



Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/10956
DOI URL: <http://dx.doi.org/10.21474/IJAR01/10956>



RESEARCH ARTICLE

SPRING WATER- A POSSIBLE SOURCE OF DRINKING WATER AT THE TIME OF MIDSUMMER IN COASTAL BELT OF KARNATAKA - A CASE STUDY OF RAMATHIRTHA-GOKARNA, INDIA

Gajanan Hegde

Senior Associate, Indian Institute for Human Settlements (IIHS), Bengaluru.

Manuscript Info

Manuscript History

Received: 12 March 2020

Final Accepted: 14 April 2020

Published: May 2020

Key words: -

Spring Water, Ramathirtha, Mineral water, Dissolved Oxygen, Turbidity

Abstract

The huge scarcity of drinking water is the major problem faced by the coastal belt of Karnataka at the time of midsummer since from past three to four years. The open well drinking soft water sources are completely become dry or they get salt water due to the influence of sea water near the coastal belt. The present study is based on the analysis of spring water sources at Ramathirtha of Gokarna situated in India for its quality with respect to potable drinking water. In recent years many countries have started use of spring water as the source drinking water as they have a quality almost equals to specification given for drinking water [1]. The spring water at its origin doesn't contain any pollutants and it is to be considered as mineral water or the bottled water as it contains essential minerals from the rock beds. The specification for the drinking water quality in India has given by IS 10500:2012, CPCB classification of Water and WHO guidelines are considered here to classify the spring water quality. Physico-chemical parameters like pH, Turbidity, Conductivity, Sulphates, Hardness, Total alkalinity, Nitrates, Chloride, DO, BOD, TDS, TSS and Microbiological parameters are measured in this study reveals that suitability of spring water for drinking purpose and has a good content of minerals. Both the spring water and open well water samples at the time of midsummer were collected for comparing the quality of drinking water. This case study was undertaken in the month of April-May of three consecutive years and the water quality is found to belong to Class 'A' of Drinking water. Hence, it has been suggested that spring water source can be used as a source of drinking water at coastal area and it may be considered as a permanent source of natural mineral water in near future at the coastal belt of Karnataka.

Copy Right, IJAR, 2020,. All rights reserved.

Introduction:-

Increase in urbanization, industrialization, agricultural activity and various human activities have increased the pollution of surface water and ground water. As the safe and potable drinking water is needed, various treatment methods are adopted to raise the quality of drinking water. Water should be free from the various contaminations viz. Organic & inorganic pollutants, heavy metals, pesticides etc. As well as its parameter like pH, electrical conductivity, alkalinity, total hardness, TS, TDS, turbidity, Sulphate content, dissolved oxygen should be within a permissible limit. Spring waters are considered to be having more essential mineral content and suitable for drinking

Corresponding Author: -Gajanan Hegde

Address: -Senior Associate, Indian Institute for Human Settlements (IIHS), Bengaluru.

purpose compared to open well water. Spring is a kind of water resource. It is formed when the side of a hill, a valley bottom or other excavation intersects a flowing body of groundwater at or below the local water table, below which the subsurface material is saturated with water. A spring is the result of an aquifer being filled to the point that the water overflows onto the land surface. They range in size from intermittent seeps, which flow only after much rain, to huge pools flowing hundreds of millions of gallons daily [2].

In this present study a case of ramathirtha spring water from gokarna-a holy pilgrim place of Karnataka, India is taken into consideration for explaining the importance of spring water sources at coastal belt of Karnataka. In the history it is mentioned in the Ramayana that Rama came to know from vasistha that ravana was a Brahmin. To be relieved from the sin lord brahma kept his kamandal (holy jug) upon the peak of the mountain and who went away the satyaloka (heaven). It is being famed as HOLY KAMANDAL. So many penance purifacteries dwelled here and penance themselves besides gaining their will powered desires. The same holy places and cylindrical image are shining brightly till today also.

Rama came to gokarna accompanied by seeta by laxmana on the piligrimage. Rama after creating a teerta performed penance to propitiate mahadeva. It is said that he who takes bath in the holy waters of ramathirtha and worships rama at ramanavami day reciting ashtakshari japa is to be freed from the sin of brahmahatya.

