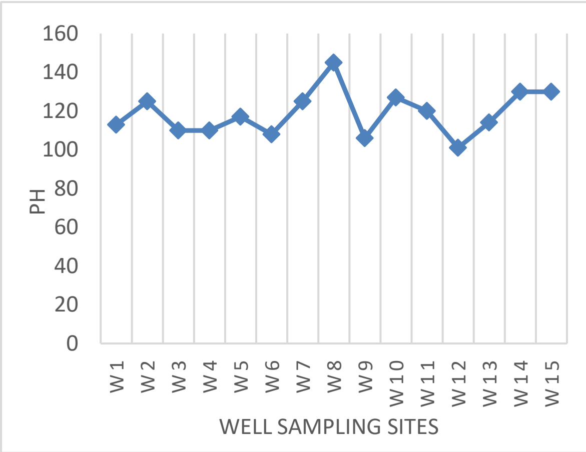

Figure 2: Fluctuation in pH across different sampling sites.

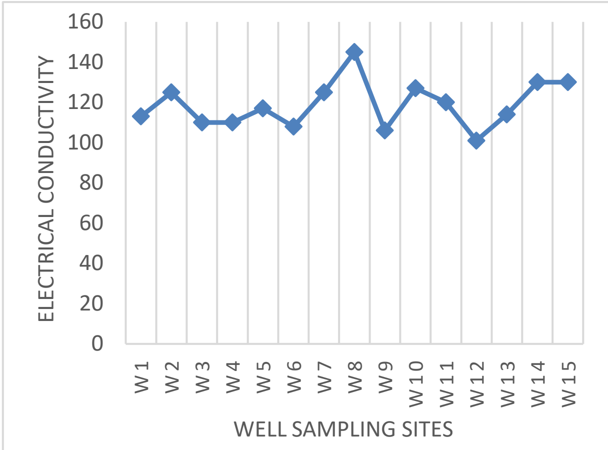

Figure 3 : Fluctuation in Electrical Conductivity across different sampling sites.

Table 3. Correlation coefficients (r) of the water quality parameters.

Parameters	Turbidity	EC	TDS	PH	Temp.	TH	TA	Chloride	Ca	Mg	Nitrate	Fluoride	Fe
Turbidity	1												
Electric conductivity	0.435	1											
TDS	0.426	0.998	1										
PH	0.176	-0.07	-0.07	1									
Temp.	0.208	0.217	0.218	0.462	1								
Total Hardness	0.416	0.853	0.85	0.123	0.159	1							
Total Alkalinity	-0.06	0.47	0.462	0.338	0.163	0.47	1						
Chloride	-0.107	0.189	0.194	-0.23	0.272	-0.13	-0.03	1					
Ca	0.547	0.626	0.611	0.293	0.062	0.68	0.446	-0.231	1				
Mg	0.369	0.762	0.755	0.089	0.384	0.762	0.448	-0.049	0.661	1			
Nitrate	0.196	0.152	0.136	0.306	0.314	0.151	0.441	0.176	0.19	0.23	1		
Fluoride	0.144	0.282	0.284	-0.15	-0.146	0.283	-0.24	-0.302	-0.07	0.24	-0.091	1	
Fe	0.185	0.392	0.412	-0.14	0.035	0.323	-0.12	-0.046	-0.09	0.18	-0.245	0.745	1

