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Evaluation of Physico-Chemical Quality of Drinking Water in Bilaspur District of Chhattisgarh State

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Abstract: ***Quality of water influences the health status of any populace; besides biological, analysis for physical and chemical properties including trace element contents are very important for public health studies. Ground water quality of Bilaspur district, with respect to fifteen physico-chemical parameters was examined for throughout the year (April, 2013 to March, 2014) to assess its suitability for drinking purposes. Eighty one samples of drinking water of different sources were collected from different area within district for proper analysis. Four samples from each block were collected. For all three source of drinking water (Hand-pump water, Tap water and Bore well water) fifteen Physico-chemical parameters were analyzed, considering all three season (summer, rainy and winter) and observed values were compared with standard values recommended by World Health Organization (WHO). Analysis of result showed that available water especially tap water is not suitable for public health.***

Keywords: Drinking water, Physico-chemical analysis, Water quality, Ground water, Bilaspur district.

1. Introduction

Water is an essential ingredient of living beings in the universe, without it, the imagination of any sort of life on this planet futile and mirage. As the most essential commodity for human consumption water is one of the most important renewable resources, which must be prevented from deterioration in quality. Various physicochemical parameters like pH, alkalinity, total hardness, total dissolved solid, calcium, magnesium, nitrate, sulphate have a significant role in determining the portability of drinking water (Ahipathy and Puttaiah, 2006; Gawas *et al.*, 2006; Gupta *et al.,* 2004; Jeyraj *et al*., 2002; Jitendra *et al.,* 2008; Patel and Ragothaman 2005; Sankar *et al.*, 2002; Sirsath *et al.*, 2006; Solanki, 2012; Tiseer *et al.*, 2008; Udhayakumar *et al.,* 2006; Venkatasubramani *et al.*, 2007;). Quality of surface and ground water is inadequate even for costummering living and is getting deteriorated due to unwise utilization of water resources, dehumanizing manner of organization, industrialization and other developed activities. Today many rivers receive million litres of industrial effluents (Adekunle, 2009; Adhikari and Gupta, 2002; Jain *et al.,* 2003; Mahanta *et al.,* 2004; Sharma *et al.,* 2002; Tyagi *et al.,* 2000,), sewage domestic waste (Adnan *et al.,* 2005; Prakash and Somshekhar, 2006; Tanwir *et al.,* 2003), agricultural waste (Demir *et al*., 2003; Fatta *et al.,* 1999; Ikem *et al.,* 2002) and land drainage etc. that cause degradation of water quality the accelerated pace of development and population growth has led to the scarcity of potable water.

The major sources of drinking water supply in our country are groundwater, which is being tapped on a large scale by wells, tube wells and borings. However, the quality of drinking water is extremely poor and except 15-20% of Indian population, who get piped filtered clean drinking water the rest have to depend upon unfiltered natural water. So far as the state of Chhattisgarh is concerned, the situation regarding drinking water standard is deplorable like many other states in India and abroad. Keeping in view the aforesaid facts the present investigation is being proposed to evaluate the quality and suitability of drinking water consumed by urban as well as rural people of Bilaspur district by scientific study of physico-chemical properties in various samples of available drinking water.

2. Material & Methods

In order to assess the quality of drinking water available or supplied and consumed by urban as well as rural people resides within Bilaspur district of Chhattisgarh state of India, an exhaustive survey for consideration of source of drinking water in practices and three categories of drinking water on the basis of their source were taken into consideration viz. Hand-pump water (Hw), Municipal water / Stored tank water or Tap water (Tw) and Bore-well water (Bw). The samples of drinking water of each source from different sampling sites of all study area were collected periodically in all three seasons (summer, rainy and winter) during present course of investigation.

