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Ground water Chemical assessment in Chikmagalur District of Karnataka

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Abstract

The present study deals with the ground water chemistry in relation to few physico-chemical parameters in 10 areas of Chikmagalur district in Karnataka during January-July 2020. In this study, pH values varied from 7.21-8.6. The turbidity values ranged between 6 and 40 NTU. The values of electrical conductivity ranged between a minimum of 750 to a maximum of 1410 µmhos/cm Total hardness values varied from a minimum of 585 to a maximum of 1520mg/1. Calcium values ranged from a minimum of 62.5 mg/l to a maximum of 128.4 mg/1. Magnesium varied from 36 mg/1 to 98.5 mg/1. The nitrate values ranged minimum of 42 mg/1 to a maximum of 410 mg/1 The phosphate content ranged from 0.5 mg/1 to 0.94 mg/1. Chloride values ranged from a minimum of 76.5 mg/1 to a maximum of 400.2 mg/1 respectively. However, iron level fluctuated from 0.5 mg/l to 3.34 mg/l. Nitrate was maximum at Birur area and lesser in Bettadahalli region. Total hardness was highest in Birur and lowest in Singatagere region. However, iron content was peak in Koppa region and lowest in Avathi area. 90% of the ground water samples showed high salinity and 10% showed medium salinity. One-way ANOVA,post-hoc Tukey HSD test, Scheffé, Bonferroni and Holm multiple comparison tests are carried out for physico-chemical parameters of ground water samples.

Key words : Ground water, Physico-chemical parameters, Chikmagalur district, Karnataka.

Water is lifestyles as it is the basis for fitness, hygiene, improvement and prosperity. Therefore, efficient water manipulate is vital to civil society for betterment of quality of existence. It is a fundamental human want and basis for the existence of surroundings. "Without water there is no life. It is critical for many factors of economic and social

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improvement and for residence, agriculture, energy production and it is a essential aspect of environment. It is of the most vital object needed through using humans / plants and other living beings for their survival. Vegetation in flip cannot develop without water and growth of plant life additionally relies upon bacterial movement, whilst bacteria want water in order to thrive. The bacterial actions convert vegetable depend into green soil. New plant life which broaden on this soil is probably grown by using retaining nutrients thru their roots in the shape of solution in water. Thus, an ecological chain is being maintained. Water keeps ecological balance among residing organism and the surroundings wherein they stay[21,42].

Water reveals quite a number of physical and chemical residences that assist the molecule to act as fine suitable medium for the life activities. Most of the biochemical reactions that arise within the metabolism and increase of the living cells involves water. Water has been a often occurring solvent, on account that many of the additives dissolve in water[38].

Groundwater is an vital supply of water deliver at some point of the area. It is used m irrigation, industries and domestic utilization continues to growth in which perennial, water resources are absent. The satisfactory of groundwater used for these functions is greater important due to the fact the case of quantity. The geology of precise place has a greater have an impact on at the prevalence and wonderful of water and its motion. Many a time groundwater incorporates a higher mineral content than the floor water while there is slow circulate and longer duration of contact. Changes in groundwater quality with the passage of time have a hydrologic significance. The first-class also varies due to change in chemical composition of formation[21,39].

Groundwater is used in irrigation, industries and domestic usage increase where perennial surface water source are lacking. The modernization, over exploitation, rapid industrialization and increased residents has lead to fast degradation of the environment. To meet the rising demand it is imperative to recognize the fresh water resources and also to find out remedial methods for improvement of water quality. Industrial waste and the municipal solid waste have emerged as one of the leading cause of pollution in surface and ground water. In many parts of the country available water is rendered non-potable because of the presence of excess heavy metals. The situation gets worsen during the summer season due to water scarcity and also in rain water discharge[11].

The groundwater quality is slowly degrading in Chikmagalur district due to increases human activities and commercial practice. Therefore, the present study is undertaken to investigate some physico-chemical parameters of the ground water of Chikmagalur town of Karnataka.

