Assessment of Ground Water of different taluks of Tumkur District, Karnataka

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ABSTRACT
Humanand industrial activities causes the subsurface water pollution leads to the serious situation almost everywhere. This activity involves evaluating the quality of ground water. The samples of ground water of two taluks of Karnataka were collected and their physico-chemical parameters are analyzed. Study areas of present research work are Kurubarahalli village and town bore well of Chikkanayakanahalli taluk and Maridasanahalli village and Pavagada rural of Pavagada taluk. Determination and comparison of thirteen physico-chemical parameters like electrical conductivity and pH, chloride, fluoride, sulfates, nitrates, COD, BOD, DO, total hardness, alkalinity, acidity of these two taluk's water samples are done using water quality standards. In some regions, people are making extensive use of groundwater for irrigation. Analysis results show that fluoride and chloride concentrations are excessiveand deficiency in the study areas. Due to this, people are suffering with serious health effects in these areas. So, steps should be taken to avoid ground water pollution and usage of ground water to a large extent.

Keywords: Ground water pollution, physico-chemical parameters, fluoride, chloride, water quality standard measures.

1. INTRODUCTION

Water found underground in saturated zones beneath the surface of the soil is known as ground water (Figure 1).In subterranean materials like sand, gravel, and other rocks, ground water fills the pores and fissures in a manner similar to how water fills a sponge [1]. Significant natural resources in the nation are ground water [2].Aquifers are the rock materials that allow ground water to naturally flow out of them or that can be pumped out (in amounts that are useful). In an aquifer, ground water normally travels slowly, ranging from 7 to 60 centimeters (3 to 25 inches) per day. Water might stay in an aquifer for hundreds or even thousands of years [3,4]. The source of approximately 40% of water utilized for public supply and approximately 62% of water used for agriculture is ground water [5]. Roughly 37% of the liquid supplied to homes and businesses by county and city water departments comes from groundwater (public supply). More than 90%of drinking water is supplied to the majority of the rural population.An estimated 1,386,000,000 cubic kilometers of water are present on earth [6].Sources of ground water include wells and springs that lie below the surface of the earth. The most common features of ground water are its nearly total lack of oxygen, consistent temperature and chemical composition and mild turbidity. In India, ground water is a crucial water source for industrial, agriculture and residential uses [7]. The greatest risk to human health comes from India's natural ground water, which has the highest concentrations of fluoride, arsenic, and iron [8].

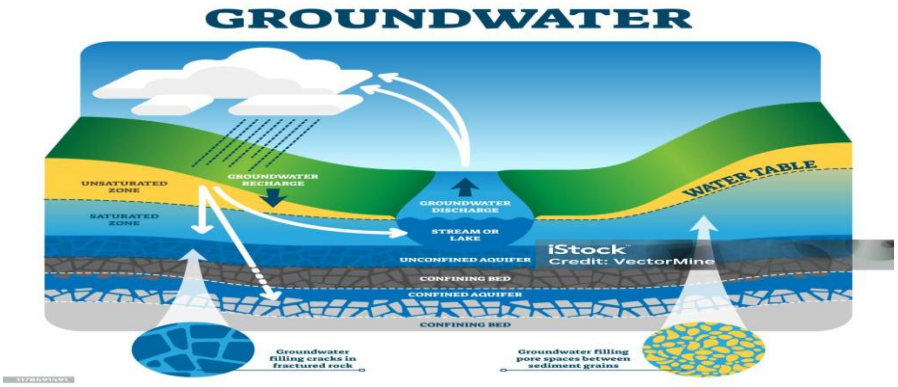

Figure 1. Image of Ground Water.

1.1 Factors contributing to the degradation of water quality

Pollutants from both point and non-point sources are present in water, which degrades its quality. Non-point sources are un-measurable sources of pollution and point sources are organized sources like sewage systems and surface drains that carry industrial waste fluids [9].These sources are many and impacted by the watershed's overall land-use patterns. These consist of both human activity and natural processes [10]. Large-scale degradation of the quality of water is caused by rivers being the primary conduit for the conveyance and absorption of agricultural runoff, animal feces, and industrial and urban wastewater. The composition of circulating ground water can vary greatly because of the existence of different impurities and pollutants [11].