Physico-chemical analysis of sample water was conducted in laboratory except two parameters i.e. temperature and pH,

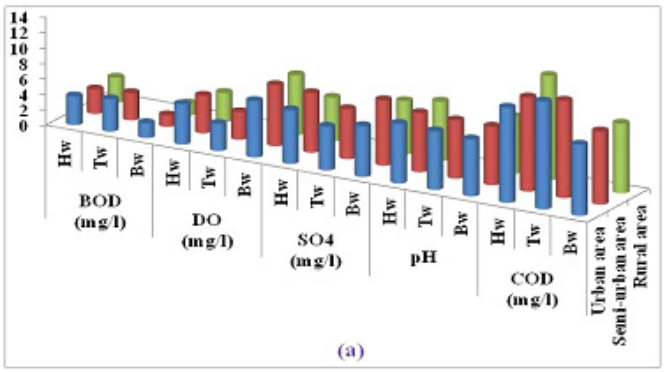
which were examined at collection spots using mercury filled glass thermometer and digital pH meter respectively (Buragohain *et al;* 2009). Titratable acidity and total acidity, total alkalinity and total hardness were determined using standard procedures as described by FAO (1997). For some of the chemical parameter, like dissolved oxygen (DO) and alkalinity, the samples were taken in brown glass bottles avoiding any kind of bubbling and were fixed at the site with preservatives. Standard methods were employed, as suggested by A.P.H.A. (1998); Trivedi and Goel, (1984) and Kumar and Ravindranath (1998).

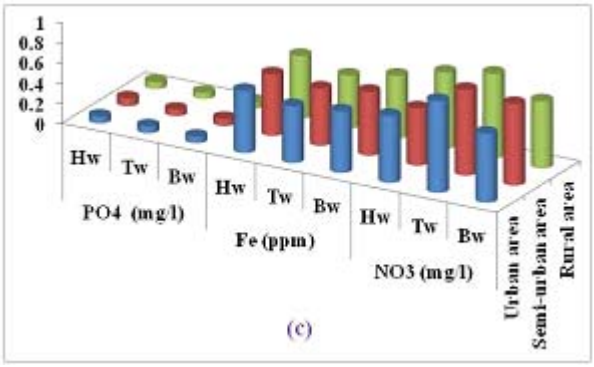
Variation in the Value of different Physico-chemical parameters of 72 drinking water samples, as observed during present investigation has been computed in Table – 1. And diagrammatically presented in Figure – 1 (a, b & c). Whereas the entire value as mention in the Table - 1 are the mean (±SD) value of three samples of all three sources collected from urban, semi urban and rural area during summer, rainy and winter season, however no any samples of tap water in rural area was found. The range value of each parameters considering the source wise and area wise have been compare with standard value as recommended by WHO, as mentioned in Table – 2 and Table – 3 respectively.

3. Result and Discussion

Table 1: Physico-chemical properties of different samples of drinking water collected from available sources during different season.

