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Investigation of ground water quality in selected areas of Huvinahadagali Taluk in Ballari District, Karnataka

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ABSTRACT

The study area of Huvinahadagali taluk located in the Ballari district, Karnataka, The important geological formations in this area were Dharwar rock of pink and grey granite. The investigation of water quality for its suitability for agricultural and domestic purposes was carried out. Thirty ground water samples were collected from the study area of Huvinahadagali taluk have been evaluated. The quality analysis was performed through the estimation of calcium, magnesium, sodium, potassium, iron, zinc, manganese, carbonate, bicarbonate, sulphate, chloride, fluoride, nitrate, total alkalinity, total dissolved solids, turbidity, pH, electrical conductance and total hardness. Based on these analysis, in the study area majority of the water samples fall under C_3S_2, C_4S_1, C_4S_2 and C_4S_3 as per USSL, these water samples were not suitable for irrigation. The presence of E-coli in only two dug wells indicated potential and dangerous facel contaminations, which require immediate attention. Fluoride was most dominant ion responsible for contamination of the ground water. Seven water samples of the study area were prone to excess fluoride concentration (>1.2 mg/l) and not suitable for drinking purpose. These studies indicate that the water quality of 20% of the dug wells are suitable for both domestic and irrigation purposes, where as in the 80% of the water samples, one or the other chemical constituent was found beyond WHO permissible limits. The study indicates the need for periodic monitoring of ground water in the study area.

Key words: Ground water, trilinear diagram, percent sodium, permissible limit

1. INTRODUCTION

Water is life. It is colorless, odorless and tasteless liquid. It is essential for all forms of growth and development-human, animal and plant. Also water is a fundamental and a basic need for sustaining daily life. As the human population increases, as people express their desire for a better standard of living and as economic activities continue to expand in scale and diversity, the demand for fresh water resources continues to grow. Among the various sources of water, ground water is said to be the safest water for drinking and domestic purposes. Nevertheless, several factors, like discharge of agricultural, domestic and industrial wastes, land use practices, geological formation, rainfall patterns and infiltration rate are reported to affect the quality of ground water in an area (APHA, 1975). In Karnataka, there is no significant work on water quality except by Jayanthi (1993), Ayed (2002) , Jayalakshmi Devi et al. (2005). Mallangoud et al.(2017),Bharathi et al.(2016) and Thotappaiah et al.(2016).In view of the above, it is clear that water quality assessment studies in Karnataka especially in Ballari district are inadequate. Therefore, the present study has been undertaken to assess the water quality of Huvinahadagali taluk in Karnataka. The Huvinahadagali taluk, situated between $14^{0}\,35^{1}$ to $15^{0}\,08^{1}$ north latitude and $75^{0}\,45^{1}$ to $76^{0}\,13^{1}$ east longitude, is in the western part of the district The taluk has a population of about 64,25, 490. The average annual rain fall of the study area is 450 mm. The average annual maximum temperature is 40^{0}C and minimum is 26^{0}C.

2. MATERIALS AND METHODS

The present study provides the quality of ground water. Thirty water samples were collected during post monsoon, November 2016 and analyzed for calcium, magnesium, sodium, potassium, iron, zinc, manganese, chloride, carbonate, bicarbonate, fluoride, sulphate, nitrate, total hardness (TH), total alkalinity (TA), total dissolved solids (TDS), pH, electrical conductance (EC), turbidity and coliform bacteria. Further the sodium adsorption ratio (SAR), corrosivity ratio (CR), percent sodium and magnesium ratio were calculated. The techniques and methods were followed for collection, preservation, analysis and interpretation are those given by Rainwater and Thatcher (1960), Brown et al.(1970), ICMR (1975), Hem (1985) and APHA (1995).

3. RESULTS AND DISCUSSION

The results obtained from the analysis of water samples from different villages of Huvinahadagali taluk are shown in Table 1. Standard methods (APHA, 1975) have been employed in the analysis of the water samples. A comparison of the physico-chemical ground water samples has been made with WHO (1988) and ISI (1991) which shows the different types of water in the study area according to hydrochemistry classification. From Table 1 the following observations were made for different parameters.