Study area :

Chikmagalur district is well-known for its coffee plantations. 'The Younger Daughter's Town' and encompasses an area of 7,201 sq. Km. The district spans across the latitudinal

parallels of 12° 54' 42" and 13°53' 53" north and the longitudinal meridians of 75° 04' 46" and 76° 21' 50" East. Shivamogga, Davangere, Chitradurga, Tumkur, Hassan, Dakshina Kannada and Udupi districts of Karnataka mark Chikmagulur's geographic boundaries. The 2001 Census has attested a internet populace length of 11,39,104 [6]. Although now not in the leading edge of industrial enterprise, agriculture is the backbone of Chikmagulur, one of the leaders in coffee production in the globe. Chikmagalur with its lovely panorama, coffee blossoms and salubrious ambiance in the Deccan Plateau has a properly-developed tourism quarter. The places selected for floor water sample collection are Avathi, Bettadahalli, Kudregundi, Kalasapura, Birur, Kadur, Koppa, Duglapura, Lingadahalli and Singatagere (Fig. 1).

In the current research, a total of 10 water samples from 10 localities were accrued in clean two litre polythene cans, the cans had been then sealed air- tight and are classified at the cans. Analysis became completed for different physico-chemical parameters in keeping with the techniques outlined via standard strategies[1]. Therefore, as quickly as the gathering of water, pH was measured immediately. Later, the other parameters were analysed inside the laboratory. Hence, the water become carried to the laboratory in appropriate inert bottles. The samples have been analyzed the usage of numerous analytical method of APHA[1], BIS[3] and NEERI[28].

Statistical; analysis :

One-way ANOVA with post-hoc Tukey HSD test, Scheffé, Bonferroni and Holm multiple comparison tests are carried out by using astatsa.com software (Tables 3&4).

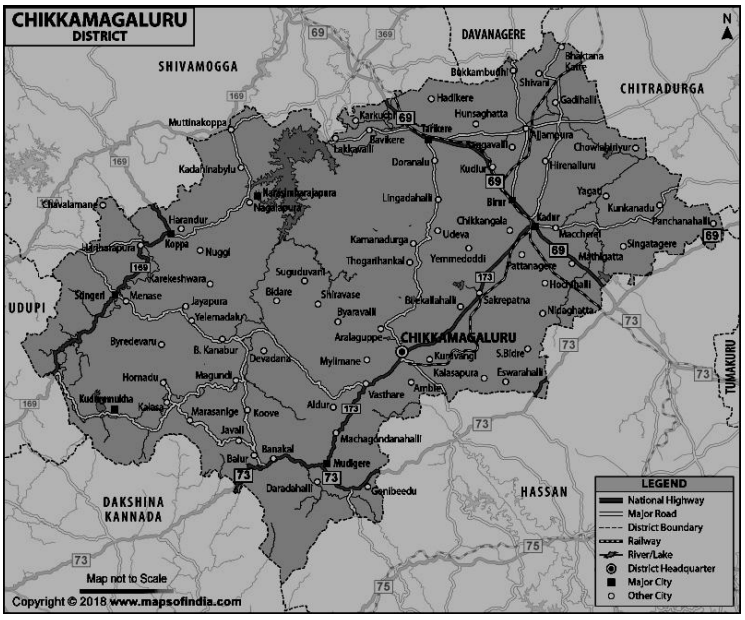

Figure 1. Study area map

Figure 2. Bore wells for ground water sample collection

pH is a degree of hydrogen ion concentration. It is used to express the intensity of acidic or alkaline situation of an solution. It is one of the crucial signs and symptoms of water fantastic and is of amazing significance to residing structures due to the fact both cellular shape and feature may be affected by using even small adjustments in pH, immoderate values of pH lead to scale formation in water warmers and reduce the germicidal ability of chlorine[26] . The expertise of pH is essential in the choice of coagulants for water purification. The acidity (low pH) will now not have an effect on the fitness but slightly acidic ground water is corrosive and can dissolve metals, mainly copper from pipes and pumps. The corrosion can shorten the monetary life of plumbing, heat water cylinders and in a few times, the dissolved metals in the water might also moreover cause contamination[21,32]. In the prevailing research, pH values varied from 7.21-8.5. The approved pH for ingesting purposes is among 6.5-8.5 [3]. In the existing take a look at all of the water samples analyzed are all properly with in the permissible limits. The research indicate that with the aid of and huge, the groundwater resources had been found to be alkaline[7,9,23,27].