Study Area	Source of drinking water	Season	PHYSICO-CHEMICAL PARAMETERS														
			Temp. ^0C	pH	Alkalinity mg/l	Free CO_2 mg/l	DO mg/l	BOD mg/l	COD mg/l	Chloride mg/l	Total hardness mg/l	Ca hardness mg/l	Mg hardness mg/l	NO_3 mg/l	Fe ppm	PO_4 mg/l	SO_4 mg/l
URBAN AREA	Hand pump water	Summer	28.7 ±1.81	7.7 ±0.7	88.2 ±3.31	20.9 ±2.3	4.4 ±1.4	4.5 ±1.01	12.35 ±1.8	35.92 ±2.62	166.3 ±3.7	39.7 ±2.31	42.1 ±2.7	0.59 ±0.1	0.69 ±0.21	0.06 ±0.012	7.58 ±1.8
		Rainy	26.9 ±1.9	7.8 ±1.12	88.5 ±2.9	21.2 ±1.8	5.4 ±2.5	3.55 ±1.06	13.2 ±2.3	34.93 ±3.0	171.12 ±3.8	34.01 ±3.4	34.1 ±2.2	0.68 ±0.23	0.54 ±0.25	0.06 ±0.013	6.39 ±1.65
		Winter	19.5 ±2.3	7.6 ±1.5	91.5 ±2.7	23.7 ±2.1	5.8 ±2.6	3.05 ±1.2	11.3 ±2.1	36.93 ±2.8	143.2 ±3.4	34.31 ±2.6	28.3 ±2.8	0.72 ±0.21	0.62 ±0.23	0.08 ±0.01	6.86 ±1.55
	Tap water	Summer	28.4 ±2.4	7.5 ±1.1	91.5 ±2.5	23.9 ±1.9	2.93 ±2.9	4.85 ±1.5	14.05 ±2.6	29.32 ±2.7	157.05 ±3.5	39.5 ±2.9	40.2 ±2.3	0.92 ±0.33	0.62 ±0.28	0.06 ±0.01	5.78 ±1.84
		Rainy	26.1 ±1.7	7.7 ±1.3	91.7 ±3.72	24.4 ±2.5	3.67 ±2.3	4.25 ±1.8	14.6 ±2.3	27.81 ±2.2	160.83 ±3.0	35.6 ±3.5	26.4 ±3.4	0.96 ±0.28	0.52 ±0.1	0.06 ±0.02	5.41 ±1.64
		Winter	21.2 ±1.8	7.5 ±1.4	94.5 ±3.3	24.2 ±2.9	3.9 ±1.8	3.46 ±1.2	13.12 ±2.0	26.38 ±2.6	157.72 ±3.55	36.37 ±2.64	34.7 ±3.0	0.85 ±0.23	0.55 ±0.28	0.08 ±0.012	5.73 ±1.51
	Bore well water	Summer	28.9 ±2.5	7.3 ±0.7	75.1 ±2.7	24.9 ±2.1	6.5 ±2.5	2.4 ±0.6	9.2 ±1.8	46.75 ±2.9	187.82 ±3.7	38.5 ±2.2	38.9 ±2.8	0.65 ±0.25	0.68 ±0.21	0.06 ±0.01	7.08 ±1.47
		Rainy	27.1 ±2.1	7.4 ±1.5	78.5 ±2.9	24.3 ±2.6	7.5 ±1.4	1.99 ±0.9	9.41 ±2.4	44.19 ±2.3	190.06 ±3.0	30.7 ±2.6	25.4 ±2.9	0.74 ±0.1	0.55 ±0.28	0.05 ±0.0	6.03 ±1.55
		Winter	19.8 ±2.4	7.4 ±1.2	73.5 ±2.7	24.1 ±2.3	7.9 ±1.9	1.35 ±0.9	8.95 ±2.1	43.68 ±2.9	187.38 ±3.5	19.19 ±2.8	30.8 ±2.2	0.66 ±0.24	0.6 ±0.23	0.08 ±0.032	6.56 ±1.49
SEMI- URBAN AREA	Hand pump water	Summer	28.9 ±2.8	7.7 ±1.3	98.5 ±3.81	19.6 ±1.8	4.6 ±2.9	3.5 ±1.6	12.85 ±2.6	25.84 ±2.7	179.3 ±3.85	41.6 ±2.3	38.1 ±2.6	0.56 ±0.27	0.66 ±0.33	0.07 ±0.03	8.4 ±1.58
		Rainy	27.7 ±2.21	7.6 ±1.4	116.2 ±3.7	18.7 ±1.4	4.84 ±1.9	3.11 ±01.3	12.18 ±1.9	23.9 ±2.6	176.67 ±3.7	35.5 ±2.9	31.6 ±2.7	0.59 ±0.21	0.63 ±0.1	0.08 ±0.031	7.2 ±1.84
		Winter	20.2 ±1.9	7.6 ±0.7	91.1 ±3.3	18.4 ±2.9	5.12 ±2.3	2.85 ±1.1	11.5 ±2.0	21.06 ±2.55	169.34 ±3.5	36.92 ±2.6	33.2 ±3.0	0.55 ±0.28	0.54 ±0.21	0.08 ±0.014	7.5 ±2.0