1.2 Causes of Water Pollution and its Effects

There are numerous ways to characterize water pollution. Water has one or more contaminants that have accumulated to the point that they are harmful to humans or animals [12]. A vast range of chemicals, pathogens, and sensory alterations are as considered pollutants in water [13, 14]. A large number of chemicals are poisonous. When water's natural quality is altered to the degree where it is dangerous for humans to drink, this is known as water pollution [15]. The physical parameters of water can change due to eutrophication, temperature changes, electrical conductivity, and acidity. Among the most dangerous repercussions of water pollution are infectious diseases that affect humans.Approximately 50,000 million gallons of waste water, from both home and industrial sources, are produced annually in India's cities. As a result, pollutants find their path into rivers, groundwater, and other bodies ofwater. Fluoride can enter into the human body through drinking water where the concentration of fluoride is high in ground water, which is one of the effects of water pollution.

1.3 Area of Study

Tumkur district is situated between 13° 06'30" and 13° 31' North latitude and 76° 59' to 77° 19' East longitude.There are 11 meteorological grid points identified.Tumkur taluk's primary aquifer is composed of shale, granitic gneiss, and weathered and fractured granites. The research area's groundwater is found in the worn and fractured granite of the gneisses under water table conditions [16].

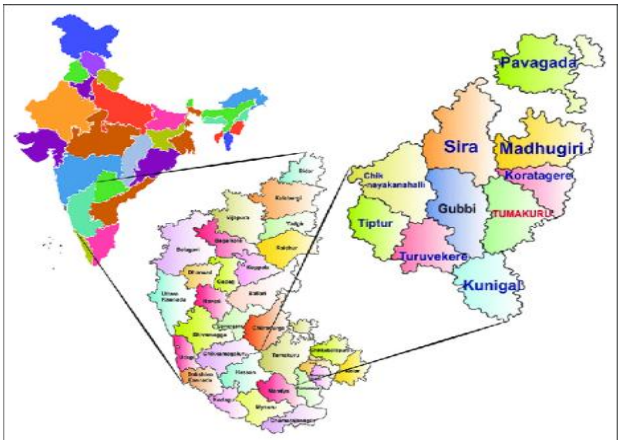

Figure 2. Location of Tumkur Map

Samples of groundwater are taken from two different taluks of Tumkur district namely Pavagada taluk and Chikkanayakanahalli taluk for physico-chemical analysis. In Pavagada taluk samples of ground water of two different villages are collected namely Maridasanahalli village and Pavagada rural. In Chikkanyakanahalli, samples of ground water are taken from the place behind Government PU College which are in the town of Chikkanayakanahalli itself and from Kurubarahalli village.

1.3.1 Pavagada Taluk

A taluk in Karnataka, India's Tumkur district is called Pavagada, also known as Pamukonda. It was formerly a part of the Mysore kingdom. Despite being physically part of the Karnataka state's Chitradurga district, it is a part of Tumkur district. The distance from Bengaluru, the state capital, is 157.8 km (98 miles). It is situated at an average elevation of 2,119 feet, or 646 meters. The river Uttara Pinakini empties into this taluk. Due to Pavagada Taluk's location on the Karnataka border, the bulk of its residents speak both Telugu and Kannada. The town is well-known for its fort perched on a hill, the Sri Shani Mahatma temple, and the KoteAnjaneya temple situated in the foothills. This taluk is called the hilltop residential area for a reason. One of the state's drought-prone areas is the Pavagada Taluk in the Tumkur district. The lack of rainfall has drastically lowered the groundwater level in numerous bore wells, which has inhibited the growth of peanuts. This results in geogenic contamination of groundwater, which lowers the quality of the groundwater. There is a maximum of 2,282.16 mm and a minimum of 223.32 mm of yearly precipitation [17-19].Through tiny channels, water is sent straight to the fields. The climate in and around the Pavagada region is often hot. Both the black and red soils in this taluk have a good water-holding capacity and are well-drained.

Figure 3.Map of Pavagada Taluk

1.3.1.1 Maridasanahalli Village

The location code for Maridasanahalli village is 610548. This village is located in the Pavagada taluk of Karnataka, India, in the Tumkur district. It is located 23 km from the sub-district headquarters in Pavagada and 120 miles from the district headquarters in Tumkur. A gram panchayat, too, based on data from 2009. The entire land area of the village is 1081.6 hectares.

1.3.2 Pavagada Rural

In the Pavgada taluk, Pavagda rural is a tiny village situated 9 kilometers away from Krishnagiri village. 21 kilometers from the gramantaraPavagada. Rajavanthi, Azadnagar, Srinivasnagar, Mag Layout, and Tumkur, the district headquarters, all 102 km to the north. The rural pin code for Pavagada is 572202.

