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Status of Groundwater Quality of Kudligi Taluk Area in Bellary district, Karnataka, India

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Abstract

The study area was undertaken in the Kudligi taluk located in the Bellary district, Karnataka, India. The taluk consists mainly of pink and grey granite. The granites and their associated rocks constitute a portion of the Dharwar system.The assessment of water quality for its suitability for agricultural and domestic purposes was carried out. The results of chemical analysis for the major ions of 48 water samples collected from the study area of Kudligi 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 the analysis, certain parameters like sodium adsorption ratio, percent sodium and magnesium ratio were calculated. The hydrochemical pattern diagram helps in hydrochemical facies classification. The trilinear diagram of shows that the majority of samples fall in Na-K-HCO_3 facies followed by Ca-Mg-Cl-SO_4 and Na-K-Cl-SO_4 facies. In the present study, 75% of water samples can be classified as good for irrigation because most of the water samples (36/48) fall in C_2S_1, C_2S_2, C_3S_1, C_3S_2 & C_3 S_3 categories on the diagram. The remaining samples fall in C_3S_4, C_4S_1, C_4S_2, C_4S_3 and C_4S_4, not suitable for irrigation purposes as per USSL classification. The presence of E-coli in only seven dug wells indicated potential and dangerous fecal contaminations, which require immediate attention. Fluoride was most dominant ion responsible for contamination of the ground water. Fluoride concentration in 5 samples was above the permissible limit and in 9 samples showed above the excessive limit. The study indicates the need for periodic monitoring of ground water in the study area.

Key-Words: Ground water quality, Kudligi, Contamination, Bellary

Introduction

Water is a fundamental and a basic need for sustaining ecosystem. Availability of water in the desired quantity and quality, at the right time and place, has been the key to the survival of all civilizations. 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, 1995).

As groundwater moves along flow lines from recharge to discharge areas, its chemistry is altered by the effect of a variety of geochemical processes (Freeze and Cherry, 1979). In Karnataka, there is no significant work on water quality except by Jayanthi (1993), Ayed (2002) and Jayalakshmi Devi et al. (2005) and Suresh et al. (2009). In view of the above, it is clear that water quality assessment studies in Karnataka especially in Kudligi taluk, Bellary district are inadequate. Therefore, the present study has been undertaken to assess the water quality of Kudligi taluk, Bellary district in Karnataka.

Kudligi taluk is one of the major taluk of Bellary district. The taluk is situated between 14^0 33^1 to 15^0 03^1 north latitude and 76^0 08^1 to 76^0 44^1 east

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longitude. It covers an area about 1602 sq.km. The climate of this taluk is marked by medium rainfall, low humidity and dryness in the major part of the year and a hot summer. The period from November to February is the dry, comparatively cool season. The period from February to June is summer followed by the South-West monsoon season from July to September, October and November form the retreating monsoon.

Material and Methods

The present study provides a detailed description of the chemical criteria of ground water. Forty-eight water samples were collected 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 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).

Results and Discussion

Hydrogeochemistry

The results obtained from the analysis of water samples from different villages of Kudligi taluk are shown in Table 1. Standard methods (Harish Babu et al.2004) have been employed in the analysis of the water samples. Comparisons of the physico-chemical groundwater samples have been made with WHO (1988) and ISI (1991) drinking water standards.

pH

The range of desirable pH of water prescribed for drinking purpose by ISI (1991) and WHO (1988) is 6.5 to 8.5. . Ground waters 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 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.

Electrical Conductance (EC)

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 315 to 3560 µ mhos/cm.

Six samples (Sample No: 27, 28, 34, 44, 45 & 47) were found to have higher values than 3000 µ mhos/cm. The higher values of EC i.e., >3000 µ mhos/cm may be due to the longer residence time and factors of lithology of water bodies (Harish Babu et al., 2004).