	Tap water	Summer	28.95 ±1.8	7.5 ±1.3	119.1 ±3.5	23.1 ±1.9	2.9 ±2.6	3.78 ±1.4	13.05 ±2.12	27.51 ±3.0	184.21 ±3.45	39.6 ±2.55	36.4 ±2.3	0.85 ±0.23	0.59 ±0.27	0.07 ±0.016	6.3 ±1.9
		Rainy	28.4 ±1.9	7.5 ±1.5	104.4 ±3.71	22.3 ±2.5	3.6 ±1.8	3.65 ±1.3	12.6 ±2.3	26.89 ±2.9	186.01 ±3.8	27.2 ±2.7	25.3 ±2.6	0.84 ±0.33	0.54 ±0.25	0.06 ±0.01	6.2 ±1.7
		Winter	22.7 ±2.1	7.6 ±1.2	94.3 ±2.9	22.2 ±2.1	4.2 ±1.4	3.14 ±1.1	12.1 ±1.9	26.01 ±2.2	181.4 ±3.4	33.34 ±3.5	33.2 ±2.2	0.86 ±0.1	0.57 ±0.24	0.06 ±0.0	6.9 ±1.75
	Bore well water	Summer	28.65 ±2.7	7.5 ±1.4	91.4 ±3.7	18.3 ±2.6	7.7 ±2.9	1.75 ±0.7	10.15 ±2.6	36.79 ±2.8	188.72 ±3.55	39.7 ±2.3	31.5 ±2.7	0.74 ±0.27	0.68 ±0.23	0.07 ±0.02	8.8 ±1.55
		Rainy	27.3 ±2.1	7.6 ±1.1	77.9 ±3.71	18.2 ±2.3	7.87 ±2.5	1.66 ±0.41	9.3 ±2.5	35.14 ±2.3	186.78 ±3.32	28.7 ±2.8	18.7 ±3.4	0.86 ±0.33	0.56 ±0.27	0.07 ±0.01	8.2 ±1.35
		Winter	20.4 ±2.3	7.5 ±0.7	82.8 ±2.9	17.5 ±1.4	8.16 ±2.1	1.06 ±0.85	8.9 ±1.8	33.88 ±2.7	183.06 ±3.8	30.56 ±2.6	32.3 ±2.8	0.82 ±0.25	0.66 ±0.1	0.07 ±0.03	8.4 ±1.23
RURAL AREA	Hand pump water	Summer	27.4 ±2.52	7.6 ±1.3	94.3 ±3.3	17.9 ±2.1	3.34 ±1.3	3.5 ±0.7	14.1 ±1.9	24.96 ±3.4	167.17 ±3.65	37.5 ±2.55	40.7 ±2.3	0.71 ±0.23	0.68 ±0.33	0.07 ±0.012	5.9 ±1.53
		Rainy	26.9 ±2.4	7.7 ±1.2	93.5 ±3.7	17.2 ±1.8	3.78 ±2.1	3.65 ±0.9	13.4 ±2.3	23.34 ±3.0	162.12 ±3.5	25.8 ±2.6	31.3 ±2.9	0.7 ±0.21	0.61 ±0.24	0.06 ±0.011	5.4 ±1.91
		Winter	19.7 ±1.7	7.7 ±1.5	95.5 ±3.3	16.7 ±2.5	4.23 ±2.56	2.55 ±0.6	13.01 ±2.0	23.1 ±2.6	169.78 ±3.4	31.81 ±2.9	31.7 ±2.7	0.85 ±0.24	0.58 ±0.25	0.08 ±0.03	5.7 ±1.67
	Tap water	Summer	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		Rainy	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		Winter	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Bore well water	Summer	28.95 ±2.1	7.4 ±1.2	65.1 ±2.96	15.2 ±1.4	7.1 ±2.9	1.7 ±0.9	9.65 ±2.4	31.98 ±2.8	174.45 ±2.95	38.1 ±3.0	33.5 ±3.4	0.65 ±0.23	0.64 ±0.1	0.06 ±0.01	7.1 ±1.55
		Rainy	27.2 ±1.9	7.4 ±1.1	73.6 ±3.1	15.1 ±2.5	7.45 ±2.3	1.75 ±0.15	8.89 ±2.6	30.76 ±2.7	170.22 ±2.3	22.6 ±2.2	24.6 ±2.6	0.69 ±0.33	0.58 ±0.28	0.05 ±0.012	6.7 ±1.35
		Winter	20.4 ±2.40	7.3 ±1.4	77.5 ±3.3	16.6 ±2.3	8.7 ±1.8	1.27 ±0.34	8.5 ±2.3	30.33 ±2.3	168.61 ±3.4	36.84 ±2.6	28.7 ±2.3	0.65 ±0.1	0.65 ±0.25	0.09 ±0.02	6.9 ±1.7





