Research article Available online www.ijsrr.org ISSN: 2279–0543

International Journal of Scientific Research and Reviews

"Physico-Chemical And Microbiological Analysis Of Groundwater In Bathindi, Jammu, (J&K)"

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ABSTRACT

Drinking water quality of a tube well and its two distribution points viz. Narwal pumping station, home and tap in a lane, supplied by Public Health Engineering department in Bathindi area, was analyzed bi-monthly for a period of four months viz. February, 2018 – May, 2018 and has been described. Comparison of various physico-chemical (temperature, total dissolved solids, pH, electrical conductivity, dissolved oxygen, free carbon dioxide, carbonate, bicarbonate, chloride, calcium, magnesium, total hardness and biological oxygen demand) and microbial quantitative (MPN index/100ml.) parameters with National and International standards at three sites of Bhathindi area, evinces that all the parameters are within permissible limits. The water quality comes under the category of satisfactory except for 2nd and 4th (Tubewell, Home and Tap), 1st and 6th (Home and Tap), 7th (Tubewell) and 8th (Tubewell and Tap) readings which is due to entry of sewage and soil sediments in the distribution pipes. Analysis of co-efficient matrix has shown significant results with various parameters at three sites. All the ground water samples of site I show Water Quality Index (WQI) less than 50 and is indicative of water quality that is suitable for drinking without causing health problems. But some water samples show WQI above 50 at both consumer points which is indicative of water quality that is not suitable for drinking and can cause health problems.

KEYWORDS: Groundwater, distribution, physico-chemical, MPN index/100 ml., water quality index.

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INTRODUCTION

Groundwater is an important source of drinking water for mankind. It contains over 90% of fresh water resources, is an important reserve of good quality water and it is also used for agricultural, industrial, household, recreational and environmental activities all over the world. The quality of ground water varies from place to place, with the depth of water table and from season to season and is primarily governed by the extent and composition of dissolved solids present in it. In recent years, an increasing threat to ground water quality due to human activities has become of great importance. The adverse effects on ground water quality are the results of man's activity at ground surface, unintentionally by agriculture, domestic and industrial effluents, sub-surface and surface disposal of sewage and industrial wastes. The quality of ground water is of great importance in determining the suitability of particular ground water for a certain use. The quality of water may be described according to the physico-chemical and microbiological characteristics[1].

J&K State is located in the northern part of India. In this study, Narwal-Bathindi area of Jammu district area is selected. The Jammu district is located at 32° 44´ N Latitude and 74° 52´ E Longitude, at an altitude of 753 feet, above mean sea level. The study was conducted from February, 2018 to May, 2018. Total 24 samples from 3 different locations were collected, 8 from each site. 8 samples were taken from Narwal pumping station and 16 samples were taken from two distribution points i.e. home and tap in lane in Bathindi area, for which there is no published record available till date.

EXPERIMENTAL SECTION

MATERIALS AND METHODS

Physico-chemical and Microbiological Analysis:

Bi-monthly, water samples from the three sampling sites were collected in the sterilized and clean plastic bottles for physico-chemical analysis of water by standard methods and pre-sterilized BOD bottles for bacteriological analysis by multiple tube method[2].

Co-efficient of correlation:

Co-efficient Matrix and Co-efficient of correlation (r) of MPN index per 100 ml. was calculated.

Water Quality Index:

Water Quality Index was calculated for assessing the suitability of ground water for drinking purposes[3,4] by following equation:

$$\mathbf{WQI = 9\sum_{n=1} qn.Wn}$$

RESULTS AND DISCUSSION

PHYSICO-CHEMICAL CHARACTERISTICS:

The results of physico-chemical characteristics of three sampling sites have been tabulated in Table 1.

Temperature:

Air temperature varied from 17°C to 35°C / 16°C to 29°C / 17°C to 32°C at all three sites, respectively. Lowest value is observed in the month of February and highest in May of present investigation.

At all three sites, water temperature ranged between 23°C and 29°C / 20°C and 27°C / 21°C and 32°C, respectively. Thermostatic characteristics of ground water may explain narrow variation in water temperature. Increased solar radiation due to comparatively longer day length, may explain May rise in air and water temperature[5]. The difference in temperature is due to the seasonal variations[6].

pH:

pH varied between 6.66 and 7.21 / 7.15 and 7.68 / 7.41 and 7.66 at all three sites, respectively[7,8,9,10,11]. This variation may be due to variation in free carbon dioxide, dissolved oxygen, caused during agitation of water in pipes. An inverse relationship of pH with free carbon dioxide and direct with dissolved oxygen is already on record[5].