The US Salinity Laboratory (1954) classified groundwater's on the basis of electrical conductivity up to 250 µ mhos/cm as excellent,250 to 750 µ mhos/cm as good, 750 to 2250 µ mhos/cm as fair and >2250 µ mhos/cm as poor category. Among 48 samples, 15 samples fall into the category of 'Excellent to Good',20 samples fall into the category of 'Good to Permissible', 06 samples fall into the category of 'Doubtful to Unsuitable', while 07 samples of study area fall into the category of Unsuitable.

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 106 to 1350 mg/l. Out of 48 samples collected, 30 samples fall into the 'Fresh Water' category while 18 samples fall into the 'Brakish Water' category.

Total Hardness (TH)

Total hardness is due to the presence of salts of Ca and Mg is the most abundant in groundwater. In the present study, the total hardness of water samples ranged from 90 to 682 mg/L. This indicates that, out of 48 samples, only 28 samples have total hardness content within ISI permissible limit (300 mg/L) while 17 samples have excessive limit (400-500 mg/L) and only 3 samples fall into the very hard category(>600 mg/L).

Total Alkalinity (TA)

The total alkalinity of water is a measure of its capacity to neutralize acids. Most of the groundwaters contain substantial amounts of dissolved carbon dioxide, bicarbonates and hydroxides. In the present study, alkalinity ranges between 100 to 373 mg/L. The high amount of alkalinity in the study area samples may be due to the presence of country rocks. Only 17 samples were within the permissible limit (200 mg/L) while 31 samples have above the permissible limits but within the excessive limit (600 mg/L).

Chloride (Cl^-)

Excessive chloride in potable water is not particularly harmful and the criteria set for this anion is 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 5.5 to 380 mg/L. Only 03 samples have above the permissible limit but within the excessive limit (600 mg/L).

Fluoride (F^-)

From the study it is clearly shows that increasing fluoride concentrations with depth are due to increased chemical reaction with increasing groundwater residence time. Long term use of groundwater for drinking has resulted in the onset of wide spread fluorosis symptoms, from mild forms of dental fluorosis to crippling skeletal fluorosis. The fluoride content in the study area ranged between 0.1 to 2.3 mg/L. This indicates that, out of 48 samples, fluoride concentration in 5 samples was above than the permissible limit (0.6 mg/L) and in 9 samples having above the excessive limit (1.2 mg/L).

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 2.0 to 73.0 mg/L. In 5 samples the concentration of NO_3^- was above the permissible limit. The determination of nitrate is important particularly in drinking water as it has adverse effects on health above 50 mg/L. When water with high nitrogen concentration is used for drinking, it causes diseases like *methaemoglobinaenia.* Few data are available for concentrations of nitrate in groundwater 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.

Iron

In the present study, the iron varied from 0.00 to 0.7 mg/L. The permissible limit for iron is 0.3 to 1.0 mg/L. The concentration of iron in all water samples of the study area is well within the permissible limit.

Zinc

The concentration of zinc in water samples varied from 0.30 to 1.0 mg/L.The permissible limit of zinc is 5 mg/L. These results are well below the permissible limit.

Manganese

The manganese ranged from 0.00 to 0.50 mg/L. The permissible limit for manganese is 0.4 mg/L. The results indicated that all the samples of the study area are well within the permissible limit except Sample No.16.

Irrigational Quality of Water

To understand the suitability of water for irrigational purposes, certain ratios of fundamental importance are described below:

Sodium Adsorption Ratio (SAR)

Excessive sodium in waters 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. SAR is an important parameter for the determination of the suitability of irrigation water because it is responsible for the sodium hazard (Todd, 1980). The waters were classified in relation to irrigation based on the ranges of SAR values (Richards, 1954). Out of 48 samples, 43 samples are suitable for irrigation and remaining 05 samples of the study area are unsuitable for irrigational purpose.

