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Ground Water Quality Profile of Jammu District and Impact on Human Health

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ABSTRACT

Ground water is the lifeline of the people in India. Major part of population is dependent on groundwater for their drinking requirements. This article delineates on the chemical quality of groundwater present in Jammu District of Union Territory of Jammu & Kashmir. Perusal of this article will help us understand the various chemical changes occurred in the ground water of the district. Chemical quality analysis has been carried out and results have been discussed for physio-chemical changes occurred in the ground water in district in the recent 5 years. Ground water samples from 69 different locations in Jammu District are selected to study the changes occurred in ground water quality from 2015-2020. This analyzed hydro-chemical data lead us to identify chemical changes occurring in the groundwater of study area. The water type in the study area is of Ca-Mg-HCO_3 and Na-K-HCO_3 type. The hydro-geochemistry of the district can be known and this can help us in consumptive use of water resources and thus planning and management of groundwater resources in the study area.

Keywords: Ground water, Jammu, Cation, Anion, Water Quality, Variation

INTRODUCTION

Water is the essential part of the life. Without water, life cannot exist. 71 percent of the Earth's surface is water-covered. The Oceans hold about 96.5 percent of all Earth's water. Water also exists in the air in the form of water vapor, in rivers, lakes, springs, glaciers , in the ground as soil moisture and in aquifers.(1). As reported 96.5 percent of earth's water is found in ocean, this water is very much saline and its composition contains lot of chemical compounds which are not suitable for human use. (2) Thus, the common source for the water usage in human life is groundwater. The water present in aquifers below the surface is known as groundwater. Groundwater is considered to be the largest fresh water resource and considered to be the safe for drinking purposes among all water resources. The primary use of water in everyday's life is drinking water which should be of good quality and free from any harmful substances. Groundwater is vital element to sustain life as from a numerous years it has been used for domestic purposes such as drinking, irrigation and other uses.

But with years passing by and rapid growth in population, urbanization and agricultural activities has lead to deterioration in quality and depletion of groundwater (3, 4). The Central Ground Water Board has classified the country in three zones of overexploited, critical and semi critical with respect to ground water exploitation (5). Jammu and Kashmir is considered as the safe zone for ground water development.

Due to geo-genic and anthropogenic activities many contaminants got mix with the groundwater and thus make it unsuitable for drinking. Thus, the chemical quality studies of groundwater are inevitable. Numerous studies with different chemicals such as arsenic, nitrate, fluoride and other inorganic chemicals in ground water (6-10) have been carried out in different parts of the country to assess the threat posed to chemical quality of ground water. The safe drinking water guidelines have been issued by Bureau of Indian Standards (11). If any chemical constituents in water exceed its limit it may lead to harmful effects in the life of human. There are numerous water borne diseases and thus checking the chemical quality of water becomes fundamental (12-15).

This article will provide the depth knowledge of chemical quality of groundwater in Jammu District. Major anions, cations and also trace ions were analyzed to have the overview of the groundwater quality. A comparison has been drawn to better understand the changes taken place in the groundwater quality of the district.

STUDY LOCATION

The Jammu district derives its name from Raja Jambolochan which is known as the founder of Jammu city. Jammu city is also referred as the "City of Temples". This city is also the winter capital of Union Territory of Jammu & Kashmir. The district lies between 32°33'07" & 33° 07'30" and 74°27'00" & 77°21'00" East. The district has it's headquarter at Jammu itself. The Jammu city is 600km away from the national capital Delhi and is well connected by Air, Rail and road network.

Jammu is situated on a hillock namely Shivalik ranges, on the bank of river The district is bounded by Udhampur districts in the north and northeast , Samba & Kathua district in the east and southeast and Rajouri district in the west. It has International Border with Pakistan in the West and southwest.