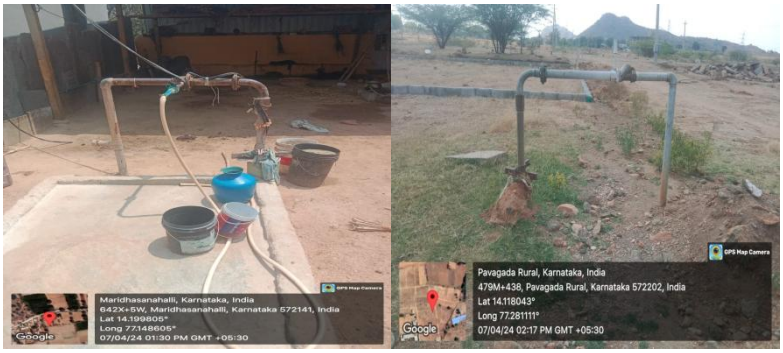

Figure 4. Sources of ground water sample collection

2.2 Chikkanayakanahalli Taluk

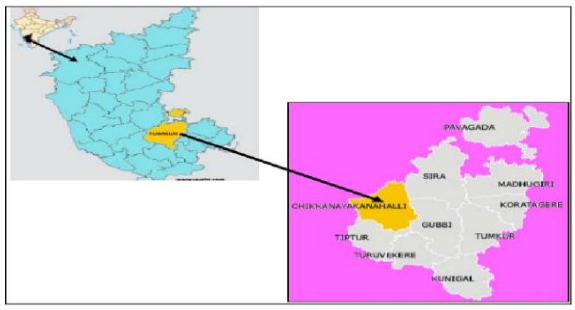

Figure 5.Map of Chikkanayakanahalli Taluk

The Suvarnamukhiriver's constituent, Chikkatore, passes through Chikkanyakanahalli as it flows northward. The Borankanive reservoir in Chiknayakanahallitaluk was built over the Suvarnamukhiriver as a famine relief project [20].

2.2.1 Town Borewell

Ground water sample is collected from bore well which is situated at behind Government PU College, in the town of Chikkanayakanahalli taluk.

Figure 6. Source of Ground Water Collected

2.2.2 Kurubarahalli Village

In the Tumkur District of Karnataka State, India, Kurubarahalli is a small village or hamlet located in the Chiknayakanhalli Taluk. It is a part of the Bangalore division. It is situated 67 kilometers to the west of Tumkur, the district headquarters. Kannada is the local language of Kurubarahalli.

3. MATERIALS AND METHODOLOGY

The samples of ground water of four different places were collected, samples of two from Pavagada taluk and two from Chikkanayakanahallli taluk. The samples of ground water got collected in bottles and variousphysico-chemical parameters were analyzed namely electrical conductivity, nitrate, sulfate, pH, COD, BOD, DO, alkalinity, total hardness, acidity, chloride, calcium and magnesium hardness and fluoride. Chloride and fluoride concentrations are mainly concerned point here.

4. RESULTS AND DISCUSSIONS

Samples of ground water got collected from two different taluks namely Pavagada taluk from two different villages namely Pavagada rural (sample-1) and Maridasanahalli (sampla-2) and Chikkanyakanahalli taluk from two different places in town namely Kurubarahalli (sample-1) and behind Government PU College (sample-2).

Table 1. Results of Physico-chemical Parameters of Ground Water Samples

Sl. No.	Parameter	Acceptable limit- mg/L	Permissible limit- mg/L	Achieved Values - mg/L			
				Pavagada		Chikkanayakanahalli	
				Sample-1	Sample-2	Sample-1	Sample-2
1	pH	6.5	8.5	7.2	7.26	7.1	6.94

2	Conductance (µS/cm)		<150	1.4	1.2	1.1	1.09
3	Sulfate	200	400	170	53	29	28
4	Nitrate	45	No relaxation	1.5	0.3	0.8	1.1
5	COD		250	772	386.2	635.2	743.71
6	Total Hardness	300	600	984	804	229	244
7	Alkalinity	200	600	540	840	200	232
8	Chloride	250	1000	1186	345.4	48	63.5
9	Acidity	15	400	57	64	26	62
10	Calcium Magnesium Hardness	75 30	200 100	184 800	140 664	214 15	144 100
11	DO	6.5	8	29.7	3.9	23	27
12	BOD	1	5	9	6.4	8.8	6
13	Fluoride	1	1.5	2.47	1.3	0.52	0.74

Concentrations of fluoride and chloride of four different samples from two different taluks namely Chikkanayakanahalli and Pavagada have been plotted in Fig 7 and Fig 9 respectively.Figure 7. represents the graph of fluoride concentrations of ground water samples of Chikkanayakanahalli and Pavagada taluks. Sample of ground water along x-axis and concentration of fluoride along y-axis is plotted. In this graph, it is seen that fluoride concentrations of ground water sample-1 is 0.52mg/L and that of sample-2 is 0.74mg/L of Chikkanayakanahalli taluk, and values are lower than the acceptable value (1.0mg/L). Fluoride concentrations of Pavagada taluk ground water sample-1 is 2.47mg/L which is more than the permissible limit and water sample-2 is 1.3mg/L which is within the permissible limit (1.5mg/L).

