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Physicochemical and Microbiological Assessment of Drinking Water from Different Sources in Junagadh City, India

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Abstract In the present study, physicochemical and microbiological characteristics of the drinking water were determined in November 2014 from different locations in Junagadh region, Gujarat, India. Total 22 water samples were collected from different locations in and around Junagadh city. E.C (Electrical conductivity), TDS (total dissolved solids), Salinity, pH and DO (Dissolve oxygen) were analyzed for different water samples. The results indicated that E.C, TDS and Salinity were highest in W-12. pH, hardness and DO were observed higher in W-5, W-11 and W-6 Samples respectively. Enteric pathogen *E. coli* was found in samples viz W-22 and Enterobacter was present in the most of water samples. No coliforms were observed in samples number 1, 4, 15, 17, 18, 19 and 20. Total aerobic microbial count was higher in W-10. In conclusions relative to the water adequacy of springs and drills, water tanks and supply network, as well as the possible reasons for water quality problems are presented in the study. Generally, the water quality depends on its chemical and microbiological condition. The water is easily infected during its transportation from the source to the internal water supply network and finally to the consumer. The condition of the water supply networks is a factor which contributes to the water quality.

Keywords: *groundwater, water quality, coliforms, phsico-chemical parameters*

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1. Introduction

Water becomes contaminated by pathogens such as coliform group bacteria, *Salmonella* and dysentery causing bacilli. The human faecal material carried in sewage is often dumped into the rivers and lakes that may lead to water contamination [1,2]. Ground water is the major source of drinking water in both urban and rural areas. Ground water crisis is not the result of natural factors. Prolonged discharge of industrial effluents, domestic sewage and solid waste dump causes the groundwater to become polluted and created health problems [3,4]. Water of good drinking quality of basic importance to human physiology of man's continued existence depends very much on its availability [4,5]. Only 1% part is available on land for drinking, agriculture, domestic power generation, industrial consummation, transportation and waste disposal [6,7,8]. Water quality means the physical, chemical and biological characteristics of water [9]. The first edition of standard methods was published in 1905. Since then it has been considered to be the best available guidance of water analysts, which covers all aspects of water and wastewater analysis techniques and categorizes the analytical methods based on the constituent and not on the type of water [10]. Our dependence on fresh water resources has accelerated in last century due to rapid growth in world population and economic development [11]. This has resulted in increasing numbers of cases of water borne diseases and other health hazards [3,12]. Ground water contains high amount of various ions, salts etc. So if we were using such type of water as potable water then it leads to various water-borne diseases [13]. Unsafe drinking water contributed to numerous health problems in developing countries such as the one billion or more incidents of diarrhea that occur annual [5,14]. According to world health organization (WHO), there were estimated 4 billion cases of diarrhea and 2.2 million deaths annually. 1% of the ground water level is threatened either directly or indirectly by pollution [15]. Non pathogenic faecal organisms are best indicators of faecal pollution. However in all cases faecal coliform contents and *E. coli* is used as the major tool in the assessment of the health risk borne by pathogen in water [13,15]. Several water analyses have been regularly conducted by different scientific groups across the country. The present work is a primary attempt

to examine the water quality of various potable water resources in and around Junagadh city.

2. Material and Methods

2.1. Sample Collection

Total 22 water samples were collected in November 2014, from different locations (Vishnu colony, Dipanjali, Ashoknagar, Junagadh agriculture university, Tinwala farm, Willigdom Dam, Pir Paratha Dam, near Planaaterium, Dolatpara, GIDC-2, Sakkabaugh Zoo, Khodiyar Mandir, Khamdhrod road, Narsinh Mehta Sarovar, Jagnath mahadev, Joshipura, Near patel samaj kyadavadi, Santeshvar mahadev, Bypass road, Khallilpur, Vadla phatak of Junagadh city, Gujarat, in India, (Table 1). All the samples were collected in sterilized bottles and were stored at 4°C till further investigation and analysis of water-quality parameters was carried out as per standard methods of APHA [10].