Ramathirtha is the beautiful location in gokarna. It is about 2 km away from gokarna. Gokarna is a famous historical town which is nearer to Ankola (26km) & Kumta (32km). Ramateerta is a situated on the gokarna main beach road at a distance of about 1km. The area of ramateertha is the about 51sq.meters. An artificial water tank which is 20 steps below the ground level is very spacious was constructed here to take bath by the pilgrims. The spring water from a height at the middle of the hill falls in to this tank from two different points called Ramateertha & Laxmanateertha. Thus ramateertha is considered to be holy water for drinking purpose. Even till date water still flows after 1000s of years even if there is a severe drought. Daily many peoples are coming to ramateertha and take the water for the drinking purposes. Daily many foreign peoples are coming here to take meditation and taking the natural breeze in evening times. Thus it is a holy place to cool mind, meditation etc [3].

Sample collection:

The water samples were collected in plastic bottles in the month of April of two consecutive drought years viz; 2018, 2019 and 2020 at the midsummer season. The samples were collected from three sampling sites and noted as Site 1, 2 (Ramathirtha) and 3 (Laxmanthirtha) as shown below fig 2. All the sampling procedures followed here are with respect to standard methods prescribed by APHA (American public health association 1995) [4]. The collected samples are brought to laboratory for analysis and stored in the deep freezer at 4⁰ C up to the completion of analysis. The analyzed result of each sample was compared with ISO 10500:2012, Drinking water quality and WHO (World Health Organization 1993) standards [5, 6].

Geographical location & sampling sites:

The present study is focused on the two source of spring water viz; Ramahirtha and Laxmanathirtha collected from Gokarna town, Karwar district, Karnataka State, India. The spring Water is naturally coming from the rock & soil of the mountains or the hill. The hill Rocks are made of one or more minerals. The three sampling sites and sample collection area are shown in the below fig 1 and 2.



Figure1:- Sampling sites at Ramathirtha and the location of gokarna on the map of Uttar Kannada district.



Figure 2:- Sampling location of Ramathirtha and Laxmanathirtha at Gokarna.

Materials and Methods:-

All the chemicals used here in this analysis are of analytical grade and purchased from Himedia Company. The samples collected in polythene bottles are stored in deep freezer till the completion of analysis.

Physico-chemical Assessment:

The physico-chemical parameters of water quality will analyze using standard methods given by APHA, IS 10500:2012 & WHO. The analytical procedure given by NEERI manual of water pollution is also referred for the laboratory analysis. [7]

The work was carried out on the following lines.

1. Physico-chemical characterization of drinking water quality such as pH, hardness, total alkalinity, sulphate, calcium, BOD, temperature, dissolved oxygen(DO), total dissolved solid(TDS), turbidity, conductivity, Nitrates etc. [8]
2. Microbiological analysis carried out for total coliform and fecal coliform.
3. Data processing by using statistical methods.

Table 1:- Method of Analysis.

Serial no.	Studied parameter	Method used
1	Temperature	Recorded by digital thermometer
2	pH	Recorded by pH meter
3	Total alkalinity	Titrimetric
4	Hardness	EDTA titration method
5	Conductivity	Recorded by Conductivity meter
6	Turbidity	Recorded by turbidity meter

7	Sulphate	Spectrophotometric
8	DO	Modified Winkler's method
9	BOD	Modified Winkler's method
10	Nitrates	Spectrophotometric
11	Sodium	Flame Photometer
12	Potassium	Flame Photometer
13	TDS	Gravimetric
14	TSS	Gravimetric
15	Microbiological analysis	MPN method and Fecal coli form

Result and Discussion: -

The laboratory analyses are carried out by following the standard procedures mentioned in the IS 10500:2012 Drinking water quality and American public health association (APHA). The guidelines give by CPCB and WHO for classification and analysis of water and waste water are also considered for the complete analysis of collected samples [9, 10]. The analysed tests results are tabulated in the below table no. 2 and 3.

Temperature:

Temperature is a physical quantity is measured by using potable pen type thermometer. It is denoted in $^{\circ}\text{C}$. It affects to conductivity and solubility of the sample. The temperature ranges of ramateertha and laxmanathirtha water samples is found to be 26.8-27.7 $^{\circ}\text{C}$ at the time sampling.

pH:

In chemistry pH (potential of Hydrogen) is a logarithmic scale used to specify the acidity or basicity of an aqueous solution(sample). It is approximately the negative of the base 10 logarithm of the molar concentration measured in units of mol/liter. Highly acidic or basic water pH is regarded as dangeourous to human health as it contains high range of dissolved mineral ions. The pH range 6.5 to 8.5 is the acceptable level as given in the IS 10500:2012, drinking water quality.

$$\text{pH} = -\log[\text{H}^+]$$

$\text{pH} < 7 = \text{acidic}$
 $\text{pH} > 7 = \text{basic}$
 $\text{pH} = 7 = \text{neutral}$

The analysed samples of Ramathirtha and Laxmanthirtha spring waters have shown pH in the range of 5.76 to 7.07.