The presence of turbidity causes light to be scattered or detected in the sample rather than instantaneously passing through it. Instead of the overall focus of the depend gift in the water samples, the size, morphology, and refractive index of the suspended particle determine. Depending on the level of turbulence, the size of the suspended count changes and spans from colloidal to course dispersion, as well as from naturally occurring inorganic components to those that are incredibly organic in nature. It lessens the mild penetration, restricts the production of phytoplankton, which in turn lessens the photosynthetic activity and oxygen depletion. Outstanding amounts of topsoil are washed into receiving streams during flood conditions and soil erosion. Sand makes groundwater much less cloudy, therefore, sand is a great filtering media. In the present study, the turbidity values ranged amid 6 to 40 NTU. The BIS [3] applicable limit for turbidity is 25 NTU. In the present observation, cross their permissible restrict on the subject of the BIS requirements.

Electrical conductivity is a proportion

of water's capacity to convey electric current. Unadulterated water is a terrible guide of solidarity and such materials are called electrolytes. Its charge depends upon on focus and level of separation of the particles notwithstanding relocation speed of the electric discipline. In the current observation, the upsides of electrical conductivity went among a negligible of 750 to a the greater part of 1410 µmhos/cm . Inferable from the way that during set up-rainstorm season the disintegration of salts, minerals and different soil components will expand because of increment inside the groundwater table [21,37].The greater part of the inorganic salts, for example, sodium, chloride, potassium, sulfate and nitrate are responsible for expanding the EC levels of groundwater structures.

The variability of EC may want to be defined to the natural attention of ionised substances present in water. Higher the awareness of acid, base and salts in water, better could be the EC [14]. However the better values of electrical conductivity (>2000 µmhos/ cm), may be due to lengthy house time and lithology. Ballulcraya and Ravi[2] had proved the version of the conductivity of the water because of the residential instances and the geographical features of the web sites. Similar observation become made by means of Paliwal[29]. Hedge *et al*.[10] found the EC between 839) µmhos/cm 15,310 µmhos/cm and the effects of analysis showed that, 5 samples have the conductivity values above one thousand µmhos/cm indicating excessive mineralization in the vicinity. Tiwari[43] confirmed that the electrical conductivity ranged from 375 to 925 µmhos/cm.

Classification of water quality for irrigation purpose :

Table-1. Classification of water quality for irrigation purpose(According to the classification made by United state salinity Laboratory; Mayur C. Shah *et al*.[22]).

Electrical conducti-vit µmhos/cm	Category of water	% sites of Chikma-galur area
< 250	Low salinity (Excellent)	0
250-750	Medium salinity (Good)	10%
750-2250	High salinity (Fair)	90%
> 2250	Very high salinity (Poor)	0

The classification of water quality of Chikmagalur town for irrigation purpose is presented in Table-1. It suggests that water samples of all the 10 site of Chikmagalur area was quite good and 09 sites were fair for irrigation purpose due to high salinity of ground water (Table-1).

Total hardness of water is the amount of basic earth metals present in it. Calcium and magnesium are the statute cations giving hardness. It is characterized as the consideration of multivalent cations. At immersed conditions, the cations respond with anions in water to areas of strength for frame. Hardness in normal water comes especially from the draining of molten rock and carbonate rocks (dolomite, calcite and limestone). Water contain the solvent salts is known as troublesome water[30]. Temporary hardness (carbonate hardness) is because of carbonate and bicarbonates of calcium and magnesium. Permanent hardness is a result of sulfate, chlorides of calcium and magnesium.

In the current examination, the total hardness values differed from 585 to 1520 mg/1. The BIS[3] ideal limitation for general hardness is 600 mg/1. The total hardness (ppm) has been arranged in expressions of reciprocals of calcium carbonate hardness[1,16,21]. The results acquired propose that more than 80 % of water tests contemplated has a place with the exceptionally hard class.