Table 1. Sources of 22 groundwater samples collected from different sources in Junagadh City

Sr. No.	Name	Source
W-1	Vishnu colony	Bore
W-2	Dipanjali-2	Bore
W-3	Ashoknagar	Bore
W-4	Junagadh agriculture university	Bore
W-5	Tinwala farm	Bore
W-6	Willigdon Dam	Surface water
W-7	Pir Paratha Dam	handpump
W-8	Near plnetorium	Well
W-9	Dolatpara	Bore
W-10	Dolatpara GIDC-2	Bore
W-11	Sakkarbaug zoo	Well
W-12	Khodiya Mandir,	Well
W-13	Khamdhrol road	Bore
W-14	Near Trupti clinic	Surface water
W-15	Narsinh Mehta Talav	Bore
W-16	Jagnath mahadev	Bore
W-17	Joshipura	Bore
W-18	Near Patel samaj, kyadavadi	Bore
W-19	Santeshvar mahadev	Bore
W-20	Bypass road	Bore
W-21	Kahllilpur chokdi	Bore
W-22	Vadla Phatak	Bore

2.2. Physico-chemical Parameters

The collected water samples were analyzed for various physico- chemical and microbiological parameters. The procedure for analysis was followed as per standard methods of analysis of water and wastewater [15].

2.2.1. pH and EC

The pH and EC is determined by Elico, model LI.120 Digital multimeter which gives direct value of pH and EC.

2.2.2. Total Dissolved Solid

The 50 ml of water sample is filtered through ordinary filter paper and water is collected in the evaporating dish of known weight. Further it is heated and water is totally evaporated. Whatever dissolved solid matter is present gets accumulated at the bottom of evaporating dish. The evaporating dish is cooled and weighed. By weight difference method the total dissolved solid is determined [10].

2.2.3. Total Suspended Solid

This can be determined by the weight difference of total solid and total dissolved solid. TSS =TS –TDS

2.2.4. Dissolved Oxygen

Dissolved oxygen was determined by modified Winkler's method

2.2.5. Chemical Oxygen Demand

Dichromate reflux method.

2.2.6. Nitrate

The values of nitrate were estimated by spectrophotometrically at 410 nm. The values of nitrate were calculated with calibration curve. Results were expressed as mg/l.

2.2.7. Chloride Content

The chloride content of water sample is determined by titrated the water sample against 0.02 M silver nitrate solution using potassium chromate as an indicator.

2.3. Microbiological Parameters

Total aerobic microbial count (TAMC), most probable number (MPN) of Coliform bacteria and IMViC test for differentiation in coliform bacteria were also determined in collected twenty two water samples.

3. Results and Discussion

The examined physico-chemical and microbiological parameters showed considerable variations in different samples. The observations are depicted in (Table 2, Table 3, Table 4 and Figure 1).

3.1. Temperature

The temperature was found in the range of 27-31oC in month of November (Table 2). The variation in the water temperature may be due to different timing of collection and influence of season [9,17]. Water temperature varies with changing climatic condition. Stated that temperature is important in controlling both the quality and quantity of plankton flora.

3.2. pH

pH is affected not only by the reaction of carbon dioxide but also by organic and inorganic solutes present in water (Table 2). Any alteration in water pH is accompanied by the change in other physic-chemical parameters [4]. pH maintenance (buffering capacity) is one of the most important attributes of any aquatic system since all the biochemical activities depend on pH of the surrounding water. It was concluded that the pH of

water were slightly alkaline (7.5 to 8.7) and were within the maximum limit set for domestic use as per APHA. High value of pH may results due to waste discharge, microbial decomposition of organic matter in the water body [11,18]. The high pH in this case may be attributed to sewage discharge by surrounding human population.

Figure 1. Location of 22 groundwater samples collected from different sources in Junagadh City

3.3. Conductivity

Electrical conductivity is a measure of water capability to transmit electric current and also it is a tool to assess the purity of water (Figure 2). Electrical conductivity found in the range 0.825-2.332 mS/cm. One of the reason of salinity is the high concentration of captions such as sodium, calcium and magnesium whereas chloride, phosphate and nitrate as anions [11,19].