The climate of the district can be classified as sub-humid to sub-tropical type. The summer season starts from April and lasts till June is followed by southwest Monsoon. The sub humid to sub-tropical district receives normal annual rainfall of 1246 mm. The temperature varies from cold in winter with minimum temperature touching 4 ºC to heat wave in summers when the temperature shoots up to 46 ºC degree centigrade. January is the coldest month and temperature comes as low as 4.0ºC. Most of the rainfall is received through the southwest monsoon starting last week of June to end of September (16-17).

Jammu city is the main economic centre of the administrative division of Jammu. The city has a number of small industries. Jammu has a number of wood grain mill. The famous local Basmati Rice is produced in RS Pura area near Jammu and processed in rice mills in Jammu. The local population is dependent on the groundwater to meet their daily requirements such as drinking, irrigation etc.

Fig. 1- Administrative Map of Jammu District of Jammu & Kashmir

Geological Aspect of the District:

Jammu district falls in sub-mountainous region at the foothills of the Himalayas. Jammu district can be divided in two major units' viz. Siwalik ranges (Hilly area) and outer plains. Siwalik range rises gradually in the north part of the district and outer plains merges with the Indo-Gangetic plains in the south. Outer Plains can be divided into Kandi and Sirowal belts.

Groundwater in this district mainly occurs in the Kandi & Sirowal sediments and to some extent in Siwalik rocks. In hard rocks, it occurs as small isolated bodies in the weathered portions and cracks, joints etc. and manifests in the form of springs. Groundwater occurs in the outer plains in the saturated parts of alluvium sediments in the pore spaces. It occurs both under water table and confined conditions in the Sirowal and under unconfined conditions in Kandi belt. The flow direction of groundwater is broadly form north to south and corresponds roughly with the topographic slope (17).

METHODOLOGY

For comparing the ground water quality the of the Jammu district, 69 samples of groundwater are selected from different National Hydrograph Stations installed by Central Ground Water Board in the district. These groundwater sampling locations are selected in such a way that it gives a purview of the whole Jammu District. The samples were collected and stored as per the procedures laid down in the American Public Health association (18). The samples were analysed for major cations and anions through conventional methods like volumetric titrations and modern sophisticated instruments such as UV-Vis Spectrophotomer, Flame Photometer etc. All the results are reported in Parts per Million (ppm) or mg/L.