Electrical Conductivity:

Electrical conductivity ranged from 0.265mS/cm and 0.704mS/cm / 0.26mS/cm and 0.537mS/cm / 0.266mS/cm and 0.402mS/cm. March and April increase in electrical conductivity at Site I and Site III may be attributed to the rains. Chemostatic characteristics of ground water may explain a narrow difference of electrical conductivity record[5]. Variable records of mineral constituents like bicarbonate, chloride, calcium, magnesium, total hardness, etc. may explain variations in electrical conductivity. The variable rate of infiltration of domestic waste is known to increase electrical conductivity[5].

Total Dissolved Solid:

At all three sites of study area, TDS varied between 0.133mg/l and 0.354 mg/l / 0.21 mg/l and 169 mg/l / 0.2 mg/l and 193.7 mg/l, respectively, and the water is suitable for drinking purposes. Lowest value is observed in the month of February and highest in March at Sites I and III. Lowest value is observed in the month of February and highest in May at Site II. The higher value is due to the presence of salts in high amount, because of high rate of leaching during the rainy day.

Dissolved Oxygen:

Dissolved oxygen remained fairly present throughout the study period and has shown variation from 3.63 mg/l and 5.45 mg/l / 3.63 mg/l and 10.9 mg/l / 4.45 mg/l and 12.72 mg/l, at all three sites of study area, respectively. Its highest record is in the month of March and lowest value in the month of May[7,11,12]. The variation in the dissolved oxygen is due to aeration of water during pumping, variable records of temperature, free carbon dioxide, dissolved solids, microbes and decomposition of organic matter[12].

Biochemical Oxygen Demand:

BOD ranged between 0.57 mg/l and 1.81 mg/l / 0.57 mg/l and 5.45 mg/l / 1.05 mg/l and 5.45 mg/l[12,13,14]. A good amount of dissolved oxygen in water and good filtration of water by rocks in the catchment has correlation with variable records of BOD in the ground water[12]. Growth of algae at breakage points of pipes and sewage contamination during crossing pipes underground or through drains lead to increase in BOD values in the water[12].

Free Carbon Dioxide:

At Site I**,** free carbon dioxide varied between 8.85mg/l to 44.27mg/l; at Site II, it was present only in 3 samples and varied between 8.85mg/l to 17.7mg/l and at Site III, showed its presence in 4 samples and ranged between 15mg/l and 17.7mg/l[5,15]. Agitation of water during its pumping from ground through pipes lead to loss of free carbon dioxide and also responsible for the carbonate absence[5]. Well marked variations in free carbon dioxide in tap water may be due to agitation of water during its flow through pipes, deposits of biofilms inside the pipes and entry of organic matter along with soil sediments and sewage through pipes during crossing of pipes in the drains, etc. and its microbial decomposition[5].

Carbonate:

Carbonate was present in 5 (Site II) samples and 4 samples (Site III) and ranged between 5.35mg/l and 120.65mg/l and 4.46mg/l and 12.06mg/l, respectively. Carbonate remains generally absent in groundwater but its presence in consumer points may be due to the entry of sewage, sediments etc in the pipes through back siphonage, cracks, dislocation, defective joints breakage etc.[5].

Bicarbonate:

Bicarbonate varied between 269.85 mg/l and 409.53 mg/l / 134.92 mg/l and 299.33 mg/l / 171.72 mg/l and 247.62 mg/l[16,17]. It recorded highest record in the month of February and lowest value in the month of April at Sites I and III, respectively. Variations in bicarbonate in ground water may be due to variable records of bicarbonate minerals in rocks and soil and their dissolution in water, microbial decomposition of organic matter and variable infiltration rate of surface run off[18]. Percolating carbon dioxide enriched water increases the solvent action of the water due to the breakage in the pipelines, carbon dioxide and organic matter in the vicinity and its decomposition[5].