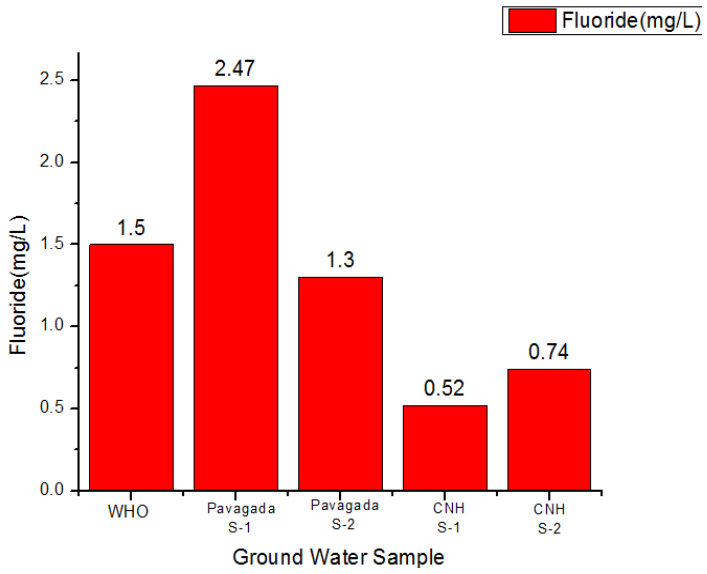

Figure 7.Concentration of Fluoride in Ground Water Samples

In the body, most fluoride is contained in bones and teeth. Fluoride is necessary for the formation and health of bones and teeth. Both high as well as low concentration of fluoride affects human health.High fluoride effects are low amounts of hemoglobin, degeneration of muscle fibers, deformities of red blood cells, skin eruptions, headache, gastrointestinal issues, depression, nausea, urinary tract malfunction, tinglingsensation in finger and toes and poor immunity, modification of the kidney, liver, pulmonary, digestive, central nervous, reproductive, and excretory systems' functioning mechanisms[21].Treatment for excess of fluoride includespreventing further accumulation of fluoride by reducing fluoride consumption, individuals who reside in regions where the content of fluoride in water is high ought not to consume fluoridated water or take fluoride supplements. Children should alwaysbe instructed not to swallow fluoridated toothpaste, installing new water sources in their place (digging a new well),

reverse osmosis water treatment [22], joining a different, bigger water system in a different town or area, electrolysis of water[23], removing non-compliant wells from the supply system and combining water from wells with reduced fluoride contents [24].Health effects of deficiency of fluoride are tooth decay and osteoporosis. Measures to prevent deficiency of fluoride includes consuming enough fluoride can make tooth decay less likely and may strengthen bones, the addition of fluoride (fluoridation) to drinking water that is low in fluoride or the use of fluoride toothpaste and supplements [25].

Figure 8.Dental and Skeletal Fluorosis

Figure 9 represents the graph of chloride concentrations of samples of ground water ofChikkanyakanahalli and Pavgada taluks. Sample of ground water along x-axis and concentration of chloride along y-axis is plotted. In this graph, it is seen that chloride concentrations of ground water sample-1 is 48mg/L and sample-2 is 63.5mg/L of Chikkanayakanahallitalukand values are lower than the acceptable limit (250mg/L). Chloride concentrations of Pavagada taluk ground water sample-1 is 1186mg/L which is more than the permissible limit (1000mg/L) and ground water sample-2 is 345.4mg/L which is within the permissible limit.