Conductivity:

It is a measure of materials ability to conduct an electric current. It is measured in terms of unit mS. The conductivity of Ramateertha and laxmanthirtha spring water are found to be falls in the range from 0.04 to 0.13 mS.

Total alkalinity:

Total alkalinity is the total concentration of bases and total dissolved solids (TDS) in water expressed as parts per million (ppm) or milligrams per litre(mg/l) of calcium carbonate (CaCO_3).

$$\text{Total alkalinity} = \frac{A \times B \times N}{\text{Sample volume}}$$

Where, A = amount of acid used to reach neutralization point (ml)

N = Normality of acid

B = Eq. wt of CaCO_3 in mg/l.

The analysed samples have shown results of alkalinity in the range of 8 to 24 mg/l.

Table 2:- Water Quality Analysis Results for the month of April 2018 and 2019.

Parameter	Sample site 1		Sample site 2		Sample site 3	
Latitude	14 ⁰ 32 22.80"		14 ⁰ 32 36.5492"		14 ⁰ 32 23.2869"	
Longitude	74 ⁰ 18 44.91"		74 ⁰ 18 55.0944"		74 ⁰ 18 46.8182"	
Year	2018	2019	2018	2019	2018	2019
Temperature $^{\circ}\text{C}$	26.8	26.8	26.9	26.8	27.7	26.2

pH	6.95	6.85	7.07	7.10	6.76	6.52
Conductivity mS	0.04	0.04	0.13	0.12	0.04	0.04
Total alkalinity mg/l	24	23	20	21	8	10
Turbidity NTU	2.8	2.9	1.6	1.7	1.2	1.3
Hardness mg/l	2.9	2.8	7.3	8.2	7.6	7.2
TDS mg/l	36	37	38	38	55	56
TSS mg/l	490	485	492	491	489	456
TS mg/l	526	525	530	532	544	536
DO mg/l	6.8	6.9	6.7	6.8	6.6	7.2
BOD mg/l	1.8	1.9	1.2	1.9	2.0	1.9
Sulphate ppm	<5	<5	21	20	<5	<5
Nitrate mg/l	18.00	20.21	24.02	24.05	23.20	23.50
Sodium mg/l	20.21	21.20	20.31	21.20	20.32	20.10
Potassium mg/l	3.75	3.23	2.25	2.12	3.10	3.12
Total Coliform cfu	ND	ND	ND	ND	ND	ND
Fecal coliform cfu	ND	ND	ND	ND	ND	ND

Table 3:- Water Quality Analysis Results for the month of March 2020.

Parameter	Sample site 1	Sample site 2	Sample site 3
Latitude	14 ^o 32 22.80"	14 ^o 32 36.5492"	14 ^o 32 23.2869"
Longitude	74 ^o 18 44.91"	74 ^o 18 55.0944"	74 ^o 18 46.8182"
Temperature °C	26.7	26.6	27.8
pH	6.90	7.02	6.70
Conductivity mS	0.04	0.12	0.04
Total alkalinity mg/l	22	21	10
Turbidity NTU	2.1	1.5	1.2
Hardness mg/l	2.9	7.0	7.2
TDS mg/l	36	41	52
TSS mg/l	485	490	484
TS mg/l	522	531	541
DO mg/l	6.6	6.8	7.6
BOD mg/l	1.8	1.9	1.8
Sulphate ppm	<5	18	<5
Nitrate mg/l	21.20	20.23	19.20
Sodium mg/l	20.00	18.95	22.52
Potassium mg/l	3.25	2.21	3.10
Total Coliform cfu	ND	ND	ND
Fecal coliform cfu	ND	ND	ND

Turbidity:

Turbidity is the cloudiness or laziness of fluid caused by large numbers individual particles that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality. It is measured in NTU. The analysed result of Ramathirtha and laxamanthirtha water turbidity is found to be in the range of 1.2 to 2.8 NTU.