Chloride:

Chloride ranged between 24.6 mg/l and 35.26 mg/l / 11.48 mg/l and 24.09 mg/l / 12.22 mg/l and 22.96 mg/l[19,20]. Its highest record is observed in the month of April and May and lowest value in the month of March at Sites I and III, respectively. The concentration of chloride in water samples is generally due to the low deposits of chloride in rocks in catchment area, variable deposits of organic matter in the soil and sewage infiltration[5,12]; domestic waste, poor sanitary conditions and leaching[21].

Calcium, Magnesium and Total Hardness:

At all three sites, calcium, magnesium and total hardness fluctuated between 47.29 mg/l and 197.17 mg/l / 24.9 mg/l and 109.44mg/l / 7.74 mg/l and 86.85 mg/l; 0.52 mg/l and 31.45 mg/l / 4.95 mg/l and 22.23 mg/l / 3.12 mg/l and 28.74 mg/l and 144.84 mg/l and 580.5 mg/l / 91.2 mg/l and 359.56 mg/l / 32.18 mg/l and 318.41 mg/l, respectively[22,23]. Their highest record is in the month of May and lowest value in the month of March and April at Sites I and III, respectively. This variation may be coincided with nature and weathering of rocks in the catchment and water depth, variable records of free carbon dioxide, variable deposits of organic matter in the soil and sewage infiltration[5]; entry of sewage and sediments through leakage in the pipes, microbial decomposition of dead organic matter and deposits of biofilms inside the pipes, dead ends[12].

Table No. 1: "Comparison of water quality with National and International standards"

Stations→	Site 1		Site 2		Site 3		WHO (2008)		BIS (2012)	
Parameters↓	Min.	Max.	Min.	Max.	Min.	Max.	Desirable Limit	Permissible limit	Desirable Limit	Permissible limit
Air Temp. (°C)	17	35	16	29	17	32				
Water Temp. (°C)	23	29	20	27	21	32				
pH	6.66	7.21	7.15	7.68	7.41	7.66	6.5-8.5	No relaxation	6.5-8.5	No relaxation
EC (mS/cm)	0.265	0.704	0.266	0.537	0.266	0.402		1500*	3000	
TDS (mg/l)	0.133	0.354	0.21	169	0.2	193.7	600	1000	500	2000
DO (mg/l)	3.63	5.45	3.63	10.9	4.45	12.72		5-7		
BOD (mg/l)	0.57	1.81	0.57	5.45	1.05	5.45		5		
CO_2 (mg/l)	8.85	44.27	8.85	17.7	15	17.7				
CO_3'' (mg/l)	-	-	5.35	120.65	4.46	12.06				
HCO_3'(mg/l)	269.85	409.53	134.92	299.33	171.72	247.62	300*	600*	300	600
Cl' (mg/l)	24.6	35.26	11.48	24.09	12.22	22.96	250	600	250	1000
Ca^{2+} (mg/l)	47.29	197.17	24.9	109.44	7.74	86.85	100	300	75	200
Mg^{2+} (mg/l)	0.52	31.45	4.95	22.23	3.12	28.74	30*	150*	30	100
T H (mg/l)	144.84	580.5	91.2	359.56	32.18	318.41	100	500	200	600

WATER QUALITY INDEX (WQI):

Water Quality Index (WQI) of various physico – chemical parameters at three sites, ranged between 36.60 and 49.81; 35.72 and 63.31 and 45.34 and 60.97, respectively (Table 2). On the basis of Water Quality Index value, water has been categorized as[3,4,12]:

Water Quality Index	Status
0 - 25	Excellent
26 - 50	Good
51 - 75	Poor
76 - 100	Very poor
100 and above	Unsuitable for drinking

All the ground water samples of site I show Water Quality Index (WQI) less than 50 and is indicative of water quality that is suitable for drinking without causing health problems. But some water samples show WQI above 50 at both consumer points which is indicative of water quality that is not suitable for drinking and can cause health problems. This is due to garbage dumping near pipelines and sewage entry.

Table No. 2: "Water Quality Index"

S. No.	Site I	Site II	Site III
1.	36.60	35.72	46.86
2.	42.12	45.58	45.34
3.	46.34	44.74	49.41
4.	43.77	50.44	60.98
5.	42.02	54.07	53.65
6.	45.70	60.18	56.48
7.	49.81	56.29	49.89
8.	46.17	63.31	58.88

COEFFICIENT OF CORRELATION:

Analysis of co-efficient matrix of tube well (Tables 3-5) has shown significant results with various physico-chemical parameters at all the three sites.