3.1 pH

The pH values of ground water varied from 7.1 to 8.7 indicating slightly alkaline nature. Ground water with pH value of about 10 are exceptional and may reflect contamination by strong base such as NaOH and $Ca(OH)_2$ (Langmuir,1997). The range of desirable pH of water prescribed for drinking purposed by ISI (1991) and WHO (1988) is 6.5 to 8.5. The analyzed ground water samples are within the permissible limits. There is no much distinct variation of pH in the different wells selected for the present study, indicating that the ground water is tapping from aquifers of a single formation. The slight alkaline nature of ground water may be due to the presence of fine aquifer sediments mixed with clay and mud, which are unable to flush off the salts during the monsoon rain and hence retained longer on other seasons.

3.2 Electrical Conductance (EC)

The mineral components of the water are directly related to agricultural utility and its parametric value decides the suitability for drinking and irrigation purposes. It is well known that electrical conductance is a good measure of dissolved solids and excessive presence of sodium in water is not only unsafe for irrigation but also makes the soil uncultivatable (Neeraj Verma, 1994). In the present investigation the electrical conductivity of the samples varies from 1050 to 3600 μ mhos/cm. As per WHO standards only 07 samples were within the permissible limit. However, the higher values of EC (>2000 μ mhos/cm) for 23 samples may be due to the long residence time and factors of lithology of water bodies (Harish Babu et al., 2004).

3.3 Total Dissolved Solids (TDS)

TDS indicate the nature of water quality for salinity. The water samples in the study area fall in the range of 310 to 1350 mg/l. Out of 30 samples collected, In the study area 07 samples fall into the category of 'Good to Permissible' 20 samples fall in to the category of 'Doubtful to Unsuitable', while 03 samples fall into the category of 'Unsuitable'

3.4 Total Hardness

Total hardness is due to the presence of divalent cations of which Ca and Mg are the most abundant in ground water. The water samples of the study area are classified according to hardness as suggested by Hem (1985). In the present study, the total hardness of water samples ranged from 195 to 958 mg/l. This shows that, out of 30 samples, only 03 samples have total hardness content within ISI permissible limit (300 mg/l), while 13 samples have excessive limit (600 mg/l) and 14 samples fall into the very hard category.

3.5 Total Alkalinity (TA)

Most of the ground water contain substantial amounts of dissolved carbon dioxide, bicarbonates and hydroxides. These constituents are the results of dissolution of minerals in the soil and atmosphere (Nagaraju et al., 2006). In the present study, alkalinity ranges between 83 to 498 mg/l. The high amount of alkalinity in the study area samples may be due to the presence of country rocks.

3.6 Chloride (Cl)

Chloride occurs in all natural water in widely varying concentrations. Excessive chloride in potable water is not particularly harmful and the criteria set for this anion are based primarily on palatability and its potentially high corrosiveness (Bhujangaiah and Vasudeva Nayak, 2005). Chloride in excess (>250 mg/l) imparts a salty taste to water and people who are not accustomed to high chlorides may be subjected to laxative effects. The chloride content in the study area ranged between 20 and 275 mg/l. The WHO and ISI permissible limit of chloride for drinking water is 200 and 250 mg/l respectively. The chloride value of the water samples studied is well within the permissible limit of WHO and ISI for 29 samples.

3.7 Fluoride (F)

High concentration of fluoride, often significantly above 1.5 mg/l constitute a severe problem in large parts of Karnataka (Handa, 1975 and 1988). Long term use of ground water for drinking has resulted in the onset of wide spread fluorosis symptoms, from mild forms of dental fluorosis to crippling skeletal fluorosis. High fluoride concentration in the ground water of study area correlate positively with alkalinity (bicarbonate concentration), pH, and sodium, are present in ground waters with low concentrations. The concentration of fluoride in the study area varies from 0.14 to 1.94 mg/l. The fluoride value of the water samples studied is well within the permissible limit of ISI for 23samples, where as 07 samples have high value of fluoride (>1.2 mg/l) and not safe for drinking purpose.

3.8 Nitrate (NO_3)

The WHO health-based guideline value for nitrate in drinking water is 45 mg/l. The concentration of nitrate in the present water samples varies from 4.0 to 92.0 mg/l. When water with high nitrogen concentration is used for drinking, it causes diseases like *methaemoglobinaemia.* Few data are available for concentrations of nitrate in ground water from Karnataka. Manjappa et al., (2003) quoted values between 0.08 mg/l and 308 mg/l for ground waters from Davanagere taluk in Karnataka. The presence of nitrate in water is due to domestic activities and agricultural run off which dissolved in rain water leaches into the wells (Zutshi et al., 1998). In the present study, 16 samples are well within the permissible limit of ISI out of 30 samples

3.9 Iron

In the present study, the iron concentration varied from 0.00 to 0.27 mg/l. The permissible limit for iron is 0.3 to 1.0 mg/l. The concentration of iron in water samples are well within the permissible limit

3.10 Zinc

The concentration of zinc in water samples varied from 0.43 to 1.05 mg/l. The permissible limit of zinc is 5 mg/l. These results are well within the permissible limit.