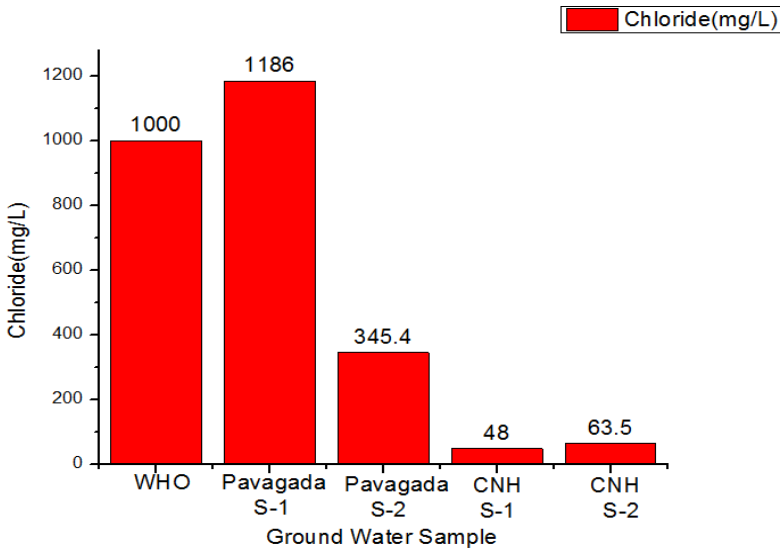

Figure 9.Concentration of Chloride in ground Water Sample

High concentration of chloride in ground water affects human health like hyperosmolality (the high concentration of osmotically active substances in theextracellular fluid results in infection, increases blood pressure, stroke, heart attack or recent surgery), oedema, weight gain, the evolution of hypertensive diseases, pulmonary oedema and cerebral oedema, gastrointestinal symptoms. Chlorides are not carcinogenic, but consuming more sodium chloride may increase the carcinogenic potential of carcinogens, such as nitrosamines and the possibility of helicobacter pylori stomach infection [26]. High chloride concentrations in freshwater can also harm aquatic organisms by interfering with osmoregulation, the biological process by which they maintain the proper concentration of salt and other solutes in their bodily fluids, difficulty with osmoregulation can hinder survival, growth and reproduction of the aquatic organisms.Treatment for excess of chloride in ground water are elevated chloride levels can be reduced by reconstruction of wells, by using water treatment devices like reverse osmosis, anion exchange or distillation treatment systems, use of substitute for the use of home-based water softeners by household, to change the technology for purifying water by replacing the ferric chloride used in the

purification process [27]. Health effects of deficiency of chloride in humans are hypochloremia such as dehydration,diarrhea or vomiting caused by fluid loss,high levels of sodium, weakness or fatigue, difficulty in breathing, hypotension (low blood pressure) and tachycardia (increased pulse rate), fever, swellingand confusion.Treatment for deficiency ofchloride in ground water are an intravenous (IV) saline solution is given to restore electrolyte levels, eat foods rich in chloride or take a supplement, sodium hypochlorite, a reasonably priced solution that dissolves in water to liberate freechlorine is used in household bleach [28].

4.9 Physico-chemical specifics

pH, conductance, sulfates, nitrates, COD, alkalinity, total hardness, chloride, acidity,magnesium and calcium hardness, DO, BOD and fluoride of ground water samples are determined and analyzed.

i) pH: The solution's pH is known as the hydrogen ion logarithm that is negative. The pH scale has three values: 0 to 7 is acidic, 7 is neutral, and 14 is alkaline.Usually drinking water pH ranges from 4.4 to 8.5. pH values of both Chikkanyakanahalli taluk (sample-1: 7.1 and sample-2: 6.94) and Pavagada taluk (sample-1: 7.2 and sample-2:7.26) are slightly alkaline in nature.

ii) Electrical conductivity: It is the water's capacity to move a current of electricity and varies both with number and types of ions the solution contains. The conductance values of two water samplesof Chikkanayakanahalli taluk of sample-1 is 1.1 µS/cm and sample-2 is 1.09 µS/cm and values of two water samples of Pavagada taluk of sample-1 is 1.4 µS/cm and sample-2 is 1.2 µS/cm. All four of the water samples fall within the allowable bound.

iii) Sulfate: Natural water contains ions of sulfate and these ions are water soluble. Sulfate values of two water samples of Chikkanayakanahalli taluk are sample-1 is 29 mg/L and sample-2 is 28 mg/L and values oftwo water samples of Pavagada taluk of sample-1 is 170 mg/L sample-2 is 53 mg/L. All four of the samples of water have sulfate value lower than the permissible limit.

iv) Nitrate: Raw water contains nitrate. It is produced from fertilizer and chemical factories, Matters of animals, decline vegetables, industrial and domestic discharge.Nitrate values of two water samples of Chikkanayakanahalli taluk of sample-1 is 0.8 mg/L and of sample-2 is 1.1 mg/L and values of two water samples of Pavagada taluk of sample-1 is 1.5 mg/L and sample-2 is 0.4 mg/L. All the four nitrate values are much lesser compared to permissible limit (45 mg/L).