Sawyer and McCarty[34] have classified water into four categories based on total hardness as Soft 0-75 mg/l; moderately Hard 75-150 mg/l; Hard 150-300 mg/l and very hard > 300 mg/l respectively. Total hardness is due to the dissolution of mineral salts present in the geological strata consisting of hard granite rocks, gneissic formation, chlorite schist and mica schist belt. The observation made in the present study reveals that all the 10 sites of the ground water belongs to very hard category.

Calcium is critical nutrient in an aquatic environment. Water receives the calcium leached from the rocks and deposits like limestone, dolomites, calcite, gypsum, amphiboles, feldspar and business waste also crucial sources of calcium[21,25]. In the present take a look at, the calcium values ranged from a minimum of 62.5 mg/l to a most of 128.4 mg/1. The BIS[3] acceptable limit for calcium is 200 mg/1 consuming water. However, within the present have a look at, the calcium values are within the prescribed restrict of BIS ingesting water standards (Table-2). Excess awareness of calcium has frequently been stated to purpose kidney or bladder stone[12,15,40].

Magnesium is an critical element of basic igneous rocks,volcanic rocks, metamorphic rocks, and sedimentary rocks and serpentine are some of the foremost magnesium bearing minerals. In ground water, the calcium content generally exceeds the magnesium content in accordance with their relative abundance in rocks but contrary to the relative solubility in their salts. As inside the case of calcium carbonate, magnesium carbonate is more soluble in water containing sodium salts[13]. Magnesium has been an essential constituent of chlorophyll with out which no atmosphere ought to work. Its high content lowers the software of water for home use[19]. High concentration of magnesium can also motive laxative outcomes[15]. In the present investigation, magnesium values numerous from at the very least 36 mg/1 to a maximum of 98.5mg/1. Garg *et al*.[5], Subba Rao *et al*.[40] and Sathisha *et al*.,[33] have also made similar findings (Fig. 3).

Nitrate is found within the soil while nitrogen and oxygen combine. Autotrophic oxidation of ammonia is known to occur in steps, the primary to nitrate and then from nitrate to nitrate. Nitrate is critical for boom of many plant species, which includes most of those we consume. Yet it becomes a hassle if it receives into water in extra quantities. Decomposition of organic matters in soils, leaching of soluble chemical fertilizers, human and animal excreta, untreated effluents of nitrogenous industries and sewage disposal are potential source of nitrate concentration in ground water[18,21].

Nitrate can reason health issues particularly those six months of age and younger. Nitrate interferes with their blood's ability to delivery oxygen. This causes an oxygen deficiency,

which leads to a dangerous situation known as "Methemoglobinemia or blue baby syndrome" in adults[8]. The maximum commonplace symptom of nitrate poisoning is bluish skin colouring, specifically across the eyes and mouth. In the present look at, the nitrate values ranged between a minimal of 42 mg/1 to a maximum of 410 mg/1 . From the information, it is clear that, the nitrate awareness multiplied at some point of monsoon season compared to put up-monsoon and pre-monsoon seasons. This may additionally be due to seepage of home wastes, agricultural runoff and septic effluents in the course of rainy season and attain the floor water table. In the existing research, the nitrate values for all of the 3 seasons are within the prescribed limit of BIS drinking water standards. A comparable observation has been made by Shivashankaran[37].

Phosphorous is reliable and does now not purpose any direct health effects to human beings and other organisms. Small amount of phosphorous in drinking water is essential for dwelling beings. However, the presence of phosphorous in large quantities in fresh water indicates pollutants thru sewage and industrial waste[17,28]. Like nitrogen, phosphorous is also an critical element to all forms of terrestrial life as nutrients element and maintaining number one productivity m the surroundings. Generally, Phosphate ranges in natural water are low and arise among 0.001 mg/1 and 0.024 mg/1 with a median concentration of 0.012 mg/1 in the tropical rivers[21,24]. Phosphorous is one of the crucial nutrient restricting the growth of the autotrophs and biological productiveness of the device. High phosphorous content material causes expanded algal growth often as blooms. In the present observation the phosphate values ranged from a minimum of 0.5 mg/1 to maximum of 0.94 mg/1. The contribution of the phosphate to the groundwater can also be due to presence of the rocks enriched with phosphorus and different mineral deposits. During natural procedure of weathering the rocks step by step releases the phosphorus as phosphate ions which soluble in water and the mineralized phosphate compounds breakdown the phosphate attention.