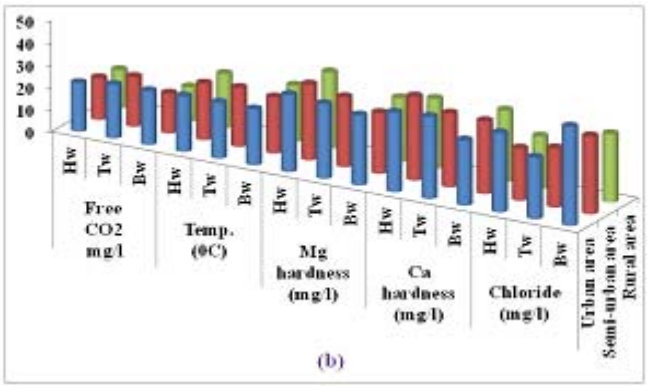


Figure: 1 (a, b & c) Variation in Physico-chemical properties of collected from different sources of drinking water.
(**Hw** = Hand pump water, **Tw** = Tap water, **Bw** = Bore well water)

Table 2: Comparison of observed data (Physico-chemical properties of drinking water from different sources) with standard recommended by WHO

Sl. No.	Physico-chemical Parameters	SOURCE OF DRINKING WATER			STANDARD WHO
		Hand pump water	Tap water	Bore well water	
1	Temp. (^{0}C)	19.5 - 28.9	21.2 - 28.95	19.8 - 28.95	15^{0}C to 21^{0}C
2	pH	7.6 - 7.8	7.5 - 7.7	7.3 - 7.6	6.5-8.5
3	Alkalinity (mg/l)	88.2 - 116.2	91.5 - 119.1	65.1 - 91.4	NA
4	Free CO_2 (mg/l)	16.7 - 23.7	22.2 - 24.4	15.1 - 24.9	NA
5	DO (mg/l)	3.4 - 5.8	2.9 - 4.2	6.5 - 8.7	4
6	BOD (mg/l)	2.55 - 4.5	3.14 - 4.85	1.06 - 2.4	2
7	COD (mg/l)	11.3 - 14.1	12.1 - 14.6	8.5 - 10.15	10
8	Chloride(mg/l)	21.6 - 36.93	26.01 - 29.32	30.33 - 46.75	250
9	Total hardness (mg/l)	143.2 - 179.3	157.05 - 186.01	168.61 - 190.06	500
10	Ca hardness (mg/l)	25.8 - 41.6	27.2 - 39.6	19.19 - 39.7	200
11	Mg hardness (mg/l)	28.3 - 42.1	25.3 - 40.2	18.7 - 38.9	50
12	NO_3 (mg/l)	0.55 - 0.85	0.84 - 0.96	0.65 - 0.86	45
13	Fe (ppm)	0.54 - 0.69	0.52 - 0.62	0.55 - 0.68	0.1
14	PO_4 (mg/l)	0.06 - 0.08	0.06 - 0.08	0.05 - 0.09	NA
15	SO_4 (mg/l)	5.4 - 8.4	5.41 - 6.9	6.03 - 8.8	205