Kelley's Ratio

It has been calculated for all the 48 water samples of the study area. The range of Kelley's ratio is from 0.27 to 3.44 epm. The ratio is less than unity in 26 samples indicating their suitability for irrigational uses and remaining 22 samples are not suitable for irrigational purpose.

Soluble Sodium Percentage (SSP)

Wilcox (1955) has recommended another classification for rating irrigation water on the basis of soluble sodium percentage (SSP). The ratio of SSP values are in the range of 7.74 to 72.3 epm. In the present study, 13 samples are fall into 'good' category, 25 samples are fall into 'permissible' category and remaining 10 samples are not suitable for irrigational purpose.

Corrosivity Ratio (CR)

Corrosion is an electrolytic process that takes place on the surface of the metals, which severely attacks and corrodes away the metal surface. Most of the corrosion problems are associated with salinity and incrustation problems associated with alkalinity.

Badrinath et al., (1984) used the Corrosivity Ratio to evaluate the corrosive tendencies of river waters. Water samples having corrosivity ratio of less than 1 are considered to be non-corrosive, while the value above 1 is corrosive. In the present study, 24 samples (50%) from Kudligi talukas are considered as corrosive, while remaining samples have corrosivity ratio values of less than 1.00 epm.

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 hazards ratio and electrical conductivity of water are known, the classification of water for irrigation can be done by plotting these results on the graph (Figure 1). Low salinity water can be used for irrigation of most crops on most soils with little likelihood that salinity will develop. According to USSL classification 75% of water samples can be classified as good for irrigation because most of the water samples (36/48) fall in C_2S_1, C_2S_2, C_3S_1, C_3S_2 & C_3 S_3 categories on the diagram. The remaining 25% of water samples fall in C_3S_4, C_4S_1, C_4S_2, C_4S_3 and C_4S_4, not suitable for irrigation purposes (Figure 1).

Graphical Methods of Representing Analysis

Piper diagram Collins (1923) first proposed a graphical method of representation of chemical analysis. The method was later 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 is very useful in bringing out chemical relationships among ground waters in more definite terms (Walton, 1970). This is useful to understand the total chemical character of water samples in terms of cation-anion pairs.

In the present study, it is noted that most of the samples of study area fall under area-2, 6 samples fall under area-2; 22 samples fall under area-3; 26 samples fall under area-4; 07 samples fall under area-5; 30 samples from study area fall under area-9a &9b; 9 samples fall under area-7; and 02 samples fall under area-8. The trilinear diagram of Kudligi taluk shows that the majority of samples fall in Na-K-CO_3-HCO_3 facies followed by Ca-Mg-Cl-SO_4 and Na-K-Cl-SO_4 facies.