The below pie chart fig. 3 represents the variation of turbidity and BOD with respect to three sampling sites.

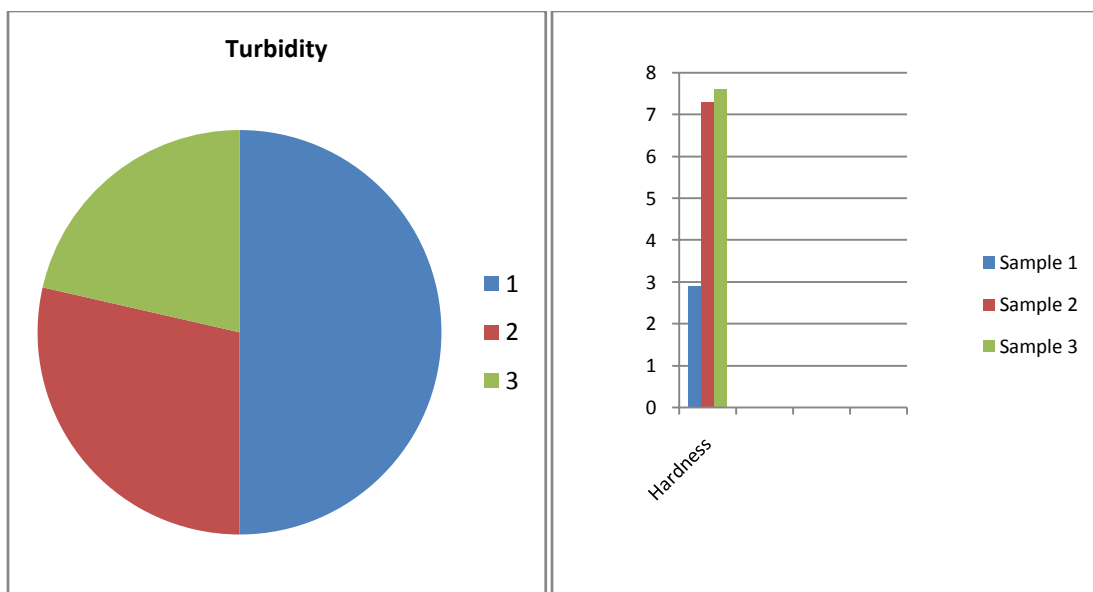


Figure 3:- Variation of Turbidity and Hardness among the three samples.

Hardness:

Hardness of water is a parameter of water that has high mineral content. Hard water is formed when water percolates through deposits of limestone and chalk which are largely made up of calcium and magnesium carbonates. Hard drinking water may have moderate health benefits but can impose critical problems in industrial settings.

$$\text{Hardness} = \frac{A \times N \times 1000}{\text{ml of sample taken}}$$

A = volume of EDTA consumed (ml)

N = normality of EDTA

The analysed results of Ramateertha and Laxmanthirtha spring water samples hardness found to be in the range of 2.9-7.6 mg/l. Based on the results the sample 3 has little more hardness as compared with other two. The variation of hardness with respect to three sampling sites as shown below fig 3.

Total Dissolved Solids (TDS):

Dissolved solids refer to any minerals, salts, metals, cations or anions dissolved in water. Total dissolved solids (TDS) comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulphates) and some a small amount of organic matter that are dissolved in water. TDS analysis of spring water samples are carried out by using evaporation method. The sample was taken in a clean and dry china dish and heated to evaporate, cool, desiccated and finally of TDS (total dissolved solids) of samples are calculated by weight loss method. The analysed samples results of TDS is found to be in the range of 36-56 mg/l.

Total Suspended solids (TSS):

Total suspended solids are solids in water that can be trapped by a filter. TSS can include a wide variety of material such as silt, decaying plant and animal matter, industrial wastes and sewage. High concentrations of suspended solids can cause many problems for stream health and aquatic life.

TSS parameter is done by filtration method. Take the sample in clean and dry beaker and poured to another beaker using funnel with filter paper. Note down the weight of TSS. The analysed results of TSS is found to be in the range of 489-492 mg/l.

Total Solids (TS):

As the name suggest, it is the sum of total dissolved solids and total suspended solids present in the water.

$$\text{TS} = \text{TDS} + \text{TSS}$$

The analysed spring water sample contains the total solids in the range of 526-544 mg/l. This range of total solids are within the permissible limits prescribed by IS 10500:2012 and WHO.