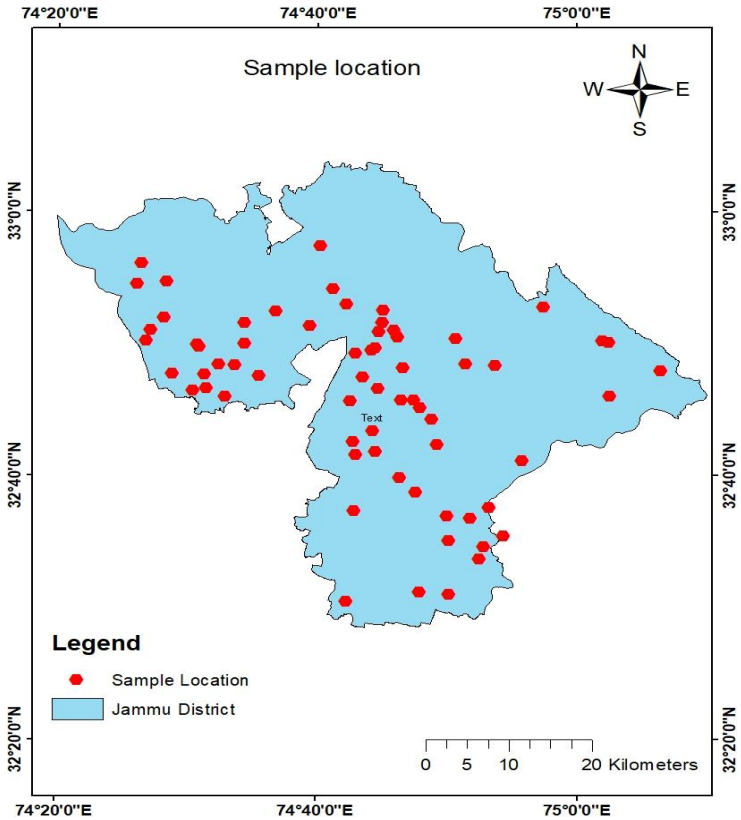


Fig. 2 Groundwater Sampling Locations in Jammu District

RESULTS AND DISCUSSION

The quality of ground water as determined by its chemical constituents present and is of great importance to acknowledge the suitability of groundwater for particular usage.69 representative locations are selected to attribute the groundwater quality data of the district for the last 5 years. These samples are collected every year in month of May-June from the National Hydrograph Stations and analysed for major cations and anions etc. This article compares the

chemical data for the year 2015, 2017 and 2020. The major chemical constituents analysed are pH, Electrical Conductivity (µs/cm) at 25 ºC, Carbonates (CO_3), Bicarbonates (HCO_3), Chloride (Cl), Sulphate (SO_4), Nitrate(NO_3), Fluoride (F), Calcium (Ca), Magnesium (Mg), Sodium (Na),Potassium (K) and Total Hardness. These physico-chemical characters of ground water play a significant role in assessing water quality. The comparative study of physico-Chemical parameters of ground water samples are given below

Table 1 Comparative Chemical data of Jammu District

Parameters	2015			2017			2020		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
pH	8.7	7.5	8.2	8.7	7.4	8.2	8.9	7.5	8.2
EC (µs/cm) at 25^0 C	2300.0	210.0	608.0	2300.0	200.0	573.2	1680.0	230.0	533.2
CO_3 (mg/l)	120.0	0.0	9.0	48.0	0.0	12.0	78.1	0.0	9.2
HCO_3 (mg/l)	902.8	42.7	250.7	732.0	67.1	221.9	688.5	119.0	262.6
Total Alkalinity	740.0	45.0	217.9	600.0	70.0	201.0	694.6	119.4	230.8
Cl (mg/l)	142.0	3.6	32.8	213.0	3.6	35.4	197.4	6.8	33.3
SO_4 mg/l	458.1	0.0	63.6	644.3	0.0	86.1	290.0	0.0	42.9
NO_3 (mg/l)	81.0	0.0	15.9	191.0	0.2	28.2	267.0	0.4	31.3
F (mg/l)	1.2	0.0	0.3	1.2	0.0	0.2	1.5	0.0	0.5
Ca (mg/l)	140.3	12.0	38.9	172.3	4.0	43.3	66.7	8.7	27.0
Mg (mg/l)	75.4	5.0	29.6	133.8	0.0	36.1	102.9	13.2	44.8
Na (mg/l)	240.0	2.9	43.3	176.0	2.6	32.5	190.0	2.3	31.9
K (mg/l)	475.0	0.4	31.2	413.0	0.2	29.6	350.0	1.6	25.7
Total Hardness as CaCO3 (mg/l)	640.0	95.0	219.1	800.0	95.0	255.1	499.0	141.0	251.1

The above mentioned chemical data represents the periodical variation that has occurred in the ground water of the Jammu District. In terms of ph value, which represents the alkaline and acidic nature of groundwater, the nature of water is neutral to alkaline in nature. Most of the samples collected from shallow ground water of Jammu district are alkaline in nature. There is scarcely variation in the alkaline nature of the water. Electrical Conductivity of ground water is generally low and the values are showing a decreasing trend**.** It may be assumed that the recharged factors are involved to improve the subsurface water quality of the study areas.

Anionic Geochemistry of Groundwater:

The Carbonates and bicarbonates concentration represents the alkanity of the ground water. The carbonates values are low as they are present in water whose pH is more than 8.3 and the average value of ph in the region is 8.2, thus suggesting the reason for low values of carbonates. However, perusal of the above data suggests that bicarbonates values are higher but within the permissible limit prescribed by BIS and there are little fluctuations in the values within the time frame of 2015 to 2020. This interprets that the groundwater in Jammu is alkaline in nature with bicarbonates dominance.