3.11 Manganese

The manganese concentration ranged from 0.04 to 0.08 mg/l. The permissible limit for manganese is 0.4 mg/l. The results indicated that all the samples of the study area are within the permissible limit.

3.12 Sodium Adsorption Ratio (SAR)

Excessive sodium in water produces the undesirable effects of changing soil properties and reducing soil permeability (Kelly, 1951). Hence, the assessment of sodium concentration is necessary while considering the suitability for irrigation. The degree to which irrigation water tends to exchange positive ions (cations) in the soil and cations in the irrigation water can be represented by the sodium adsorption ratio (US Salinity Laboratory, 1954). Sodium replacing adsorbed calcium and magnesium is a hazard as it causes damage to the soil structure. It becomes compact and impervious. SAR is an important parameter for the determination of the suitability of irrigation water because it is responsible for the sodium hazard (Todd, 1980). Out of 30 samples, 28 samples are suitable for irrigation. SAR values of the water samples vary from 5.0 to 19.8.

3.13 US Salinity Laboratory (USSL) Classification

According to a method formulated by the US Salinity Laboratory (1954), water used for irrigation can be rated based on salinity hazards and sodium or alkali hazard. When the sodium hazard ratio and electrical conductivity of water are known, the classification of water for irrigation can be done. According to USSL classification, out of 30 samples analyzed, 01 sample is found to be of C_2S_3 type (medium salinity and high SAR) and C_3S_1 type (high salinity and low SAR), which are suitable for irrigation purpose in general. 06 samples are of

C_3S_2 type (high salinity and medium SAR) such water can be used on soils with good drainage and plants with good tolerance should be selected. 03 samples are of C_4S_1 type (very high salinity and low SAR) and 06 samples are of C_4S_2 type (very high salinity and medium SAR), which are not suitable for irrigation under ordinary conditions. 12 samples are found to be of C_4S_3 type (very high salinity and high SAR) and 01 sample of C_4S_4 type (very high salinity and very high SAR), which are not at all suitable for irrigation purposes.

3.14 Percent Sodium

Sodium concentration is important in classifying the irrigation water because sodium reacts with soil to reduce its permeability (Todd, 1980; Demenico and Schwartz, 1990). Percent sodium in water is a parameter computed to evaluate the suitability for irrigation (Wilcox, 1948). The percent sodium values of the study area samples vary from 18.8 to 68.6. Percent sodium is plotted against electrical conductance, which is designated as a Wilcox diagram From this figure, 07 samples fall into the category of 'Good to Permissible' 20 samples fall in to the category of 'Doubtful to Unsuitable', while 03 samples fall into the category of 'Unsuitable'

3.15 Graphical Methods of Representing Analysis

Piper diagram Collins (1923) first proposed a graphical method of representation of chemical analysis. The method was latter modified by Piper (1944, 1953), based on the concentration of dominant cations and anions, and trilinear diagram was proposed to show the percentages at milli equivalents per litre of cations and anions in water samples. This Piper diagram modified by Davis and Dewiest (1967). The trilinear diagram of Piper are very useful in bringing out chemical relationships among ground water in more definite terms (Walton, 1970). This is useful to understand the total chemical character of water samples in terms of cation-anion pairs.

The piper diagram (Figure 1) consisting of 2 triangular and 1 intervening diamond-shaped fields. All 3 sides of the 2 triangular fields and the 4 sides of the diamond – shaped field are divided into 100 parts. The percentage reacting values at the 3 cation groups – Ca, Mg and (Na + K) – are plotted as a single point in the left triangulare field and the 3 anion groups – (HCO_3 + CO_3), SO_4 and Cl – similarly on the right triangular field. The 2 points in each triangular field show the relative concentration of several dissolved constituents of the water sample. Later a third point is plotted in the central diamond – shaped field after computing percentage reacting values for anions and cations separately. This field shows the complete chemical character of the water samples that gives the relative composition of ground water about the cation–anion point. These 3 fields reflect the chemical character of ground water according to the relative concentration of its constituent but not according to the absolute concentrations.