Table No. 3: "Coefficient of correlation between physico-chemical parameters at Site I"

	AT (°C)	WT (°C)	pH	EC (mS/cm)	TDS (mg/l)	DO (mg/l)	BOD (mg/l)	CO_2 (mg/l)	HCO_3' (mg/l)	Cl' (mg/l)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	TH (mg/l)
AT (°C)	1												
WT (°C)	0.88	1											
pH	-0.16	-0.14	1										
EC (mS/cm)	0.52	0.53	0.08	1									
TDS (mg/l)	0.52	0.54	0.08	1.00	1								
DO (mg/l)	-0.65	-0.41	0.65	-0.02	-0.01	1							
BOD (mg/l)	0.54	0.57	0.12	0.91	0.91	-0.07	1						
CO_2 (mg/l)	0.01	-0.30	-0.72	-0.12	-0.14	-0.58	-0.20	1					
HCO_3' (mg/l)	0.79	0.71	-0.49	0.63	0.62	-0.72	0.56	0.25	1				
Cl' (mg/l)	0.55	0.60	-0.77	0.46	0.46	-0.63	0.42	0.36	0.88	1			
Ca^{2+} (mg/l)	0.17	0.04	-0.33	-0.14	-0.16	-0.68	-0.07	0.28	0.39	0.27	1		
Mg^{2+} (mg/l)	0.47	0.57	-0.20	-0.13	-0.13	-0.50	-0.09	-0.27	0.49	0.41	0.52	1	
TH (mg/l)	0.27	0.19	-0.33	-0.16	-0.17	-0.70	-0.09	0.16	0.45	0.33	0.97	0.71	1

Table No. 4: "Coefficient of correlation between physico-chemical parameters at Site II"

	AT (°C)	WT (°C)	pH	EC (mS/cm)	TDS (mg/l)	DO (mg/l)	BOD (mg/l)	CO_2 (mg/l)	CO_3'' (mg/l)	HCO_3' (mg/l)	Cl' (mg/l)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	TH (mg/l)
AT (°C)	1													
WT (°C)	0.98	1												
pH	0.55	0.55	1											
EC (mS/cm)	0.62	0.61	0.31	1										
TDS (mg/l)	-0.53	-0.56	0.10	-0.82	1									
DO (mg/l)	-0.02	-0.05	0.09	-0.18	0.02	1								
BOD (mg/l)	0.69	0.62	0.38	0.39	-0.38	0.63	1							
CO_2 (mg/l)	0.18	0.24	-0.24	0.08	-0.48	0.59	0.42	1						
CO_3'' (mg/l)	-0.22	-0.22	0.49	-0.23	0.47	0.03	-0.36	-0.36	1					
HCO_3' (mg/l)	0.45	0.42	-0.07	0.69	-0.68	0.02	0.58	0.17	-0.79	1				
Cl' (mg/l)	0.55	0.48	0.42	0.86	-0.51	-0.02	0.54	-0.06	-0.25	0.73	1			
Ca^{2+} (mg/l)	0.19	0.12	-0.05	-0.02	-0.18	0.86	0.79	0.47	-0.31	0.37	0.13	1		
Mg^{2+} (mg/l)	0.06	0.00	0.01	-0.43	0.38	0.56	0.57	0.18	-0.38	0.19	-0.06	0.66	1	
TH (mg/l)	0.16	0.09	-0.03	-0.15	-0.02	0.83	0.79	0.41	-0.36	0.34	0.08	0.97	0.82	1

Table No. 5: "Coefficient of correlation between physico-chemical parameters at Site III"