Chloride is one of the most common constituent in groundwater and very stable as compared to other ions like SO_4, HCO_3, NO_3 etc. The presence of chlorides in groundwater may be attributed to the presence of chlorides from rocks, evaporates, seawater intrusion etc. The average values of the chloride ion are low and well within the limits and there is no drastic change in the chloride concentration during the study period.

Nitrate is one of the important parameter related to pollution in the groundwater. Nitrate is the end product of the aerobic oxidation of nitrogen compounds. It is contributed chiefly by nitrogenous fertilizers, decomposition of organic matter in the soil fixation of nitrogen by bacteria etc. Human and animal excreta may also add nitrate to water by bacterial decomposition. This can also originate from septic tank and sewage discharges etc. The maximum desirable limit of Nitrate concentration in ground water is 45 mg/l with no relaxation as per BIS. Nitrate in low concentration is considered relatively non-toxic, however higher nitrate concentration in drinking water is an environmental health concern. Higher concentration of nitrate causes methaemogloblanemia to infants. This is also known as blue baby disease. At very higher concentration causes gastric trouble and affects adversely central nervous system and cardiovascular systems. Thus determination of Nitrate is important and perusal of our data from Table 1 suggests that the Nitrate concentration has increased over the years. The average values are increasing and thus suggesting that

organic matter is present in the groundwater. Although the values are well within the range of BIS, but this increasing trend is alarming as most people use it for drinking purpose.

Sulphates are naturally present in the groundwater. Sulfate The occurrence of sulfate in groundwater is resulted from the oxidation of sulfur of the igneous rocks, the dissolution of the other sulfur bearing minerals. The higher concentration of sulphate in groundwater can causes gastro-intestinal problems. The values of sulphate in our study area have a little variation suggesting no major alteration to the groundwater.

Fluoride exists in the nature in a number of minerals. Fluorite (CaF_2) is a common fluoride mineral. Fluoride found in groundwater is mostly naturally occurring from the breakdown of rocks and soils or weathering and deposition of atmospheric particles. These are sparingly soluble and are present in groundwater in low concentrations. The occurrence of fluoride in natural water is affected by the type of rocks, climatic conditions, and nature of hydro geological strata. Fluoride amount is ascertained less than the permissible limit prescribed by the BIS. However, it can be seen that the fluoride concentration is increasing in the study time period.

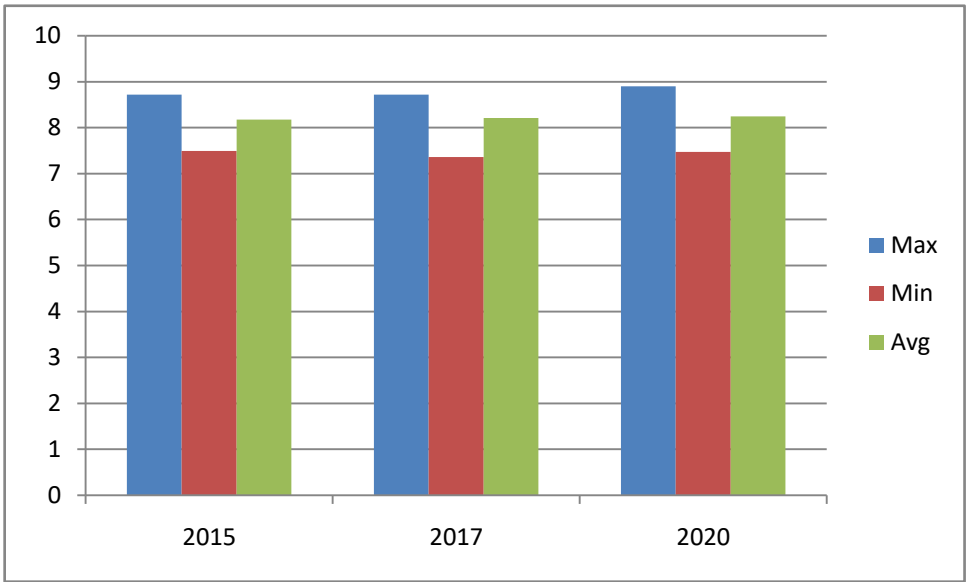
Cationic Geochemistry of Groundwater:

Calcium is a major constituent of various rocks. The limestone contains about 27.2% of calcium ions. It is one of the most common constituent present in natural water. In our study area, calcium is dominating cation. However, average values of the calcium are well within the range. The fascinating correlation can be noted between the values of Calcium and Fluoride. As already known fact that Calcium and Fluoride are correlated, it can be clearly seen from table 1 that correlation exists in the study area. The values of Fluoride are increasing and calcium is decreasing in the same time period and vice versa. Hence correlation can be clearly observed.

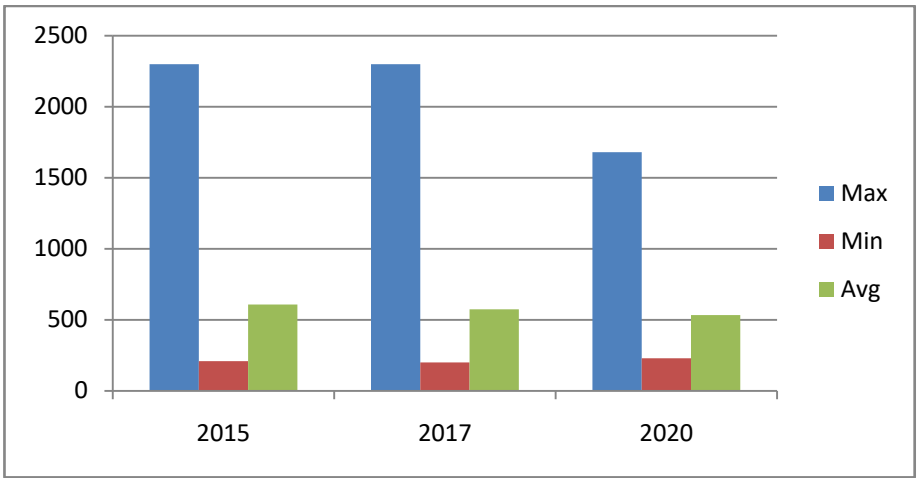
Magnesium ion is also one of the major constituent of the ground water. Both calcium and Magnesium salts are combined responsible for the hardness in the water. Magnesium is also dominant in the Jammu District. The values of Magnesium ion have increased in last 5 years, but still it is well within the range of BIS.

Hardness is due to presence of Calcium and Magnesium salts. Two types of Hardness can be present Temporary and Permanent. Temporary hardness is due to carbonate and bicarbonate of Calcium and Magnesium and whereas permanent hardness is due presence of sulphates, phosphates of Calcium and Magnesium. It is noticed that the groundwater is hard in the district and its values has been increased during the study period.Sodium and potassium are the two important alkali metals which are required by body to carry out many biological processes. In the study location, Sodium and Potassium ion are dominant. The average values of Sodium and Potassium have decreased giving indications that the recharge of the groundwater is good and no pollution is indicated.