The chloride content increases because the mineral contents increases. It is normally located in soils and rocks. The source of chloride is sedimentary rocks and saline water intrusion and the igneous rocks. High concentration of chloride makes water unpalatable and not worthy for ingesting and different purposes. Chloride ion is typically present in plant water and its presence may be attributed to the dissolution of salt discharge from chemical industries, oil wells, sewage discharges, contamination from leachates. Chlorides in excess, imparts salty taste to water and people are now not accustomed to excessive chloride will be subjected to laxative effect[31]. Chlorides in reasonable concentration are no longer dangerous to humans. Concentration substantially in excess of 100 mg/1 may also purpose physiological damage. At awareness above 250 mg/1 the water becomes salty flavor. Hence, the chlorides are generally constrained to 250 mg/1 in materials meant for public use. In the existing take a look at, chloride values ranged from at the least 76.5 mg/1 to a maximum of 400.2 mg/1 It is additionally found that chloride ion attention endure a

conjugational relationship with mineral content of the respective water samples as chloride content material increases with increasing mineral content[21,26]. The BIS[3] ideal limit for chloride is a thousand mg/1. In the present investigation, the values of chloride for all of the seasons are with inside the permissible variety as prescribed via BIS drinking water standards.

Iron is the 4th abundant element by mass in the earth's crust in the form of magnetite hematite *etc*. Generally, iron occurs in ferrous and ferric state in surface water. Heavy metals are found in drinking water because of abundance in the earth's crust. Iron deficiency causes anemia. Long term usage of high concentration of iron causes a liver disease called as haemo siderosis. In the present study, the concentration of iron varied from a minimum of 0.5 mg/l to a maximum of 3.34 mg/l.

The Nitrate was maximum level at Birur area and lesser in Bettadahalli region. Total hardness was highest in Birur and lowest in Singatagere region. However, Iron content was peak in Koppa region and lowest in Avathi area.

Manjunatha *et al.*[20] mainly addresses the physico-chemical concentration of groundwater in Challakere, Karnataka. Their results of all the findings is extremely important to the future economy and growth of rural India. Thirumala and Kiran [41] have analysed the seasonal variations in ground water in Davangere area of Karnataka. The water samples were compared with BIS standards. The ground water was moderately polluted and impact to health hazards. In their study, the water was quite good for irrigation due to elevated salinity.

Manohara *et al.*[21] have studied the ground water quality in Jagalur taluk of Davangere district, Karnataka. As per their analysis, the ground water samples are moderately polluted and can cause health hazards. In their study, the water samples were quite good (fair) for irrigation purpose due to high salinity.

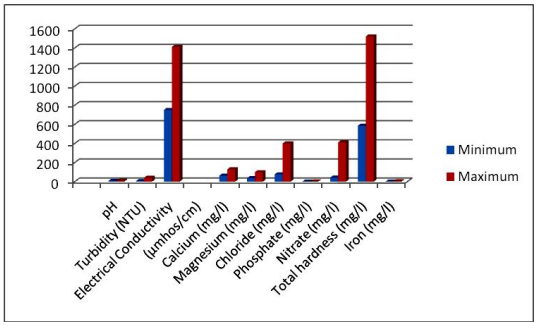

Figure 3. Minimum and maximum values of physico-chemical parameters in ground water samples of Chikmagalur taluk

Table-2. Minimum & Maximum values of physico-chemical parameters compared with WHO and BIS standards