Table 3: Comparison of observed data (Physico-chemical properties of drinking water from different study area) with standard recommended by WHO

Sl. No.	Physico-chemical Parameters	STUDY AREA			STANDARD WHO
		Urban area	Semi urban area	Rural area	
1	Temp. (^{0}C)	19.5 - 28.9	20.2 - 28.95	19.7 - 28.95	15^{0}C to 21^{0}C
2	pH	7.3 - 7.8	7.5 - 7.7	7.3 - 7.7	6.5-8.5
3	Alkalinity (mg/l)	73.5 - 94.5	77.9 - 119.1	65.1 - 95.5	NA
4	Free CO_2 (mg/l)	20.9 - 24.9	17.5 - 23.1	15.1 - 17.9	NA
5	DO (mg/l)	2.93 - 7.9	2.9 - 8.16	3.34 - 8.7	4
6	BOD (mg/l)	1.35 - 4.85	1.06 - 3.78	1.27 - 3.65	2
7	COD (mg/l)	8.95 - 14.6	8.9 - 13.05	8.5 - 14.1	10
8	Chloride(mg/l)	26.38 - 46.75	21.06 - 36.79	23.1 - 31.98	250
9	Total hardness (mg/l)	143.2 - 190.06	169.34 - 188.72	162.12 - 174.45	500
10	Ca hardness (mg/l)	19.19 - 39.7	27.2 - 41.6	22.6 - 38.1	200
11	Mg hardness (mg/l)	25.4 - 42.1	18.7 - 38.1	24.6 - 40.7	50
12	NO_3 (mg/l)	0.59 - 0.96	0.55 - 0.86	0.65 - 0.85	45
13	Fe (ppm)	0.52 - 0.69	0.54 - 68	0.58 - 0.68	0.1
14	PO_4 (mg/l)	0.05 - 0.08	0.06 - 0.08	0.05 - 0.09	NA
15	SO_4 (mg/l)	5.41 - 7.58	6.2 - 8.8	5.4 - 7.1	205

The pH values were found slightly alkaline in all sources of drinking water that ranges from 7.3 to 7.8. The temperature of sample water was found maximum during summer season and minimum in winter season that ranges from 19.3 ^{0}C to 28.95 ^{0}C. Total alkalinity was observed minimum in bore well water while maximum in tap water. Variation in the value of DO was found from 2.9 mg/l to 8.7 mg/l that is more than standard value. High DO level in community water supply is good because it max drinking water taste better, however high DO level speed up corrosion in water pipe. The B. O. D. of the samples was found ranges from 1.06 mg/l to 4.85 mg/l, whereas the maximum value was observed in tap water (3.14 – 4.85 mg/l). The maximum value of COD was observed in tap water while minimum in bore well water, varied from 8.5 mg/l to 14.6 mg/l. Total hardness of drinking water was found maximum in bore well water (168.61 mg/l – 190.06 mg/l). The variation in the value of Nitrate, Phosphate and Sulphate was also observed, which are lesser than standard value, as recommended by WHO. Similarly value of Chloride and Iron were also found with variable range whereas Chloride is lesser than standard value while Iron in higher than standard value (WHO).

4. Conclusion

In spite of variation, the observed value of Physico-chemical parameters show generally under the range of standard/ recommended value accept four parameters that are DO, COD, BOD and Iron. The values of these parameters in the most of the samples have found more than permissible limit. Similarly the value of Iron was found more than standard value, whereas the Chloride, Nitrate and Sulphate shows there very less presents than that of standard value.

Through the present investigation, we have confer the Physico-chemical properties of drinking water used by the public of Bilaspur district and findings reveal the fact that the drinking water of this area, especially in urban area and few patches of semi urban area of this district is not suitable for public health. So far the source of drinking water is concerned mostly tap water and hand pump water at some extant is not suitable for human society.

This study is alarming the management system of drinking water supply in this district. In order to meet the quality of ground water it is recommended that continuous monitoring with proper action is essential to ensure the supply of suitable drinking water.

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