Coliforms

In the study area only three samples are found to have coliform contamination. Out of 48 samples only three samples (sample No. 3, 6 & 8) have coliform contamination above 4/100 ml. The permissible limit of bacterial coliforms is 4/100ml as per WHO. Three samples (sample No. 3, 6 & 8) 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 Kudligi taluk in Karnataka state shows that only 70% of water samples have physico-chemical properties well within the permissible limits. According to USSL classification 75% of water samples can be classified as good for irrigation because most of the water samples (36/48) fall in C_2S_1, C_2S_2, C_3S_1, C_3S_2 & C_3 S_3 categories on the diagram. The remaining 25% of water samples fall in C_3S_4, C_4S_1, C_4S_2, C_4S_3 and C_4S_4, not suitable for irrigation purposes. The value of SAR in the study area, out of 48 samples, 43 samples are suitable for irrigation and remaining 05 samples of the study area are unsuitable for irrigational purpose. According to corrosivity ratio 24 samples (50%) are considered as corrosive, while remaining samples have corrosivity ratio values of less than 1.00 epm. The concentration of fluoride in the study area, out of 48 samples, fluoride concentration in samples was above than the permissible limit (0.6 mg/L) and in 9 samples having above than the excessive limit (1.2 mg/L). According to Piper's diagram, the study area is characterized by water having both temporary and permanent hardness. The presence of E.Coli in three 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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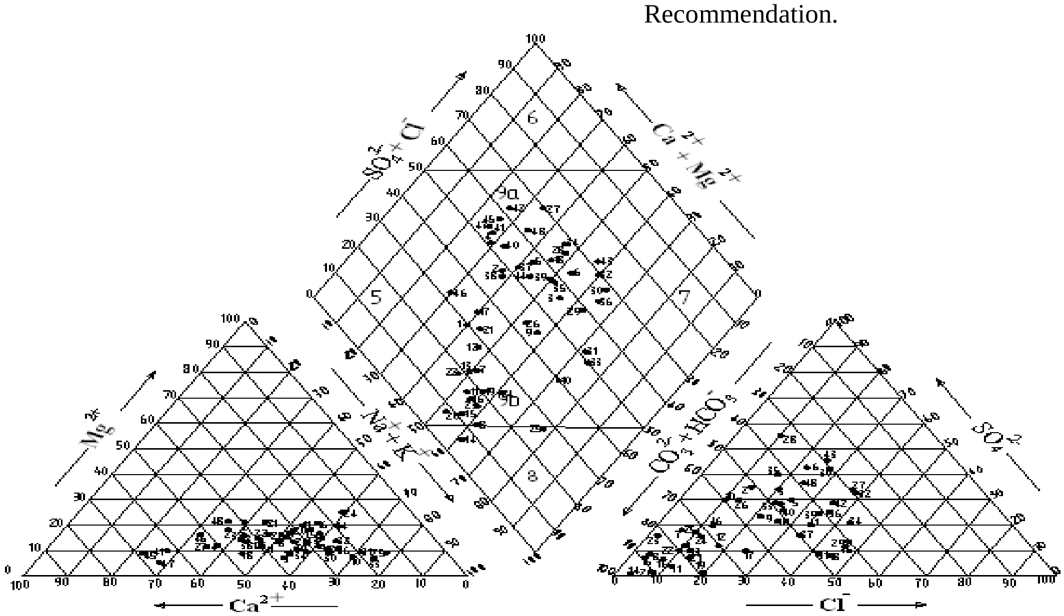