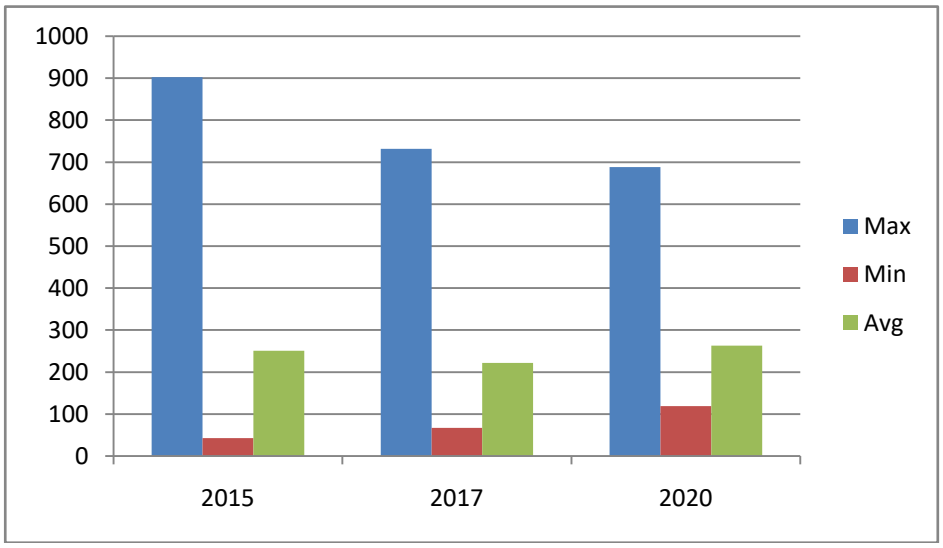
The graphical representation of variation in various paramteres is given below:



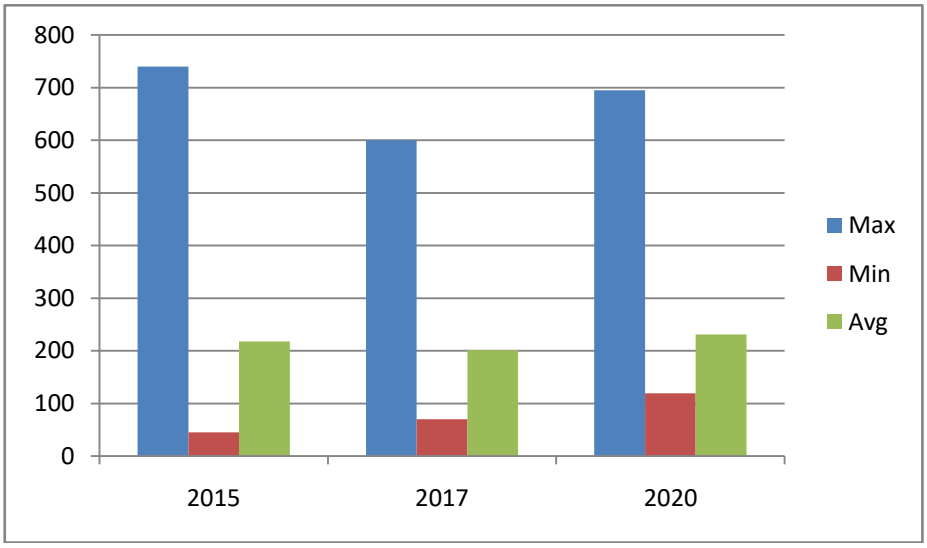
Periodical Variation of pH



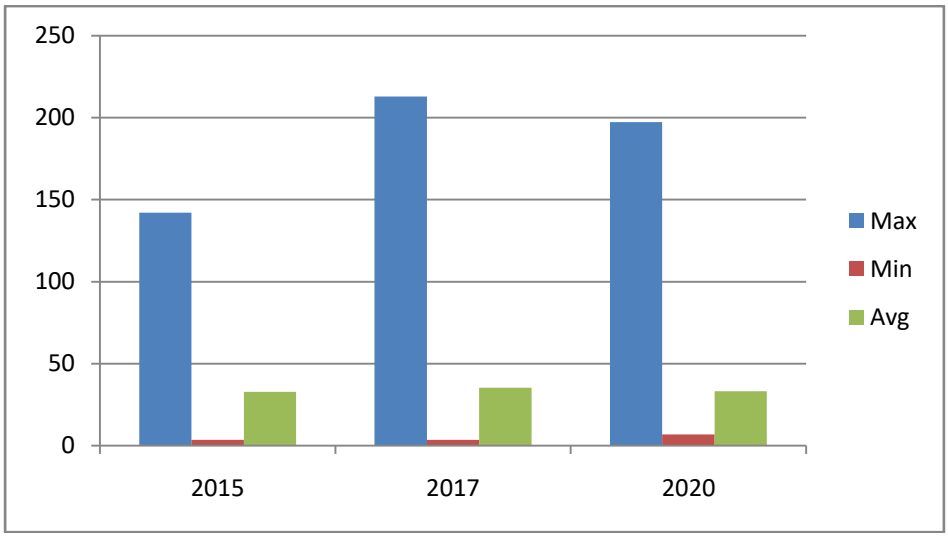
Periodical Variation of Electrical Conductivity