	AT (°C)	WT (°C)	pH	EC (mS/cm)	TDS (mg/l)	DO (mg/l)	BOD (mg/l)	CO_2 (mg/l)	CO_3'' (mg/l)	HCO_3' (mg/l)	Cl' (mg/l)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	TH (mg/l)
AT (°C)	1													
WT (°C)	0.96	1												
pH	-0.33	-0.30	1											
EC (mS/cm)	0.73	0.67	0.18	1										
TDS (mg/l)	-0.07	0.05	0.22	-0.19	1									
DO (mg/l)	-0.22	-0.04	-0.04	-0.38	0.19	1								
BOD (mg/l)	0.30	0.45	-0.02	0.01	0.27	0.82	1							
CO_2 (mg/l)	0.46	0.52	-0.14	0.22	0.49	0.26	0.59	1						
CO_3'' (mg/l)	-0.55	-0.55	0.25	-0.12	-0.38	-0.24	-0.63	-0.89	1					
HCO_3' (mg/l)	0.74	0.65	-0.24	0.61	0.07	-0.60	-0.24	0.02	-0.14	1				
Cl' (mg/l)	-0.28	-0.11	0.11	-0.41	0.03	0.81	0.71	0.31	-0.24	-0.81	1			
Ca^{2+} (mg/l)	-0.06	-0.08	-0.69	-0.23	0.14	0.00	-0.25	-0.06	0.08	0.25	-0.40	1		
Mg^{2+} (mg/l)	0.23	0.27	-0.61	-0.06	0.34	-0.33	-0.30	0.19	-0.08	0.46	-0.41	0.67	1	
TH (mg/l)	0.05	0.05	-0.72	-0.18	0.23	-0.13	-0.29	0.03	0.03	0.36	-0.44	0.96	0.86	1

WATER QUALITY STANDARDS:

Comparison of the various physico-chemical characteristics of water with National and International Standards[24,25] reveals that all the physico-chemical parameters analyzed at three stations remain within permissible limits of drinking water standards (Table 1).

MICROBIOLOGICAL STUDIES:

MPN index/100 ml of water sample (Table 6) ranged between <1 to 24 / 1 to >180 / <1 to >180 at all the three sites, respectively. The water quality of tube well, home and lane tap is found unsatisfactory except for some samples when compared with the earlier study (7-10 MPN/100ml)[7]. So water requires proper treatment before supply to the consumers. Rise in bacterial count may be due to infiltration of surface runoff and sewage water through various defective pipes[18].

Table No. 6: "Comparison of microbial water quality with National and International Standards"

Parameter→	PCC / 100 ml.	WHO		BIS		British Ministry of Health	
Sites↓		Ac	Al	Ac	Al	Class	PCC
Site 1	<1 – 24	0	10	0	10	Excellent	0 / 100
Site 2	1 - >180					Satisfactory	1 - 3 / 100
Site 3	<1 - >180					Suspicious	4 - 10 / 100
						Unsatisfactory	> 10 / 100

CO-EFFICIENT OF CORRELATION:

Analysis of co-efficient of correlation between MPN and the physico-chemical parameters at three sites has shown significant results of MPN/100 ml with air temperature (0.61), water temperature (0.79), magnesium (0.58) / air temperature (-0.83), water temperature (-0.85), pH (-0.62), chloride (-0.76) / air temperature (-0.77), water temperature (-0.71), BOD (-0.59), carbonate (0.73), respectively (Table 7).

Table No. 7: "Coefficient of correlation between various physico-chemical and microbiological parameters"

Stations→	Site I	Site II	Site III
Parameters↓			
AT (°C)	0.62	-0.84	-0.78
WT (°C)	0.79	-0.86	-0.72
pH	0.03	-0.63	0.22
EC (mS/cm)	0.39	-0.47	-0.44
TDS (mg/l)	0.40	0.38	0.15
DO (mg/l)	-0.17	0.11	-0.15
BOD (mg/l)	0.25	-0.34	-0.59
CO_2 (mg/l)	0.67	-0.11	-0.48
CO_3'' (mg/l)	-	-0.26	0.73
HCO_3' (mg/l)	0.47	0.04	-0.36
Cl' (mg/l)	0.33	-0.77	-0.08
Ca^{2+} (mg/l)	0.10	0.09	0.25
Mg^{2+} (mg/l)	0.59	0.30	0.26
TH (mg/l)	0.24	0.17	0.28

WATER QUALITY STANDARDS:

Comparison of the microbial count with National and International Standards and British Ministry of Health (1957) reveals that the water quality remains within permissible limits of drinking water at three sites throughout the study period except for two samples which require proper treatment before its supply to consumers (Table 6).

ACKNOWLEDGEMENTS

Thanks are due to the Head, Department of Environmental Sciences for providing laboratory and library facilities.

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