DO:

Dissolved Oxygen is the amount gaseous oxygen dissolved in the water. Oxygen enters the water by direct absorption from the atmosphere, by rapid movement or as a waste product of plant photosynthesis. Water temperature and the volume of moving water can affect dissolved oxygen levels.

DO analysis is carried by using modified Winkler's method. It's a titrimetric method of analysis described in IS 10500:2012 and also in CPCB guide manual for water and waste water analysis.

$$DO = A \times N \times 1000$$

Sample taken

A = Sodium thiosulphate consumed (ml)

N = Normality of $\text{Na}_2\text{S}_2\text{O}_3$

The analysed sample a result shows that amount of dissolved oxygen in the collected springs sample was found to be in the range of 6.6 -7.6 mg/l. The central pollution control board classification for class water says that the DO should be 6mg/l or more. The graphical representation of variation of DO as shown in the fig. 4.

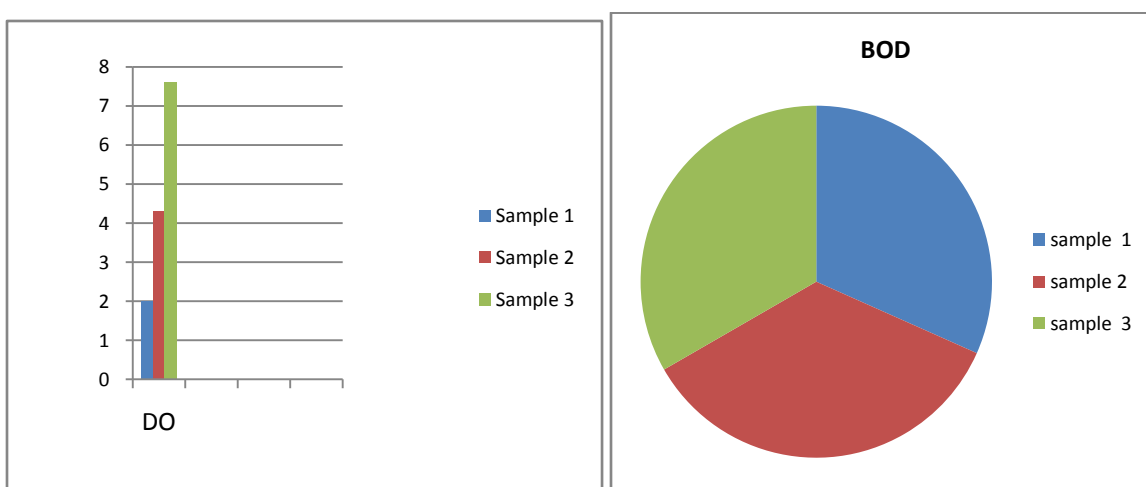


Figure 4:- Variation in DO and BOD.

Bio Chemical Oxygen Demand (BOD):

Biochemical Oxygen Demand is the amount of dissolved Oxygen needed by aerobic biological organisms to breakdown organic material present in a given water sample at certain temperature over a specific time period. The BOD value is most commonly expressed in milligrams of oxygen consumed per liter of sample during 3 days of incubation at 20°C and is often used as a surrogate of the degree of organic pollution of water.

The method used here is modified Winklers method (titration against $\text{Na}_2\text{S}_2\text{O}_3$). The first day DO and the third day DO after incubation is measured. Thus, the actual biological oxygen demand is to be calculated by using following formulae.

$$BOD = (D_1 - D_2) \times 1000$$

Water sample taken

D_1 = 1 day DO

D_2 = 3 day DO after incubation.

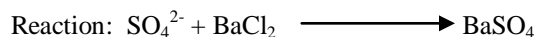
The analysed result of BOD is found to be in the range of 1.8-2.2 mg/l. The BOD of drinking water should equals to 2 mg/l is considered as class A of drinking water as per guidelines given by central pollution control board. The results are graphically showed in fig 4.