Fig. 1 Piper trilinear diagram of borewell samples of Kudligi taluk

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

SNo.	Tu (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^{-}	SO_4^{2-} (mg/L)	NO_3^{-} (mg/L)	TA (mg/L)	TDS(mg/L)	Fe (mg/L)	Zn (mg/L)	Mn (mg/L)	Coliform Bacteria (MPN/100ml)
1	1.0	7.4	870	230	76.2	39.0	76.0	2.8	31.0	0.0	196	0.6	54.0	42.0	246	290	0.09	0.63	0.04	--
2	1.0	7	1000	175	69.1	26.0	58.0	0.9	37.5	5.0	118	0.5	78.0	57.0	229	310	0.18	0.82	0.06	--
3	1.2	7.9	1600	315	55.0	9.0	82.0	0.6	134.0	10.0	276	0.8	210.0	73.0	298	530	0.18	1.02	0.04	**18**
4	1.4	7.6	1300	235	89.0	22.0	68.0	0.2	94.0	11.0	188	1.0	116.0	65.0	312	380	0.05	0.64	0.06	--
5	1.2	7.4	1300	288	72.1	30.0	78.0	2.4	86.0	0.0	148	1.1	105.0	29.0	201	340	0.09	1.02	0.05	--
6	1.0	7.4	1500	360	56.1	14.0	84.0	0.0	67.0	14.0	96	1.0	130.0	32.0	213	490	0.45	0.89	0.02	**39**
7	1.0	7.2	350	95	43.7	24.0	72.0	2.2	10.5	0.0	122	0.9	29.0	3.0	100	106	0.09	0.78	0.04	--
8	1.4	7.4	430	120	34.9	20.0	79.0	5.2	9.5	0.0	158	1.4	14.0	2.0	108	160	0.65	0.68	0.03	**19**
9	1.6	8.0	1650	455	35.0	18.0	73.0	1.3	193.5	19.0	484	0.9	225.0	13.0	302	630	0.36	1.02	0.05	--
10	1.6	7.8	650	210	55.3	20.0	180.0	1.1	37.0	10.0	212	1.0	112.0	6.0	192	260	0.09	0.66	0.01	--
11	1.8	7.8	670	112	60.1	44.0	112.0	8.0	29.0	10.0	202	1.0	10.0	64.0	178	246	0.02	0.75	0.03	--
12	1.6	7.6	920	130	65.3	22.0	76.0	1.4	50.5	0.0	208	0.6	36.0	37.0	128	280	0.09	0.59	0.06	--
13	1.4	7.6	630	118	60.5	24.0	79.0	5.3	36.0	0.0	224	0.5	28.0	25.0	151	180	0.01	0.68	0.04	--
14	1.2	7.8	495	102	57.7	62.0	176.0	10.5	13.5	0.0	266	0.9	2.0	16.0	168	160	0.09	0.76	0.06	**00**
15	1.4	7.3	315	140	25.7	19.0	54.0	1.3	7.5	0.0	168	2.0	13.0	13.0	109	200	0.01	0.82	0.06	--
16	1.0	7.5	450	105	66.1	58.0	146.0	5.9	20.5	5.0	196	0.8	17.0	56.0	162	140	0.09	0.82	0.52	--
17	1.2	7.8	850	208	81.0	32.0	72.0	3.4	85.5	0.0	216	1.1	28.0	10.0	192	430	0.27	0.86	0.05	--
18	2.0	7.9	1580	360	164.3	34.0	168.0	0.5	215.5	0.0	230	0.7	34.0	42.0	196	460	0.72	0.76	0.05	--
19	1.8	7.3	760	150	60.1	21.0	98.0	5.8	74.5	5.0	298	1.1	10.0	26.0	272	220	0.09	0.62	0.07	--
20	1.3	7.4	480	90	39.3	23.0	65.0	2.8	21.5	10.0	238	1.0	3.0	15.0	290	130	0.54	0.77	0.03	--
21	1.1	7.9	660	298	46.4	28.0	54.0	1.6	53.0	0.0	260	0.8	69.0	25.0	178	380	0.18	0.66	0.04	--
22	1.1	7.0	710	175	36.9	18.0	46.0	2.0	27.0	0.0	228	1.5	28.0	14.0	272	260	0.18	0.54	0.02	**00**
23	1.0	7.4	460	210	34.1	23.0	72.0	6.0	5.5	10.0	196	1.3	35.0	15.0	229	160	0.18	0.84	0.05	--
24	1.1	7.2	340	105	19.2	32.0	78.0	1.8	22.0	10.0	128	2.0	25.0	3.0	152	125	0.17	0.82	0.05	--
25	2.1	8.0	1200	260	17.6	12.0	102.0	1.4	50.0	10.0	362	2.3	85.0	38.0	151	440	0.02	0.97	0.04	**00**
26	1.2	7.4	700	175	42.5	16.0	68.0	0.9	34.0	10.0	128	1.8	70.0	4.0	168	260	0.01	0.76	0.02	--
27	2.6	8.2	3350	423	85.4	20.0	56.0	0.8	251.0	0.0	196	1.0	217.0	15.0	275	1190	0.03	0.65	0.05	--
28	2.0	8.6	3150	480	66.6	28.0	84.0	5.4	122.0	0.0	386	1.1	610.0	22.0	296	1200	0.03	0.58	0.04	--