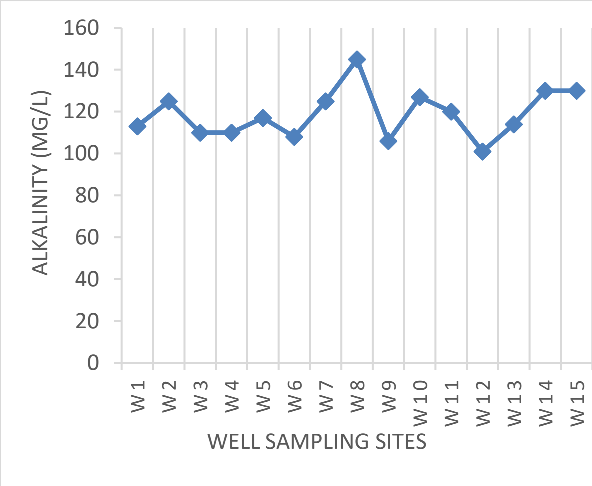

Figure 4: Fluctuation in Alkalinity across different sampling sites**.**

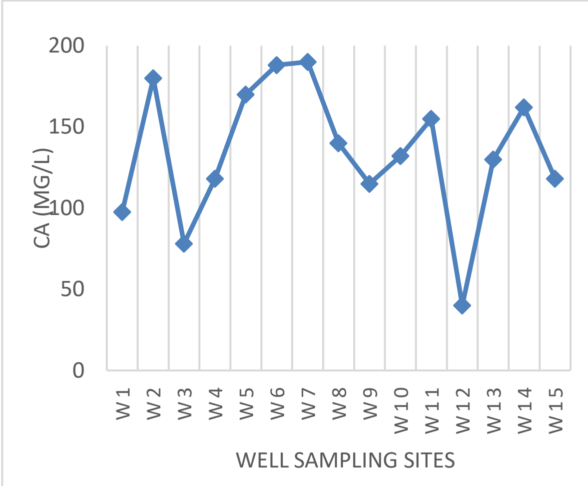

Figure 5 : Fluctuation in CA Hardness (mg/l) across different sampling sites.

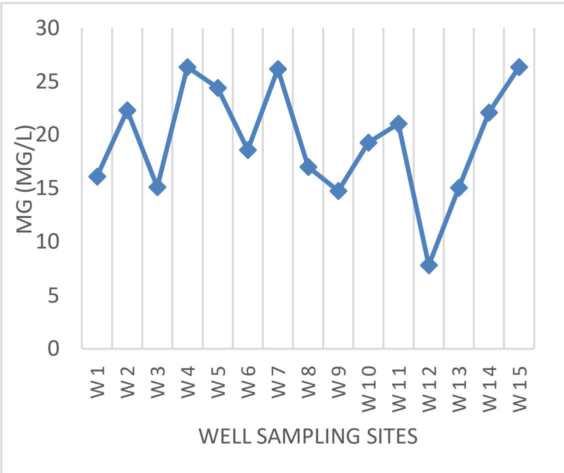

Figure 6: Fluctuation in Mg Hardness (mg/l) across different sampling sites.

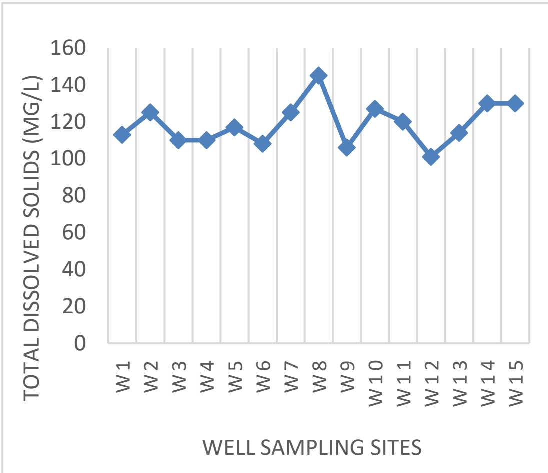

Figure 7: Fluctuation in Total Dissolved Solids across different sampling sites.

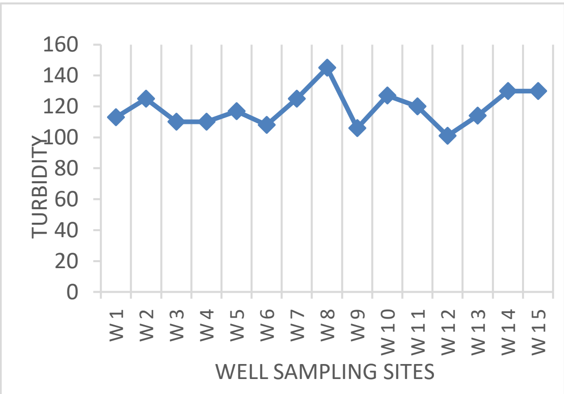

Figure 8: Fluctuation in Turbidity across different sampling sites.