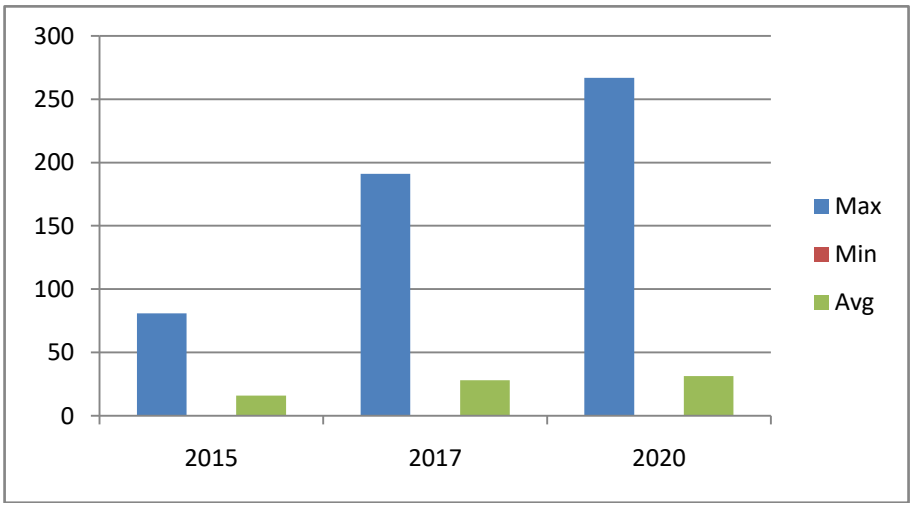
.Periodical Variation of Bicarbonate



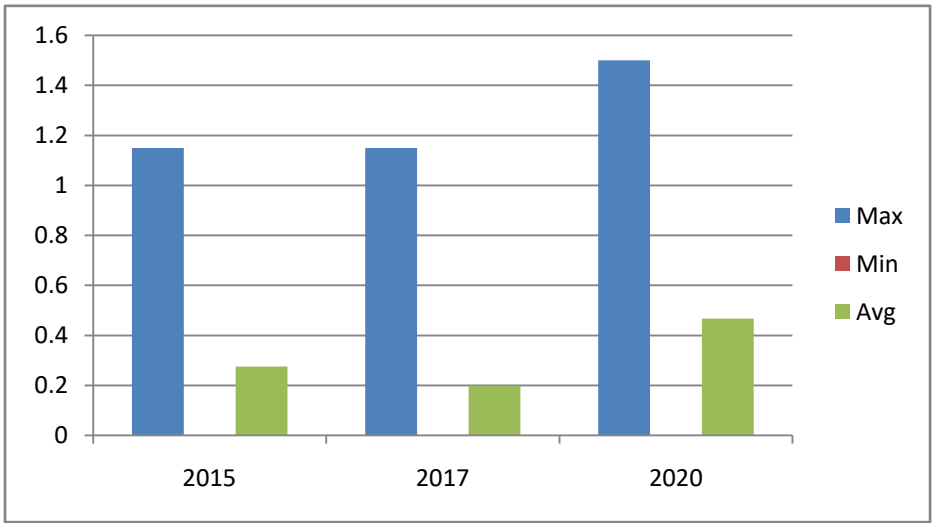
Periodical Variation of Total Alkanity



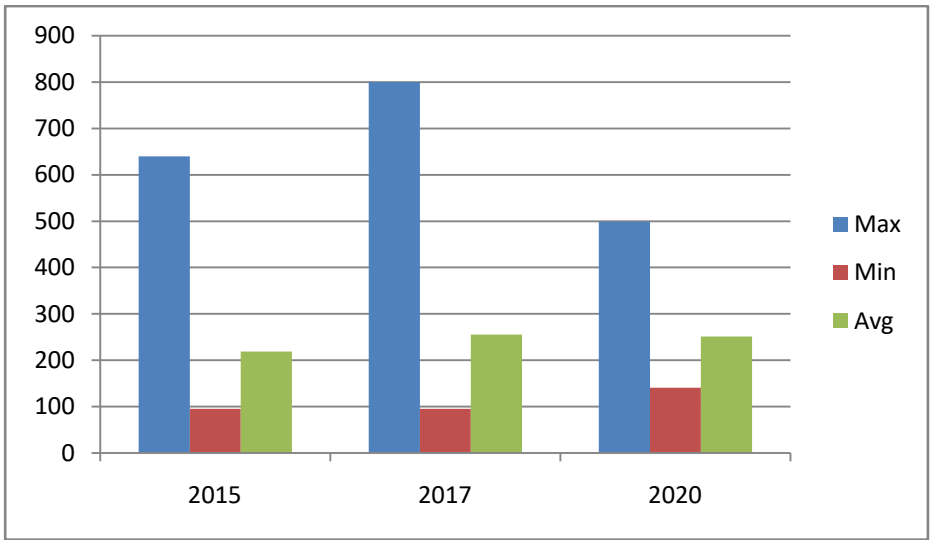
Periodical Variation of Chloride



Periodical Variation of Nitrate



Periodical Variation of Fluoride



Periodical Variation of Total Hardness

CONCLUSION

It is inferred that the geochemistry of the groundwater in Jammu District has little fluctuations over the last 5 years. No drastic change has been observed in the major cations and anions indicating that the groundwater is of good chemical quality and can be used for drinking and other domestic purposes. The hydro-chemical faces in the study area are of Ca-Mg-HCO_3 and Na-K-HCO_3 type. The permissible concentrations of all chemical constituents suggest that the quality of the groundwater is mainly controlled by geogenic processes. The one major anion which has increase over the years is only nitrate (97%) and this may be attributed to the anthropogenic activities. The rise in nitrate concentration is alarming which infers that there is contamination in the ground water. The increase is due to the lack of proper sewage and sanitation and increase in the usage of fertilizers containing nitrogen thus resulting into ground water and surface water contaminations of Nitrate. The remedy is that the village sewages shall be disposed of properly after proper treatment and far away from the source of the groundwater. The other anthropogenic activities may also be checked. The open dug wells, tube wells and other sources of groundwater shall be properly cleaned. Ground water contamination by improper disposal of domestic and industrial solid waste is a concern and special efforts shall be made to address this problem. From the graphical representation, the correlation between fluoride and calcium can be seen. The values of Calcium and Fluoride are inversely proportional. Perusal of the data suggests that the hydrochemistry has not changed over the years and water is of good quality. Explored chemical quality variation in subsurface water for the last five years on the basis of electrical conductivity has improved with 12.30%, if the same pattern will continue there may be least chance of alteration in the quality for next five years. However, if any drastic changes occur in natural system, it may impact the groundwater quality.

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