v) COD: Values of COD of two water samples of Chikkanyakanahalli taluk of sample-1 is 635.2 mg/L and sample-2 is 743.71 mg/L and values of two water samples of Pavagada taluk of sample-1 is 772 mg/L and sample-2 is 386.2 mg/L. All the four values of water samples have more values of COD compared to the permissible limit 250 mg/L.

vi) Total Hardness: The existence of calcium and magnesium salts in water is what causes it to be hard. The hardness values of two water samples of Chikkanayakanahalli taluk of sample-1 is 229 mg/L and sample-2 is 244 mg/L. Both the values are lesser than the permissible limit (300-600 g/L). The values of two water samples of Pavagada taluk of sample-1 is 984 mg/L and sample-2 is 804 mg/L. Both the values are higher than the permissible limit.

vii) Alkalinity: The alkalinity of water is due the presence of various ions like OH^- (hydroxide ion), HCO_3^- (bicarbonate ions), CO_3^{2-} (carbonate ions) or the mixture of two ions. The alkalinity values of two water samples of Chikkanyakanahalli taluk of sample-1 is 200 mg/L and sample-2 is 232 mg/L which are within the permissible limit (200-600 mg/L). The two values of water samples of Pavagada taluk of sample-1 is 540 mg/L which is also within the permissible limit and sample-2 is 840 mg/L which is higher than the permissible limit.

viii) Chloride: Natural water contains chlorides in the form of NaCl and $CaCl_2$, which are found close to mines. Drinking water contains chlorides due to the mixing of salty water with sewage from homes and businesses. The chloride values of two water samples of Chikkanayakanahalli taluk of sample-1 is 48mg/L and sample-2 is 63.5 mg/L. Both the values are lesser compared to the permissible limit (250-1000 mg/L). The results of two water samples of Pavagada taluk of sample-1 is 1186 mg/L which is higher compared to the permissible limit and sample-2 is 345.4 mg/L which is inside the permissible limit.

ix) Acidity: It is the water capacity to donate protons. Water will be acidic because of the appearance of dissolved CO_2, weak organic acids and strong mineral acids like H_2SO_4. The results of two water sample of Chikknayakanahalli taluk of sample-1 is 26 mg/L and sample-2 is 62 mg/L. The results of two water samples of Pavagada taluk of sample-1 is 57 mg/L and sample-2 is 64 mg/L. All the four values of samples of water are within the permissible limit (15-400 mg/L).

x) Calcium and Magnesium hardness: Calcium and magnesium salts produce hardness in water. Less amounts of magnesium and calcium provides a protective coating against corrosion. The calcium hardness values of two water samples of Chikkanayakanahalli taluk of smaple-1 is 214 mg/L which is

more compared to the permissible limit (75-200 mg/L) and sample-2 is 144 mg/L which is within the permissible limit. Magnesium hardness value of sample-1 is 15 mg/L which is lesser than the permissible limit (30-100 mg/L) and sample-2 is 100 mg/L which is within the permissible limit. The calcium hardness values of two water samples of Pavagada taluk of sample-1 is 184 mg/L and sample-2 is 140 mg/L which are within the permissible limit. The magnesium hardness values of two water samples are sample-1 is 800 mg/L and sample-2 is 664 mg/L which are more compared to the permissible limit.

xi) BOD: It is the amount of the dissolved oxygen necessary for aerobic living things to decompose organic matter in a sample of water at a particular temperature for a predetermined duration of time [29]. Theresults of two samples of water of Chikkanayakanahalliofsample-1 is 8.8 mg/L and sample-2 is 6 mg/L. The values of two water samples of Pavagada taluk of sample-1 is 9 mg/L and sample-2 is 6.4 mg/L. BOD values of all the four samples of water are more compared to the permissible limit (1-5 mg/L).

xii) DO: Is a metric used to express how much oxygen (O_2) is dissolved in water. The DO values of two water samples of Chikkanaykanahalli taluk of sample-1 is 23 mg/L and sample-2 is 27 mg/L which is higher than the permissible limit (6.5-8 mg/L). The DO values of two water samples of Pavagada taluk of sample-1 is 29.7 mg/L which is more compared to the permissible limit and sample-2 is 3.9 mg/L which is lesser than the permissible limit.

xiii) Fluoride: Fluoride is naturally added to ground water by rocks with rich fluoride and soil that interacts water with them. The fluoride values of the two water samples of Chikkanayakanahalli taluk of sample-1 is 0.52 mg/L and sample-2 is 0.74 mg/L which are lower than the permissible limit (1-1.5 mg/L) . The fluoride values of the two water samples of Pavagada taluk of sample-1 is 2.47 mg/L which is higher than the permissible limit and sample-2 is 1.3 mg/L which is within the permissible limit.