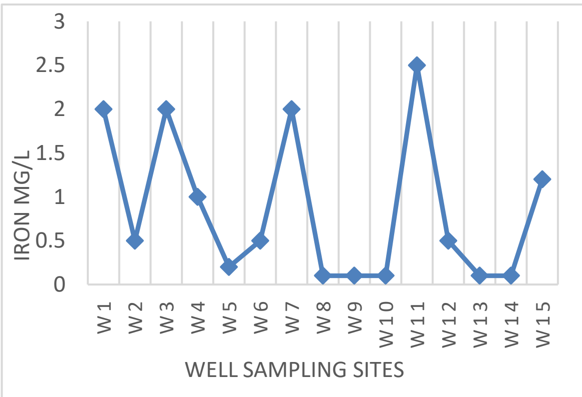

Figure 9: Fluctuation in Iron content across different sampling site

6. Conclusions

The primary objective of this study is to examine the physicochemical properties and overall quality of groundwater samples obtained from Budgam Tehsil and its surrounding areas. All locations except W1 (Humhama), W3 (Wahadatpora), W4 (DPS Humhama), W7 (Wahabpora), W11 (Choon), and W15 (Haknipora Budgam) are permissible for drinking purposes. However, the aforementioned locations show only higher levels of iron, indicating the need for treatment options such as oxidizing filters, green-sand filters, or mechanical filters to address iron contamination. The presence of iron in the region is attributed to iron-bearing minerals like hematite, magnetite, and other oxides, which can lead to the formation of iron bacteria under anoxic conditions. Excessive iron levels in water can give rise to various health-related problems, including cirrhosis, liver cancer, diabetes, cardiovascular, neurological disorders, and infertility. Additionally, high concentrations of iron may lead to undesirable alterations in the color, smell, and taste of water, as well as stain clothes and utensils. It's important to note that while low concentrations of iron are generally not harmful to human health, high levels can foster the growth of certain bacteria in water, posing a potential health risk. In this study, strong positive correlations were assessed between TDS and electrical conductivity total hardness and electrical conductivity, as well as total hardness and TDS. Overall, the water quality of the fifteen wells studied is considered good, based on the monitored elements and physicochemical characteristics. There is no evidence of water pollution affecting the groundwater samples in the Budgam and its surrounding areas. Therefore, the water from these wells can be safely utilized for drinking purposes, with minimal health risks to consumers.

References

[1] Shiklomanov, I. A. (1998). World water resources at the beginning of the twenty-first century. State of the World, 102-115.

[2] Kandasamy, Karthik & Mayildurai, R. & Mahalakshmi, R. & Karthikeyan, S. (2019). Physicochemical analysis of groundwater quality of Velliangadu area in Coimbatore district, Tamilnadu, India. Rasayan Journal of Chemistry. 12. 409-414.

[3] Iqbal MA, Gupta SG (2009). Studies on heavy metal ion pollution of groundwater sources as an effect of municipal solid waste dumping. African J. Basic and Appl. Sci. 1:117-122.

[4] Agrawal R (2009). Study of physicochemical parameters of groundwater quality of Dudu town in Rajasthan. RASAYAN J. Chem. 2:969-971.

[5] Al-Hadithi M (2012). Application of water quality index to assess the suitability of groundwater quality for drinking purposes in Ratmao–Pathri Rao watershed, Haridwar District, India. American J. Sci. Ind. Res. 3:395-402.

[6] Dix, H.M. (1981). Environmental pollution, John Wiley and sons. Toronto, Pp.54-56.

[7] Anim, F. Nyame, F.K. & Armah T. K. (2010). Coliform status of water bodies from two districts in Ghana, West Africa: implications for rural water resources management. Water Policy Uncorrected Proof, pp. 1–12.

[8] Osei F. B. & Duker A. A. (2008) Spatial and demographic patterns of Cholera in Ashanti region – Ghana. International Journal of Health Geographics, 7:44

[9] Asante, K. A. Quarcoopome T. & Amevenku F. Y. K. (2008). Water Quality of the Weija Reservoir after 28 Years of Impoundment. West African Journal of Applied Ecology 13, 1–7.

[10] Gajendran C and Thamarai P, Study on the statistical relationship between groundwater quality parameters in Nambiyar River basin, Tamil Nadu, India, International J. on pollution research, 27(4), 679 – 683, 2008.

[11] Horton, J. H., & Hawkins, R. H. (1965). The flow path of rain from the soil surface to the water table. Soil Science, 100(6), 377-383.

[12] Ryznar, John W, (1986). An Index for determining the amount of Calcium Carbonates Scale formed by a water, Nalco Chemical Company, One Nalco Centre, Naperville, Illinois, USA.