Sulphate:

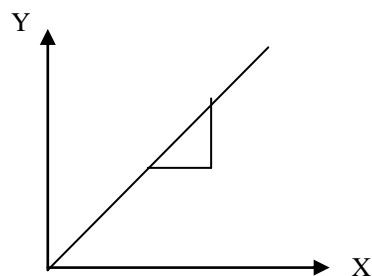
It can be found in almost all natural water. The origin of most sulphate compounds is the oxidation of sulphate ores, the presence of salts, or the industrial wastes. Sulphate is one of the major dissolved components of rain. High concentrations of sulphate in the water we drink can have laxative effect when combined with calcium and

magnesium, the two most common constituents of hardness. Bacteria, which attack and reduce sulphates, form of hydrogen sulphide gas (H₂S).

The maximum level sulphate suggested by WHO in the guidelines for drinking water quality is 500 mg/l and EU standards (1998) maximum of 250 mg/l of sulphates in water intended for human consumption. The sulphate is determined by spectrophotometric method.



The absorbance of the barium sulphates formed is measured by spectrophotometer at 420 nm & the sulphate ion concentration is determined by comparing of the reading with standard curve.



$$\text{Slope} = \frac{AB}{BC} = m$$

From the calibration graph: Y = absorbance of the sample
X = concentration of sulphate.

From graph, $Y = mX + C$

$$X = Y/m, C = 0$$

Concentration of sulphate in mg/l = $\frac{X \times 1000}{\text{ml of sample}}$

Concentration = ----- mg/l.

The analysed spring samples of ramathirtha and laxmanthirtha shows that the sulphate present in the water is found to be range of < 5 ppm to 21 ppm.

Sodium and Potassium:

The metals like sodium and potassium are analysed by using Flame photometer. The results are formulated by comparing with the standard sodium and potassium graph. The amount of sodium and potassium found in the collected spring water samples are within the limit prescribed by IS 10500:2012 Drinking water quality and WHO. Hence, it can be said that spring water from ramathirtha and laxmanthirtha has quality of natural mineral water or bottled water.

Nitrates:

Nitrate present in the spring sample was measured by using spectrophotometric method. The results obtained by the standard nitrate graph are compared with the sample and actual amount of nitrates present in the samples were tabulated. The results obtained by the spectrophotometric method shows that nitrate present in the samples are in the range of 18.0 to 24.05 mg/l.

Microbiological Analysis:

The microbiological analysis is important to identify the microorganisms presents in the water sample. This data tells about presence of bacteria in the water. The total coliform and the fecal coliform analysis were carried out in the laboratory. The fecal coliforms are the results from human and animal wastes. Fortunately, there is no total coliform and the fecal coliforms are found in the water samples. All the samples are free from any kind of microorganisms.

Table 4:- Drinking water quality acceptable limits given by IS 10500:2012 and WHO.

Sl.No	Parameters	IS 10500:2012	WHO
1	Temperature	No limit	No limit
2	pH	6.5-8.5	6.5-8.5

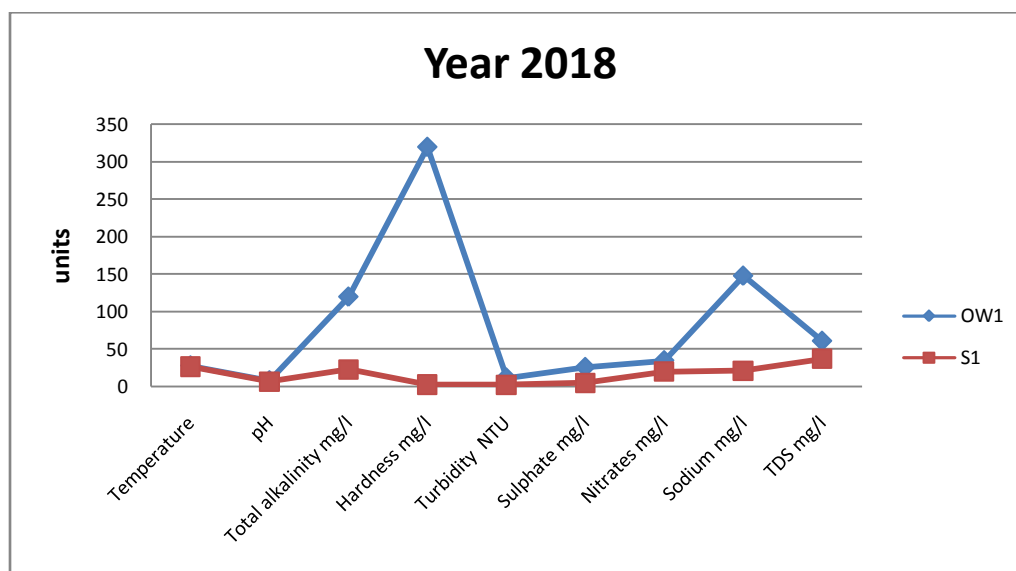
3	Total alkalinity mg/l	200	--
4	Hardness mg/l	200	500
5	Turbidity NTU	5	5
6	Sulphate mg/l	150	400
7	Nitrates mg/l	45	10
8	Sodium mg/l	--	200
9	TDS mg/l	500	1000
10	Microbiological analysis cfu	Shall not be detectable In any 100 ml sample	Shall not be detectable In any 100 ml sample