3.4. Hardness

Calcium and magnesium dissolved in water are the two most common minerals that make water "hard." [18,20]. The hardness was found to be in the range of 3.8-11.8 mg/lit. It is within desirable limit.

3.5. TDS

The most remarkable observation of investigation was the alarmingly high level of total dissolved solids (TDS) (Figure 2). The TDS of all the samples were in range of 0.329-2.397 ppt (parts per thousand) while the maximum permissible limiting value of TDS for potable water is 0.5 ppt according to WHO. High level of TDS in water used for drinking purposes leads to many diseases which are not water-borne but due to excess salts. The US Environmental Protection Agency (EPA) presents a

conceptual approach for developing a national estimate of endemic acute gastrointestinal illness(AGI) due to drinking water and a national estimate analysis developed through a model application [21].

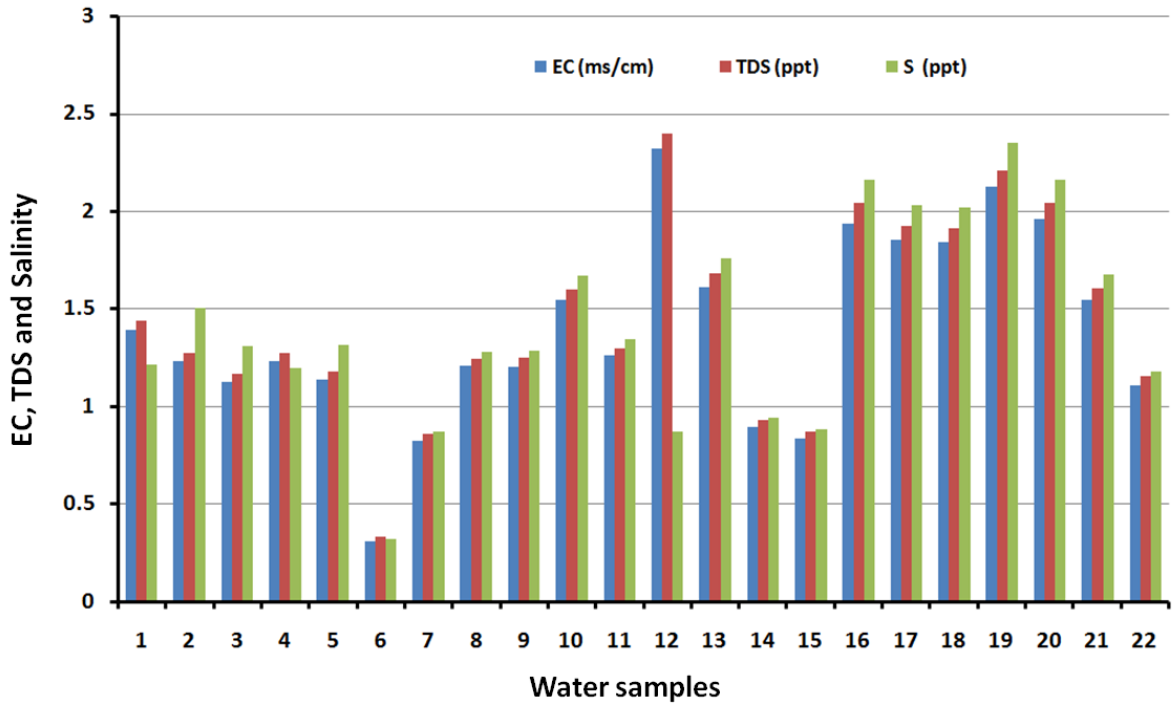

Figure 2. Electric conductivity, Total dissolved solids and Salinity of 22 groundwater samples collected from different sources in Junagadh City

Table 2. Different parameters analysis of of 22 groundwater sample collected from different sources in Junagadh City