Later Piper (1953) classified the diamond – shaped field of the trilinear diagram into 9 areas to know quickly the quality of water and they are given below.

Area-1: Alkaline earth's (Ca+Mg) exceeds alkalies (Na+K) (includes areas 5,6 and 9a).

Area-2: Alkalies exceed alkaline earth's (includes areas 7,8 and 9b).

Area-3: Weak acids (CO_3 + HCO_3) exceed strong acids (SO_4 + Cl + F) (includes areas 5, 8 and 9b).

Area-4: Strong acids exceed weak acids (includes areas 6, 7 and 9b).

Area-5: Carbonate hardness (secondary alkalinity) exceeds 50%.

Area-6: Non-carbonate hardness (secondary salinity) exceeds 50%.

Area-7: Non-carbonate alkali (primary salinity) exceeds 50%.

Area-8: Carbonate alkali (primary alkalinity) exceeds 50%.

Area-9: None of the cation and anion pairs exceed 50%.

In the present study, it is noted that 18 samples of study area fall under area-2, 12 samples fall under area-2; 16 samples fall under area-3; 14 samples fall under area-4.

The majority of samples were in type Na-K-Cl-SO_4-HCO_3 followed by Ca-Mg-HCO_3. This indicates that samples of the study area are enriched with sodium, potassium, chloride, sulphate and bicarbonate types and from this it is evident that canals play a major role in controlling the groundwater chemical compositions in shallow aquifer which consists of recent alluvium.

3.16 Coliforms

The bacteriological content is one of the most important aspects in drinking water quality. The most common and widespread health risk associated with drinking water is the bacterial contamination caused either directly or indirectly by human or animal excretia. *E.Coli* a typical facel coliform is selected as an indicator of facel contamination. In the study area only seven samples are found to have coliform contamination. Out of ten samples only two samples (sample No. 13 & 20) have coliform contamination above 4/100 ml. Sample 13 & 20 were found to be highly contaminated with coliforms while the other samples suitable for human consumption.

CONCLUSION

On the basis of the present study, analysis of ground water of Huvinahadagali taluk in Karnataka state shows that only 70% of water samples have physico-chemical properties well within the permissible limits. According to USSL classification, out of 30 samples analyzed, 15 sample are not suitable for irrigation under ordinary conditions. 12 samples are found to be of C_4S_3 type (very high salinity and high SAR) and 01 sample of C_4S_4 type (very high salinity and very high SAR), which are not at all suitable for irrigation purposes.

The value of SAR in the study area, 07 samples were in excellent type and 21samples were in good type. According to Piper's diagram, the study area is characterized by water having both temporary and permanent hardness. The concentration of fluoride in the study area, 23 samples were well within the permissible limit. 07 samples have high value of fluoride (>1.2 mg/l) and not safe for drinking purpose. The presence of E.Coli in two samples of groundwater indicates potentially dangerous situation and require immediate attention. The results also suggested that the contamination problem is alarming at present in the study area but ground water indicates potentially dangerous situation and require immediate attention.