The above results of spring water quality parameters are compared with the quality of open well water collected from Gokarna city in the month of April/May 2018 and 2019. The water samples collected from those three open wells at the heart of gokarna city are labeled as OW1, OW2 and OW3 and analysed in the laboratory for their classification of water quality parameters as per the standard protocols [11]. The results obtained by the laboratory analysis of open well water sources are tabulated in the below table no. 5.

Table 5:- Water Quality Analysis Results of open well waters for the month of April/May 2018 and 2019.

Sl.No	Parameters	2018			2019		
		OW1	OW2	OW3	OW1	OW2	OW3
1	Temperature	28.2	28.5	27.1	28.1	27.8	26.8
2	pH	8.1	7.8	7.9	8.2	8.1	7.9
3	Total alkalinity mg/l	120	122	132	120	124	128
4	Hardness mg/l	310	276	220	320	278	235
5	Turbidity NTU	10	07	08	12	09	10
6	Sulphate mg/l	25	32	28	26	30	29
7	Nitrates mg/l	36	32	38	35	31	35
8	Sodium mg/l	150	142	135	148	145	138
9	TDS mg/l	62	59	58	61	58	60
10	Microbiological analysis MPN/100 ml	<2	<2	<2	<2	<2	<2

The above result shows that the water from the entire three open well sources is highly contaminated and has an influence from sea water. It observed that high level of pH, turbidity and the hardness present in the water samples. The variation of Physico chemical parameters of open well water OW1 compared with Spring water S1 with respect to year 2019 can be shown graphically as in below fig. 5.



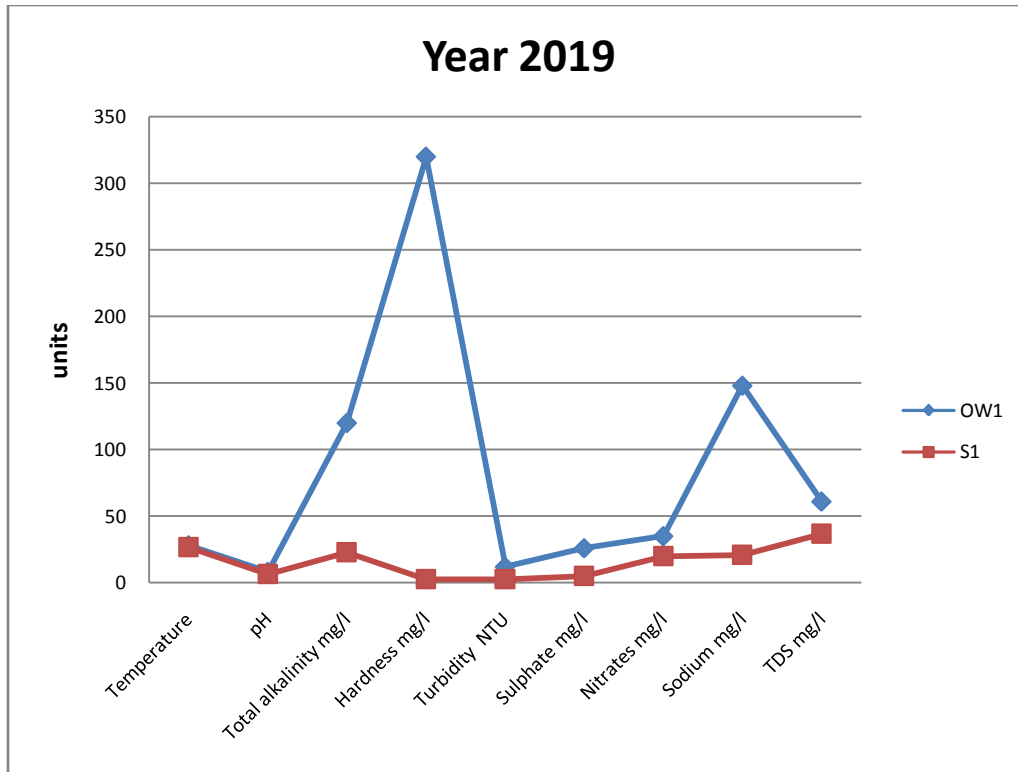


Figure 5:- Variation of drinking quality of OW1 and S1 with respect to year 2018 and 2019.