Samples	T ° C	pH	R (oham)	DO (mg/lit.)	AC	TH (mg/lit.)
W-1	29	6.72	345.8	1.5 ppm	1	9.6
W-2	30	7.08	391.9	2.0 ppm	0.8	7.4
W-3	28	7.41	428.5	2.5 ppm	0.9	4.2
W-4	29	6.79	392.4	1.4 ppm	0.6	9
W-5	29	7.75	423.7	1.3 ppm	0.9	7.2
W-6	28	7.59	149.7	3.4 ppm	0.5	3.8
W-7	27	7.05	589.1	1.9 ppm	0.9	5
W-8	29	7.07	401.6	1.7 ppm	0.8	7.8
W-9	29	7.1	400.5	2.1 ppm	0.7	7.4
W-10	28	7.44	313.8	2.1 ppm	0.8	6.6
W-11	27	7.29	384	1.3 ppm	0.7	11.8
W-12	29	7.12	208.2	1.8 ppm	0.6	8.2
W-13	29	7.17	297.5	2.0 ppm	0.5	8
W-14	29	7.38	538.4	2.6 ppm	0.7	5.4
W-15	30	7.33	575.2	2.1 ppm	0.8	4.8
W-16	27	7.39	245.4	1.1 ppm	0.8	9.4
W-17	28	7.61	269.7	1.1 ppm	0.8	9.6
W-18	29	7.02	261.6	1.1 ppm	0.9	9.8
W-19	31	7.32	226.5	1.1 ppm	0.7	10.2
W-20	29	7.19	245.1	1.2 ppm	1.0	7.2
W-21	29	7.64	311.9	1.2 ppm	0.4	6.8
W-22	29	7.22	434.5	2.8 ppm	0.8	7.6

Whereas, T= Temperature, EC= Conductivity, R= Resistance, DO= Dissolve oxygen, AC= Acidity and TH= Total Hardness.

3.6. Dissolved Oxygen

DO is a very important parameter of water quality and an index of physical and biological process going on in water which favors solubility of oxygen among the study sites (Table 2). The highest concentration (3.4 ppm (parts per million) was recorded on W- 6 but the range was not narrow for other sites. A definite trend in DO

concentration was observed on all the sites showing highest values in W-6 and lowest in W-16, W-17, W-18 and W-19 is of great importance to all living organisms. It may be present in water due to direct diffusion from air and photosynthetic activity of autotrophs. Concentration of DO is one of the most important parameters to indicate water purity and to determine the distribution and abundance of various algal groups [2,18,20].

3.7. Salinity

Salinity is the saltiness or dissolved salt content of a body of water (see also soil salinity) (Figure 2). Salinity is an important factor in determining many aspects of the chemistry of natural waters and of biological processes within it, and is a thermodynamic state variable that, along with temperature and pressure, governs physical characteristics like the density and heat capacity of the water. Salinity is found lowest in W-7 is 0.867 and highest in W-12 is 0.867.

3.8. Acidity

Acidity of water is its quantitative capacity to react with a strong base to a designated pH. Acidity is a measure of an aggregate property of water and can be interpreted in terms of specific substances only when the chemical composition of the sample is known [15]. Acidity was lowest in W-6(0.5) and highest in W-11(0.7)

Table 3. Microbial analysis of 22 groundwater samples collected from different sources in Junagadh City.

Sample	Parameters				
	Total Plate Count (cfu/gm)	*Enterobactor sp.*	Total Coliforms (cfu/gm)	*E. coli*	COD ppm
W-1	1.5×10^6	Absent	Absent	Absent	51.07
W-2	6.0×10^4	Pr.<100	Pr.<100	Absent	89.38
W-3	3.0×10^5	7.0×10^2	7.0×10^3	Absent	148.96
W-4	4.1×10^4	Pr.<100	Absent	Absent	80.86
W-5	2.3×10^4	2.0×10^2	Pr.<100	Absent	59.58
W-6	1.5×10^5	Pr.<100	Pr.<100	Absent	55.33
W-7	1.4×10^5	8.0×10^2	2.2×10^2	Absent	59.58
W-8	1.3×10^5	1.0×10^2	4.0×10^2	Absent	63.84
W-9	5.0×10^6	Absent	2.0×10^2	Absent	114.91
W-10	8.0×10^4	1.6×10^3	6.0×10^2	Absent	25.54
W-11	7.0×10^4	1.0×10^2	6.2×10^2	Absent	131.94
W-12	2.0×10^4	2.0×10^2	2.0×10^2	Absent	68.10
W-13	2.6×10^5	1.02×10^4	1.5×10^3	Absent	55.33
W-14	2.0×10^4	3.0×10^2	2.0×10^2	Absent	72.35
W-15	4.0×10^4	Absent	Absent	Absent	285.15
W-16	7.0×10^4	Absent	2.0×10^2	Absent	314.94
W-17	2.0×10^2	Absent	Absent	Absent	238.34
W-18	1.2×10^3	2.0×10^2	Absent	Absent	234.08
W-19	2.0×10^3	Absent	Absent	Absent	229.82
W-20	5.0×10^2	Absent	Absent	Absent	293.66
W-21	1.0×10^4	1.0×10^2	Absent	Absent	50.89
W-22	1.0×10^7	4.0×10^4	6.2×10^3	2.0×10^3	130.93