5. CONCLUSION

Physico-chemical parameters have been analyzed and detected for the samples of subsurface water of two different taluks namely Chikkanayakanahalli and Pavagada. From each taluk two distinct samples of water are collected. There is deficiency (48 mg/L and 63.5 mg/L) as well as more content of chloride(1186 mg/L) and deficiency of fluoride (0.52 mg/L and 0.74 mg/L) and more content of fluoride (2.47 mg/L) in samples of water. Steps should be taken to avoid polluting ground water by humans and some awareness programs should be conducted by the government. Ground water should be treated by some techniques to increase its potability for drinking purpose. Digging of bore wells and drawing of subsurface water to the greater extent should reduce, otherwise there will be scarcity of subsurface water in future. Dumping of poisonous chemicals from industries to water sources should be stopped and activities of mining should also be stopped in some areas and serious actions should be taken against those industries and activities of mining by the government. Using water filters and cleaning water storing tanks is very essential before supplying water for people for drinking purposes.

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Conflicts of Interest

"The authors declare no conflict of interest."

REFERENCES

[1] Indermitte E, Saava A, Karro, E. Exposure to high fluoride drinking water and risk of dental fluorosis in Estonia. International journal of environmental research and public health. 2009; 6(2):710-721. https://doi.org/10.3390/ijerph6020710.

[2] Fram MS, Belitz K. Occurrence and concentrations of pharmaceutical compounds in groundwater used for public drinking-water supply in California. Science of the Total Environment. 2011;409(18):3409-3417.https://doi.org/10.1016/j.scitotenv.2011.05.053.

[3] Hudak PF. Water hardness and sodium trends in Texas aquifers. Environmental Monitoring and Assessment. 2001;68:177-185.https://doi.org/10.1023/A:1010760413010.

[4] Huang G. A regional scale investigation on factors controlling the groundwater chemistry of various aquifers in a rapidly urbanized area: a case study of the Pearl River Delta. Science of the Total Environment. 2018;625:510-518.https://doi.org/10.1016/j.scitotenv.2017.12.322.