It is found that open well water at the midsummer time completely lost its characteristics of drinking water quality and therefore not suitable for drinking purpose. Hence, the spring water may be the possible source of drinking water for the people who residing in the gokarna in near future at the time of midsummer. The source of spring water doesn't require any treatment process and it can be serve as good quality drinking water for rural poor people of gokarna. In 2018 H.S. Anathanarayan et al have analysed water sample collected from kotithirtha lake of gokarna and found the quality of lake water is belonging to Class "E" of drinking water as described by CPCB [12]. Thus, the surrounding settlements of ramathirtha and laxmanthirtha can consume spring water source as a drinking mineral water as the quality of spring water belongs to Class "A" of water specification prescribed by central pollution control board.

Conclusion:-

The water samples of ramathirtha and laxmanathirtha spring water sources have shown good characteristics of drinking water specification. The Physico-chemical and Microbiological results drawn from the all the three spring water samples complies the specification given by IS 10500:2012 and WHO guidelines for drinking water quality. Simultaneous estimation of water samples from the three open wells of gokarna at the time of midsummer have shown very poor quality of drinking water and all are unfit for drinking purpose. Therefore, it has been concluded that spring water source is the alternate source of drinking water at the time of midsummer in the coastal area of Karnataka, India. In the midsummer time from March to May, severe drought occurs in the coastal Karnataka and the open well soft water sources and ground water sources gets influenced by seawater and hence gets contaminated and it may become hard water. The hard water thus obtained is neither fit for drinking purpose nor for washing and bathing. The spring water contains essential minerals like Na, Ca, Fe, Mg etc within the limit and hence it can be supplied as bottled drinking water to the surrounding villages.

Acknowledgement:-

Author of this article is grateful to Post graduate students of G.C. College (2017-2019 batch) for their invaluable help with respect to collecting samples and assisting for the analysis of samples in the laboratory.

References:-

1. Azza Daghara, Issam A. Al-Khatib and Maher Al-Jabari, 'Quality of drinking water from springs in Palestine-west bank as a case study', Journal of Environmental and public Health, 2019.
2. https://www.usgs.gov/special-topic/water-science-school/science/springs-and-water-cycle?qt-science_center_objects=0#qt-science_center_objects.
3. <https://en.wikipedia.org/wiki/Gokarna>, Karnataka.
4. APHA (2000), Standard methods for the Examination of water and waste water, 10th Edition, American Public Health Association (1995), Washington DC.
5. Indian Standard DRINKING WATER – SPECIFICATION (Second Revision) IS 10500:2012.
6. World Health Organization. Guidelines for drinking water quality (electronic resource): incorporating first addendum. Vol. 1 recommendations - 3rded.
7. NEERI, Manual of water pollution and control, 1991, 1-9.
8. Cowan, P. A.; Porcella, D. B.; Adams, V. D.; and Gardner, L.A., "Water Quality Analysis Laboratory Procedure Syllabus" (1978). Reports; Paper 520.
9. CPCB guide manual for analysis of water and waste water, 2012, 1-186.
10. Analysis of drinking water" by S.P. BHALME, Dr. P.B. NAGARNAIK in the paper of IJERA (International Journal of Engineering Research and Applications Vol. 2, 2012 pp. 3155-3158.
11. SS Sagar, RP Chavan, CL Patil, DN Shinde, SS Kekane publish "Physico-chemical parameters for testing water- A review "in International Journal of Chemical Studies (2015);3(4): 24-28.
12. H.S. Ananth Narayan, Tina Beretto, Anupama Desai and Gajanan Hegde, ' Water Quality Assessment of Kotithirta- A Holy Temple Lake of Gokarna'-Karnataka, IJRET, Vol 3, Issue 5, Apr 2018.p 624-634.