3.9. Coliforms (total and faecal) and Total Plate Count

The microbiological analysis of the water is also showed in the Table 3. The total plate countt (TPC) indicate that the highest microbial load 8.0×10^4 cfu/gm in W-10. The microbiological observations reflect the presence of *E.coli* in W-22 (Banmore) whereas *Enterobacter* was found in W-2,3,4,5,6,7,8,10,11,12,13,14,18,21,22. MPN indexing of analyzed water samples showed wide variation and were in range of <2 to >2400. The results showed that almost all water samples were not fit for drinking purposes as per WHO recommendations. The coliform bacterium is the primary bacterial indicator for faecal pollution in water [22,23], which is highest in W-2 ($7.0 \times 10^{3)}$ and also present in w-2,3,5,6,7,8,9,10,11,12,13,14,16,22.

3.10. COD

The chemical oxygen demand test procedure is based on the chemical decomposition of organic and inorganic contaminants, dissolved or suspended in water (Table 4). The result of a chemical oxygen demand test indicates the amount of water-dissolved oxygen (expressed as parts per million or milligrams per liter of water) consumed by the contaminants, during two hours of decomposition from a solution of boiling potassium dichromate. The higher the chemical oxygen demand, the higher the amount of pollution in the test sample. COD of W-10 Is highest 26.3 lowest in W-16 (19.3).

Table 4. Different parameters of 22 groundwater samples collected from different sources in Junagadh City

No.	Parameters					
	Na	K	Ca	Mg	CO_3	HCO_3
W-1	145.8	2.6	100	55.2	48	341.6
W-2	140.8	0.5	56	55.2	54	189.1
W-3	125.9	84.8	64	12	210	420.9
W-4	119.6	2.6	80	60	54	286.7
W-5	118.4	1.1	80	38.4	54	274.5
W-6	24.7	2.0	64	7.2	42	164.7
W-7	74.0	0.3	76	14.4	60	335.5
W-8	6.9	13.6	108	28.8	48	408.7
W-9	261.1	0.2	32	69.6	78	506.3
W-10	214.3	0.4	44	52.8	78	610
W-11	260.	17.6	68	100.8	72	433.1
W-12	179.3	30.6	52	67.2	66	427
W-13	118.5	3.5	20	84	60	366
W-14	108.4	29.6	16	55.2	48	408.7
W-15	81.8	34.4	48	28.8	102	378.2
W-16	225.8	6.8	56	79.2	90	85.4
W-17	213.4	7.8	44	88.8	66	457.5
W-18	202.5	7.3	56	84	66	579.5
W-19	287.7	0.9	68	81.6	36	555.1
W-20	309.4	1.1	72	43.2	48	488
W-21	207.9	0.4	44	55.2	30	329.4
W-22	94.5	0.6	88	38.4	30	396.5

4. Conclusion

The observation of study strongly suggest that water of Junagadh region is of very high TDS and needs to be lowered down within prescribed limits before using it for drinking purposes. Also, the water samples were showing microbial content beyond the portability range, which needs to be disinfected before consumption to avoid water-borne diseases. Although, the present investigation is essentially a primary work and needs to be further investigated to arrive at specified conclusion with respect to clinical implications.

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