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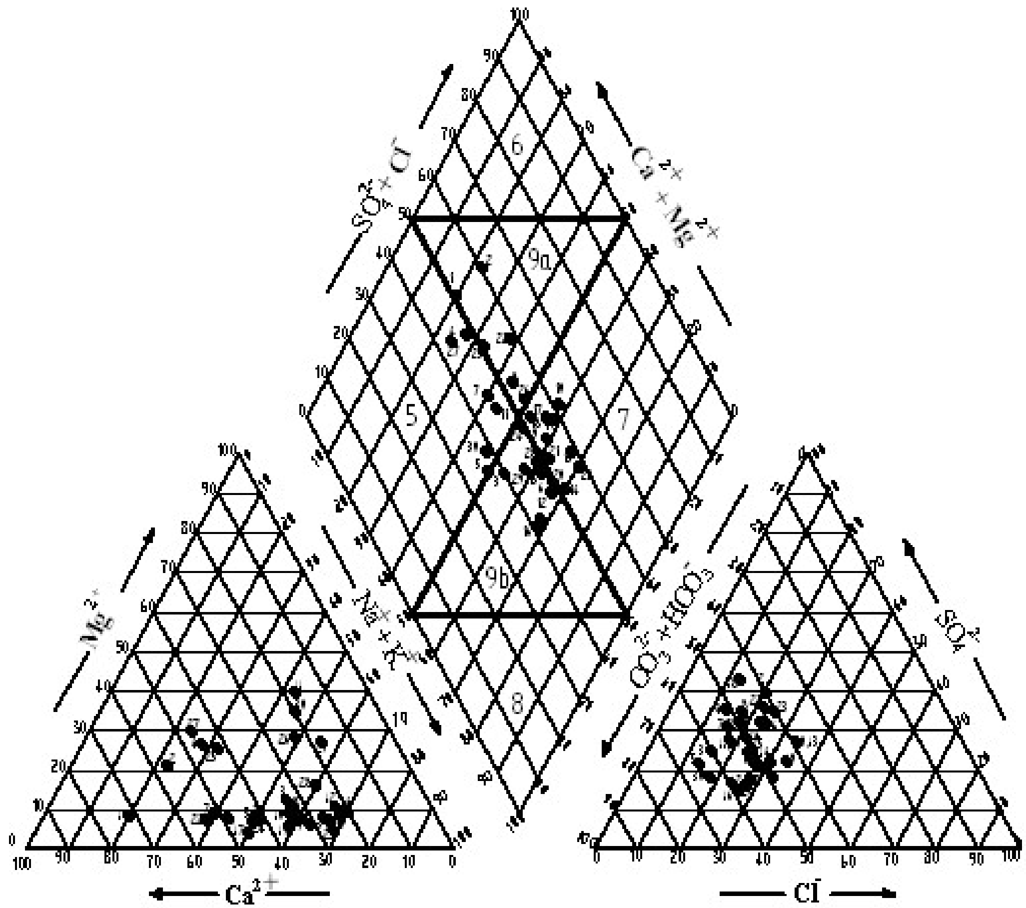

Figure.1 Piper trilinear diagram of borewell samples of Huvinahadagali taluk

Table :1 Analysis of physico-chemical factors of water samples of Huvinahadagali Taluk Karnataka