Para-meters	Mini-mum	Maxi-mum	WHO Permi-ssible limit	BIS Permi-ssible limit
pH	7.21	8.5	6.5-8.5	6.5-8.5
Turbidity (NTU)	6	40	5	0
Electrical Conductivity (µmhos/cm)	750	1410	1500	0
Calcium (mg/l)	62.5	128.4	75	200
Magnesium (mg/l)	36	98.5	150	100
Chloride (mg/l)	76.5	400.2	200	1000
Phosphate (mg/l)	0.5	0.94	0.1	0
Nitrate (mg/l)	42	410	45	100
Total hardness (mg/l)	585	1520	200	600
Iron (mg/l)	0.55	3.34	0	0.3-1.2

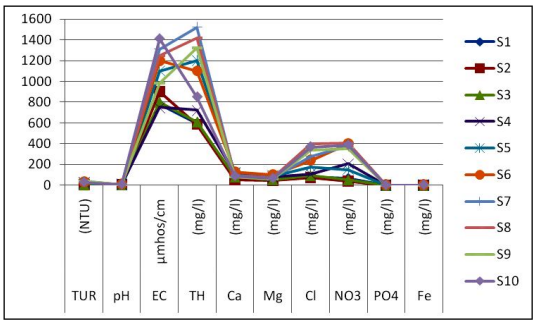

Figure 4. Physico-chemical parameters in different areas of ground water samples in Chikmagalur district, Karnataka

One-way ANOVA & Post-Hoc Tukey HSD test for ground water quality of Chikmagalur District

Table-3. Descriptive statistics of independent treatments

Treat-ment	A (Tur, pH & EC)	B (TH, Ca, Mg)	C (Cl, NO_3, PO_4)	D (Fe, PO_4, Tur)	Pooled Total
N	30	30	30	30	120
Sum	10,801.3100	11,579.4000	4,636.4400	266.7300	27,283.8800
Mean	360.043	385.9800	154.5480	8.8910	227.3657
Sum of squares	11,505,901.1941	11,181,365.2000	1,438,011.6024	7,316.4505	24,132,594.447
Sample variance	262,653.7220	231,446.4961	24,877.8991	170.5157	150,665.3519
Sample std. Dev.	512.4975	481.0889	157.7273	13.0582	388.1563
Std. Dev. of mean	93.5688	87.834	28.796	2.3841	35.4337

Table-4. One-way ANOVA of independent treatments

Source	Sum of squares	Degrees of freedom	Mean square	F statistic	P-value
Treatment	2,873,866.5293	3	957,955.5098	7.3810	0.0001
Error	15,055,310.3522	116	129,787.1582		
Total	17,929,176.8815	119			

The p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.05, suggesting that the one or more treatments are significantly different (Table-4).

Tukey HSD test :

The p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.01 which strongly suggests that one or more pairs of treatments are significantly different. Degrees of freedom for the error term í=116.

Q critical α=0.01,k=4,ν=116 = 4.5003
Q critical α=0.05,k=4,ν=116 = 3.6866
(Table-5)

Table-5. Tukey HSD data

Treatment pair	Tukey HSDq statistic	Tukey HSDp-value	Tukey HSD inferfence
A vs B	0.3943	0.8999947	insignificant
A vs C	3.1243	0.1266480	insignificant
A vs D	5.3388	0.0014320	** p<0.01
B vs C	3.5186	0.0672142	insignificant
B vs D	5.7331	0.0010053	** p<0.01
C vs D	2.2145	0.4033798	insignificant

Table-6. Scheffe multiple comparison

Treatmentspair	Scheffét-statistic	Scheffép-value	Schefféinference
A vs B	0.2788	0.9943342	insignificant
A vs C	2.2092	0.1869553	insignificant
A vs D	3.7751	0.0036735	** p<0.01
B vs C	2.4880	0.1088937	insignificant
B vs D	4.0539	0.0014804	** p<0.01
C vs D	1.5659	0.4868105	insignificant

Table-7. Bonferroni and Holm Comparison: all pairs simultaneously compared

Treat-mentspair	Bonferroniand holmt-statistic	Bonferroni p-value	Bonferroni inference	Holm p-value	Holm inference
A vs B	0.2788	4.6852340	insignificant	0.7808723	insignificant
A vs C	2.2092	0.1747573	insignificant	0.0873787	insignificant
A vs D	3.7751	0.0015225	** p<0.01	0.0012688	** p<0.01
B vs C	2.4880	0.0855981	insignificant	0.0570654	insignificant
B vs D	4.0539	0.0005491	** p<0.01	0.0005491	** p<0.01
C vs D	1.5659	0.7205908	insignificant	0.2401969	insignificant