29	1.6	8.2	2600	410	59.3	24.0	136.0	4.2	335.5	21.0	278	1.9	94.0	18.0	373	1040	0.04	0.62	0.04	--
30	1.8	7.8	1500	295	24.0	8.0	58.0	2.0	133.0	0.0	151	2.3	200.0	28.0	165	760	0.02	0.79	0.04	**00**
31	1.2	8.0	900	185	18.4	9.0	69.0	2.8	154.5	6.0	169	2.1	30.0	17.0	272	270	0.01	0.68	0.04	--
32	2.2	7.5	1400	295	22.0	14.0	52.0	2.4	156.0	0.0	121	2.3	130.0	30.0	208	450	0.06	0.83	0.05	--
33	1.0	7.2	800	145	12.8	6.0	54.0	2.0	32.0	0.0	72	1.3	41.0	6.0	231	240	0.04	0.69	0.04	--
34	1.4	8.0	3100	408	44.1	26.0	59.0	3.0	254.0	0.0	201	0.5	120.0	20.0	221	1020	0.2	0.68	0.05	--
35	2.6	7.5	1700	375	28.9	14.0	43.0	1.2	44.0	10.0	98	1.8	105.0	69.0	175	620	0.18	0.74	0.04	--
36	3.0	7.6	2200	400	19.3	8.0	46.0	2.9	117.0	0.0	116	2.0	82.0	15.0	268	780	0.54	0.54	0.06	**00**
37	3.2	7.8	3450	420	84.2	34.0	76.0	1.3	176.0	14.0	242	0.6	89.0	73.0	291	1300	0.03	0.75	0.05	--
38	3.0	7.8	1780	357	88.2	28.0	66.0	8.0	153.0	12.0	298	0.7	130.0	25.0	314	610	0.2	0.76	0.04	--
39	3.1	7.9	2300	437	96.1	26.0	120.0	1.0	187.0	0.0	234	0.4	132.0	44.0	352	810	0.3	0.80	0.05	--
40	2.8	8.2	2400	467	80.2	19.0	48.0	2.4	152.0	0.0	273	0.6	151.0	41.0	318	900	0.03	0.97	0.07	--
41	2.2	8.1	2350	486	150.3	23.0	58.0	8.7	183.5	5.0	242	0.2	110.0	37.0	298	860	0.18	0.54	0.02	--
42	1.3	7.5	1200	217	281.5	44.0	118.0	1.6	193.0	0.0	196	0.6	150.0	16.0	206	420	0.18	0.66	0.03	--
43	1.8	7.7	1650	286	70.1	31.0	127.0	4.6	197.5	0.0	205	0.7	325.0	18.0	313	630	0.09	0.63	0.05	**00**
44	3.0	8.2	3250	525	93.4	34.0	92.0	4.2	272.0	10.0	341	0.8	152.0	16.0	295	1290	0.18	0.68	0.05	**00**
45	2.4	8.1	3500	613	184.4	24.0	58.0	3.2	380.0	10.0	328	0.4	90.0	10.0	352	1320	0.27	0.33	0.02	--
46	2.0	7.2	2100	415	78.1	26.0	44.0	0.4	58.0	12.0	285	0.6	83.0	29.0	345	740	0.18	0.96	0.02	--
47	3.0	8.5	3560	682	200.0	18.0	84.0	2.8	129.5	0.0	361	0.1	320.0	35.0	346	1350	0.36	0.76	0.03	--
48	1.4	8.0	1480	348	73.4	35.0	58.0	0.8	153.0	18.0	218	0.4	225.0	26.0	279	495	0.04	0.84	0.03	--
Min.	1.0	7.0	315	90	12.8	6.0	43.0	0.0	5.5	0.0	72.	0.1	2.0	2.0	100.0	106	0.0	0.3	0.0	18.0
Max.	3.2	8.6	3560	682	281.5	62.0	180.0	10.5	380.0	21.0	484	2.3	610	73.0	373.0	1350	0.7	1.0	0.5	39.0
SD	0.7	0.4	977	148	51.4	11.6	34.2	2.4	91.6	6.2	83	0.6	107	19.3	73.1	372	0.2	0.1	0.1	11.8

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