Sample NO.	Turbidity (NTU)	pH	EC (µ mhos/cm)	TH (mg/l)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Na^{+} (mg/l)	K^{+} (mg/l)	Cl^{-} (mg/l)	CO_3^{2-} (mg/l)	HCO_3^{-} (mg/l)	F^{-} (mg/l)	SO_4^{2-} (mg/l)	NO_3^{-} (mg/l)	TA (mg/l)	TDS (mg/l)	Fe^{2+} (mg/l)	Zn^{2+} (mg/l)	Mn^{2+} (mg/l)	Coliform Bacteria (MPN/100ml)
1	2.0	8.3	2900	872	211.6	28.2	56.0	2.1	275.0	16.0	413.0	0.42	156.0	79.0	332	1050	0.09	0.86	0.06	**00**
2	1.5	8.0	2350	601	125.8	48.4	47.0	3.9	158.0	0.0	322.0	0.52	325.0	23.0	306	850	0.00	0.73	0.05	--
3	1.5	8.4	2950	886	45.0	18.4	68.0	5.8	113.0	14.0	442.0	0.68	187.0	92.0	83	1140	0.00	0.87	0.05	--
4	1.6	8.6	2400	690	110.0	62.0	68.0	1.2	129.0	4.0	491.0	0.51	315.0	65.0	89	890	0.00	0.79	0.05	--
5	1.7	8.7	3500	810	62.2	10.5	74.0	3.6	110.0	0.0	502.0	0.72	170.0	30.0	190	1350	0.09	0.57	0.04	**00**
6	1.5	8.4	3200	958	34.8	8.1	92.0	0.6	226.0	0.0	486.0	1.26	223.0	51.0	298	1250	0.00	0.76	0.05	--
7	1.2	8.0	2300	670	72.0	12.8	54.0	3.5	134.0	6.0	432.0	0.68	260.0	35.0	368	850	0.09	0.83	0.05	--
8	1.3	8.1	2700	640	80.0	13.4	69.0	0.5	155.0	10.0	396.0	0.63	285.0	20.0	296	980	0.00	0.72	0.06	**00**
9	1.1	7.8	3600	915	32.7	6.2	57.0	1.2	134.5	18.0	251.0	1.80	187.0	90.0	192	1320	0.00	0.68	0.05	--
10	1.1	7.9	2700	545	38.9	10.4	64.0	3.1	217.0	0.0	268.0	1.69	195.0	52.0	461	1080	0.00	0.79	0.05	--
11	1.6	8.1	2550	664	42.0	9.2	96.0	2.0	134.0	4.0	398.0	1.43	195.0	75.0	228	960	0.00	0.68	0.05	--
12	1.5	8.2	2400	555	21.0	10.4	65.0	1.3	172.0	0.0	412.0	1.92	120.0	10.0	220	780	0.00	0.64	0.04	--
13	1.1	7.9	2800	580	30.2	8.8	71.0	4.8	224.5	0.0	291.0	1.02	186.0	51.0	428	1020	0.00	0.73	0.05	**43**
14	1.8	7.8	2650	560	19.5	9.6	66.0	1.1	184.0	0.0	298.0	1.94	130.0	9.0	296	1040	0.09	0.71	0.06	--
15	1.2	8.1	3000	606	24.0	4.2	46.0	0.0	180.0	9.0	352.0	1.02	150.0	67.0	491	1110	0.00	0.78	0.05	**00**
16	1.1	8.1	2700	615	16.0	6.4	48.0	0.8	154.0	6.0	342.0	1.86	90.0	51.0	468	960	0.00	0.61	0.05	--
17	1.4	8.2	2200	463	71.0	4.3	76.0	1.9	199.0	0.0	382.0	0.64	140.0	78.0	498	760	0.00	0.43	0.04	--
18	1.3	7.1	1200	250	48.5	16.2	84.0	3.2	20.0	4.0	62.0	0.58	65.0	66.0	475	410	0.09	0.49	0.05	--
19	1.8	7.3	1800	410	46.2	10.2	78.0	3.4	179.0	8.0	215.0	0.56	115.0	10.0	349	620	0.00	0.43	0.05	
20	1.6	7.3	1100	210	20.1	4.2	48.0	0.8	81.0	0.0	216.0	0.94	135.0	4.0	368	320	0.00	0.61	0.04	**33**
21	1.6	7.3	2300	460	22.2	5.1	43.0	0.4	144.0	10.0	221.0	0.68	99.5	5.0	344	740	0.00	0.73	0.04	**00**
22	1.2	7..5	2550	422	76.2	10.2	52.0	2.8	124.0	0.0	242.0	0.24	218.0	40.0	336	890	0.27	0.43	0.04	--
23	1.1	7.2	1050	195	18.2	4.6	50.0	2.0	92.0	0.0	151.0	0.96	127.0	35.0	345	320	0.00	.1.06	0.07	--
24	1.1	7.6	1750	470	78.6	15.2	94.0	3.3	121.0	14.0	268.0	0.18	162.0	14.0	351	630	0.00	1.05	0.04	**00**
25	1.4	7.3	1800	404	62.0	38.0	47.0	1.0	107.0	10.0	209.0	0.14	109.0	44.0	398	310	0.00	0.98	0.08	--
26	1.5	7.4	1280	320	31.0	40.1	63.0	6.4	119.0	12.0	218.0	0.32	161.0	21.0	360	420	0.00	0.81	0.05	--
27	1.2	7.5	2320	505	108.0	64.0	51.0	0.8	130.0	0.6	261.0	0.18	65.0	92.0	310	830	0.00	0.73	0.04	**00**
28	1.2	8.2	2600	687	34.0	21.0	79.0	3.2	121.0	10.0	368.0	0.64	240.0	47.0	290	960	0.09	0.50	0.06	--
29	1.1	7.9	2700	690	38.0	56.0	126.0	4.4	104.0	12.0	292.0	0.52	160.0	41.0	83	980	0.00	1.03	0.06	--
30	1.4	7.8	2340	482	46.0	78.0	106.0	1.8	95.0	11.0	312.0	0.43	102.0	50.0	292	860	0.00	1.05	0.06	**00**
Min.	1.1	7.1	1050	195	16.0	4.2	43.0	0.0	20.0	0.0	62.0	0.14	65.0	4.0	83.0	310	0.00	0.43	0.04	33
Max.	2.0	8.7	3600	958	211.6	78.0	126.0	6.4	275.0	18.0	502.0	1.94	325.0	92.0	498.0	1350	0.27	1.05	0.08	43
SD	0.3	0.4	651	199	41.4	20.8	20.0	1.7	51.3	5.8	105.9	0.55	67.5	27.1	113.7	286	0.06	0.18	0.01	7