Table-8. Bonferroni and Holm results: only pairs relative to A simultaneously compared

Treatments pair	Bonferroni and holm t-statistic	Bonferroni p-value	Bonferroni inference	Holm p-value	Holm inference
A vs B	0.2788	2.3426170	insignificant	0.7808723	insignificant
A vs C	2.2092	0.0873787	insignificant	0.0582524	insignificant
A vs D	3.7751	0.0007613	** p<0.01	0.0007613	** p<0.01

Presently, carried research study will give greater specific answer on influence of geomorphological circumstance than anthropogenic activities in the tested groundwater samples of the have a look at region. Local geological settings may helps the growing concentration of physico-chemical traits in groundwater. The factors like gradual watercourse, longer duration of touch among aquifer and water, dissolving of minerals at the time of weathering, residential time, drainage pattern and floor water hyperlink. Porosity of the soil and rock also alters the characteristics of the groundwater. The high level contents of the parameters determined can be minimized if the groundwater is recharged with the available water inside the rainy season. This not best dilutes the components of the groundwater however also raises the groundwater level that depletes because of

huge-scale exploitation. Consequently, it is suggested that appropriate water quality administration is fundamental to keep away from any further contamination. Nearby geographical settings may bolster the expanding centralization of physico-chemical attributes in groundwater. Ground water boundaries in examining locales have fluctuated because of anthropogenic activities, yet this worth doesn't have any destructive effect for the water to use for water system reason. Consequently, the ground water in Chikmagalur taluk is reasonable for drinking, industrial, domestic and irrigation purposes .after certain level of treatment before utilization, and it additionally should be protected from the potential sources of contamination.

References :

1. APHA. (1995). Standard methods for the examination of water and wastewater; 18'" edition, AWWA, WPCF, New York, p. 1120.
2. Ballulcraya, P.N. and R. Ravi. (1999). *Indian Journal of Geological Society of India, 5 A:* 1-11.
3. BIS. (1998). Specifications for drinking water, New Delhi, 171-178.
4. Bisnoi, M. and S. Arora (2007). *J. Environ Biol., 28:* 291-294.
5. Garg, K.B.A., K.S. Anathamurthy, and R. Anand. (2004). Ground water quality Atlas of Bangalore city. Proceedings of Abstract volume of *International Seminar on Earth Resources Management, Department of Post Graduate Studies and Research in Applied Geology, Kuvempu University, Shankaraghatta,* p. 50.
6. Gazetteer of India, Karnataka State, Chikmagalure district (1981). 8-15 and 630-633.
7. Gill, S.K., G.P.S. Sahota, B.K. Sahota, and H.S. Sahota. (1993). *IJEP, 13:* 584-587.
8. Gilli, G., G. Corrao, and S. Favilli. (1984). *Sci. Total Environ, 34*(2): 35-57.
9. Govardhan, V. (1990). *IJEP, 10*(1): 54-61.
10. Hegde, S.H., S.C. Puranik, and A.K. Abbi. (1992). *Indian J. Environ. Hlth., 34*(2): 138-142.
11. Jai M. Paul, V.S. Arya, Jesteena George, K.J. Reji, and K.S. Sumitha (2014). *International Journal of Engineering Science Invention 3*(4): 21-28.
12. Kakati, S.S. and H.R. Sharma. (2007). *IJEP, 27*(5): 425-428.
13. Karanth, K.R. (1989). Ground water Assessment, Development and Management. Tata McGraw Hill Pub. Co. Ltd., New Delhi.
14. Kataria, H.C. and O.P. Jain. (1995). *Indian Journal of Environmental Protection, 5:* 569-571.
15. Kaushik, A., K. Kumar, Taruna Kanchan, and H.R. Sharma. (2002). *J. Environ. Biol., 23*(3): 325-333.
16. Kotaiah, B. and N. Kumaraswamy. (1994). Environmental engineering laboratory manual. Charotar Publishing House. Anand- 388 001, India, 111-1:3.
17. Kotaiah, C.R. (1999). Research methodology methods and techniques, 2nd ed. Vishwa-prakashan Publishers. New Delhi, 20-24.
18. Kumara Swamy, N. and D. Padmanabha Reddy, (1994). *Journal oflPHE,* India, No. 4, pp. 52-61.
19. Manivasakam, N. (1987). Industrial effluents, *Sakthi Publications,* Coimbatore.
20. Manjunatha, H., S. Thirumala, H.B.