[5] Saha D, Ray RK. Groundwater resources of India: potential, challenges and management. Groundwater development and management: issues and challenges in South Asia. 2019;1:19-42.https://doi.org/10.1007/978-3-319-75115-3_2
[6] Amini M, Muller K, Abbaspour KC, Rosenberg T, Afyuni M, Moller KN, Saar M, Johnson CA. Statistical modeling of global geogenic fluoride contamination in ground waters. Environmental science and technology. 2008;42(10):3662-3668.https://doi.org/10.1021/es071958y.
[7] Ha QK, Ngoc TDT, Le Vo P, Nguyen HQ, Dang DH. Groundwater in Southern Vietnam: Understanding geochemical processes to better preserve the critical water resource. Science of the Total Environment. 2022;807:151345-151360. https://doi.org/10.1016/j.scitotenv.2021.151345.
[8] Omonona OV, Okogbue CO. Hydrochemical evolution, geospatial groundwater quality and potential health risks associated with intake of nitrate via drinking water: case of Gboko agricultural district, central Nigeria. Environmental Earth Sciences. 2021;80(4):126-142. https://doi.org/10.1007/s12665-021-09448-2.
[9] Ahn H, Chon H. Assessment of ground water contamination using geographic information systems. Environmental Geochemistry and Health. 1999;21:273-289. https://doi.org/10.1023/A:100669751209.
[10] Huang G, Song J, Han D, Liu R, Liu C,Hou, Q. Assessing natural background levels of geogenic contaminants in groundwater of an urbanized delta through removal of ground waters impacted by anthropogenic inputs: New insights into driving factors. Science of The Total Environment.2023;857:159527-159532.https://doi.org/10.1016/j.scitotenv.2022.159527.
[11] Meenakshi, Maheshwari RC, Hazard Mater J. Fluoride in drinking water and its removal. Journal of Hazardous materials. 2006;137:456–463. https://doi.org/10.1016/j.jhazmat.2006.02.024.
[12] Simoes FDS, Moreira AB, Bisinoti MC, Gimenez SMN, Yabe MJS. Water quality index as a simple indicator of aquaculture effects on aquatic bodies. Ecological indicators. 2008; 8(5): 476-484. https://doi.org/10.1016/j.ecolind.2007.05.002.
[13] Gregory R. Galvanic corrosion of lead solder in copper pipework. Journal of the Institute of Water and Environmental Management. 1990;4(2):112- 118. https://doi.org/10.1111/j.1747-6593.1990.tb01566.x
[14] Srinivsan JT, Reddy VR. Impact of irrigation water quality on human health: A case study in India. Ecological Economics. 2009;68(11):2800-2807. https://doi.org/10.1016/jecolecon.2009.04.019.
[15] Adewoye AO, Ajibade TT, Adewoye SO, Olagunju TE, Adagunodo TA. "Pollution indices and health risk assessment of heavy metals in floodplain of urban catchment of Asia drainage systems, southwestern Nigeria". Earth and Environmental Science. 2021;655(1):012091-012101. https://doi.org/10.1088/1755-1315/655/1/012091.
[16] Ramakrishna CR, Sadashivaiah C, Ranganna G. 'Assessment of Water Quality Index for the ground water in Tumkur taluk, Karnataka State, India. E-Journal of chemistry. 2009;6(2):523-530. https://doi.org/10.1155/2009/757424.
[17] Vittala SS, Govindaiah S, Gowda HH. Evaluation of groundwater potential zones in the sub-watersheds of North Pennar river basin around Pavagada, Karnataka, India using remote sensing and GIS techniques. Journal of the Indian Society of Remote Sensing. 2005;33:483–493.https://doi.org/10.1007/BF02990733.
[18] SrinivasaVittala S, Govindaiah S,Honne Gowda, H. Morphometric Analysis of Sub-watersheds in the Pavagada Area of Tumkur District, South India Using Remote Sensing and GIS Techniques. Journal of the Indian Society of Remote Sensing. 2004;32(4):351–362.https://doi.org/10.1007/BF03030860.
[19] Nandeesha N, Khandagale V, Mahesh V, Suman AK, Velagapudi MT. Assessment of groundwater quality by integration of water quality index and GIS techniques. In AIP Conference Proceedings. 2020;2204(1):020026-020032.https://doi.org/10.1063/1.5141563.
[20] Pushpa KL, Ravikumar P, Prakash KL. Non-carcinogenic Health Risk Assessment of Fluoride and Nitrate of Groundwater–A Case Study of the Central Dry Zone of Chikkanayakanahalli Taluk, Tumkur District, Karnataka.Journal of the Geological Society of India. 2023;99:1218–1224. https://doi.org/10.1007/s12594-023-2454-2.
[21] Zelana D.Vasopressin in health and disease with a focus on affective disorders.Central Nervous System Agents in Medicinal Chemistry (Formerly Current Medicinal Chemistry-Central Nervous System Agents).2012;12(4):286–303.https://doi.org/10.2174/187152412803760609.
[22] Dhadge VL. House hold unit for the treatment of fluoride, iron, arsenic and microorganism contaminated drinking water. Chemosphere. 2018; 199: 728-736. https://doi.org/10.1016/j.chemosphere.2018.02.087.
[23] Mohapatra M, Anand S, Mishra BK, Giles DE, Singh P. Review of fluoride removal from drinking water. Journal of environmental management. 2009;91:67–77.

https://doi.org/10.1016/j.jenvman.2009.08.015.
[24] Shimelis B, Zewge F, Chandravanshi BS. Removal of excess fluoride from waterby aluminium hydroxide. Bulletin of the Chemical Society of Ethiopia. 2006;20(1):17-34. https://doi.org/10.4314/bcse.v20i1.21140.
[25] Featherstone JD. Prevention and reversal of dental caries: role of low levelfluoride. Community dentistry and oral epidemiology. 1999;27(1):31-40. https://doi.org/10.1111/j.1600-0528.1999.tb01989.x
[26] Subba Rao N. Seasonal variation of groundwater quality in a part of Guntur District, Andhra Pradesh, India. Environmental geology. 2006;49:413-429. https://doi.org/10.1007/s00254-005-0089-9.
[27] Cohen B, Lazarovitch N, Gilron J. Upgrading groundwater for irrigation using monovalent selective electrodialysis. Desalination. 2018;431:126-39.https://doi.org/10.1016/j.desal.2017.10.030.
[28] Naidoo S, Olaniran AO. Treated wastewater effluent as a source of microbial pollution of surface water resources. International journal of environmental research and public health. 2014;11(1):249-270.https://doi.org/10.3390/ijerph110100249.
[29] Prambudy H, Supriyatin T, Setiawan F. The testing of chemical oxygen demand(COD) and biological oxygen demand (BOD) of river water in Cipager Cirebon. International Journal of Physics. 2019;1360:012010-012017.https://doi.org/10.1088/1742-6596/1360/012010.