[13] Indian standard specification for drinking water. IS:10500, Ind. Standard Institute, India, ISI, (1983).

[14] Parihar S S, Kumar A, Kumar A, Gupta R N, Pathak M, Shrivastav A, and Pandey A C (2012). Physicochemical and Microbiological Analysis of Underground Water in and Around Gwalior City, MP, India. Research J. of Recent Sciences. 1(6), 62-65.
[15] Backman B, Bodis D, Lahermo P, Rapant S, and Tarvainen T, (1998). Application of a groundwater contamination index in Finland and Slovakia, Environ. Geology, 36(1–2), 55–64.
[16] Indian standards for drinking water Speciation. Bureau of Ind. Standard, New Delhi BIS 10500, (2012).
[17] Jain, C. K., Bandyopadhyay, A., & Bhadra, A. (2010). Assessment of groundwater quality for drinking purposes, District Nainital, Uttarakhand, India. Environmental monitoring and assessment, 166, 663-676.
[18] Suma Latha S, Ambika S R A and Prasad S J, (1999). Fluoride concentration status of groundwater in Karnataka, India. Current Sci. 76, 730–734.
[19] Verma S, Mukherjee A, Choudhury R and Mahanta C, Brahmaputra River (2015) Basin Groundwater: Solute Distribution, Chemical Evolution and Arsenic Occurrences in Different Geomorphic Settings. J. of Hydrology, Regional Studies, 4, 131-153,
[20] Majumdar D and Gupta N, (2000). Nitrate pollution of groundwater and associated human health disorders. Ind. J. of Environ. Health 42, 28–39.
[21] Raazia, S., & Dar, A. Q. (2021). Insights into the hydrogeological framework of the NW Himalayan Karewas (India). Environmental Challenges, 4, 100086.
[22] Raza M, Ahmad A and Mohammad A 1978 The Valley of Kashmir: A Geographical Interpretation (New Delhi: Vikas Publishing House, Pvt. Ltd).
[23] APHA (2005). Standard Methods for the Examination of Water and Waste Water (21st ed.). Washington DC: American Public Health Association.
[24] APHA, AWWA, WEF (2001). Standard methods for the examination of water and wastewater (APHA-AWWA-WEF Washington).
[25] Rao, N. S. 2006. Seasonal variation of groundwater quality in a part of Guntur District, Andhra Pradesh, India. Environmental Geology. 49, 413-429.
[26] Mitharwal S., Yadav R.D., and Angasaria R.C. 2009. Water Quality Analysis in Pilani of Jhunjhunu District (Rajasthan)- The place of Birla's Origin. Rasayan Journal of Chemistry. 2(4):920-923.
[27] Gulta D. P., Sunita & Saharan J. P. 2009. Physicochemical analysis of groundwater of selected area of Kaithal city (Haryana) India. Researcher, 1(2): 1-5.
[28] WHO (2011) Guidelines for Drinking Water Quality. 4th Edition World Health Organization, Geneva, Switzerland.
[29] Singh M.K., Jha D., and Jadoun J. (2012). Assessment of Physicochemical Status of Groundwater Samples of Dholpur District, Rajasthan, India. International Journal of Chemistry. 4(4): 96-104.
[30] Tatawat R.K., and Singh Chandel C.P. (2007). Quality of Groundwater of Jaipur City, Rajasthan (India) and its Suitability for Domestic and Irrigation Purposes. Applied Ecology and Environmental Research. 6(2): 79-88.
[31] Umavathi, Longakumar and Subhashini. (2007). Studies on the nutrient content of Sulur pond in Coimbatore, Tamil Nadu. Journal of ecology and environmental conservation, 13(5): 501-504.
[32] Saxena, U., and Saxena, S. (2013). Statistical Assessment of Groundwater Quality using Physicochemical Parameters in Bassi Tehsil of Jaipur District, Rajasthan, India. Global Journal of Science Frontier Research. 13(3):23-31
[33] Siebert S. et al. (2010). Groundwater use for irrigation global inventory. Hydrology and Earth System Sciences, 14, 1863-1880.
[34] Devendra Dohare, et al., (2014) Analysis of Ground Water Quality Parameters: A Review, Research Journal of Engineering Sciences, 3(5), 26-31, ISSN: 2278-9472.