Aravinda and E.T. Puttaiah. (2012). *The Journal of Tropical Life Science 2*(2) : 44–48.

21. Manohara, B.M., S. Thirumala, and B.R. Kiran (2021). *India. Eco. Env. & Cons. 27*(2) : 764-769.
22. Mayur C. Shah, G. Prateek Shilpkar, Pradip B. Acharya (2008). *E-Journal of Chemistry 5*(.3): 435-446.
23. Mehta. S.B. and V.H. Trivedi (1993). *IJEP, 13:* 577-579.
24. Meybeck, M. (1979). *Rw. Geolo. Dy. Geography, 21:* 215-246.
25. Mishra S.R. and Saxena (1989). *Pollution, Research 8*(2): 77-86.
26. Mohapatra T.K. and K.M. Purohit (2000). Qualitative aspects of surface and groundwater for drinking purpose in Paradeep area. *Ecology of Polluted Waters,* p. 144.
27. Narayana, A.C. and G.C. Suresh (1989). *Indian J. Environ. Hlth., 31*(3): 228-236.
28. NEERI. (1988). The manual of water and wastewater analysis., *National Environmental Engineering Research Institute,* Nagpur, Maharashtra (India), 100-106.
29. Paliwal. K.V. (1975). *Commerce Annual, 131:* 249.
30. Ramaswamy V. and P. Rajaguru (1991). *Indian Journal of Environmental Health, 33*(2): 187-191.
31. Ramprakash and Rao (1989). *Indian Journal Environment and Health, 31*(1): 73-78.
32. Samir K. and Banerji (1999). Environmental Chemistry. 2nd ed.. Prentice Hall of India, New Delhi.
33. Sathisha, N.S. and E.T. Puttaiah (2006). Nitrate and fluoride level is ground waters of Chickmagalur city. World conference on Environment and Environmental hazards. Organized by *Kalpataru Institute of Technology,* Tiptur, Kamataka.
34. Sawyer, C.N. and D.L. McCarthy (1967). Chemistry of Sanitary Engineers, 2nd, MC Graw Hill, New York, pp. 518.
35. Sharma, D.C. (1995). Essentiality and toxicity of certain trace elements; A strategy, Environmental strategies, Lodha, R.M. (ed). Himanshu Publication, Udaipur, 141-142.
36. Sharma, J.D., P. Jain, and S. Deepika. (2005). *In5ia. Fluoride, 38:* 249.
37. Shivashankaran, M. A. (1997). Hydrogeochemical assessment and current status of pollutants in groundwater of Pondicherry region. South India. *Ph.D. Thesis,* Anna University, Chennai, 80-87.
38. Singh, O., V.K. Kumara, and J. Singh. (1988). India's urban environmental pollution, perception and management. Tara Book Agency, Varanasi, pp. 190.
39. Srinivas, C.H. (2000). *Poll. Res., 19*(2): 285-298.
40. Subba Rao, N., and D. John Devadas (2005). *Journal of Applied Geochemistry, 7:* 9–23.
41. Thirumala, S. and B.R. Kiran, (2017). *International Journal of ChemTech Research 10*(7): 099-104.
42. Tiwari, D.N. (2000). *Yojana, 44*(6): 4-7.
43. Tiwari, D.R. (2001). *Indian. 1 Environ. HIth., 43*(4): 176.
44. WHO. (1984). Guidelines for drinking water quality. World Health Organization recommendations, *World Health Organization,* Geneva.