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Water Quality Index of southern part of the Kathmandu Valley, Central Nepal; evaluation of physical water quality parameters of shallow wells

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ABSTRACT

Physical water quality of shallow groundwater of the southern part of the Kathmandu Valley was studied and analysed. Being the capital city of the country, the population is increasing day by dayand consequently the demand of water supply has also increased. Analyses reveal ranges of temperature to be 15.3–24.2 °C, pH to be 5.67–8.07, electrical conductivity to be (EC) 230–2860 µS/cm, and dissolved oxygen (DO) to be 0.09–9.1 mg/L in dry season whereas in wet season temperature, pH, EC and DO ranges are respectively 19.6–27.3 °C, 5.92–8.3, 183–3030 µS/cm and 0.19–7.9 mg/L. Water Quality Index (WQI) map shows that the upstream river areas contain good water quality than the downstream areas. The areas like Kalanki and Satdobato have poor water quality according to the guidelines of Nepal Drinking Water Quality Standard.

Key words: Shallow well, Southern Kathmandu, EC, DO, Water Quality Index

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INTRODUCTION

The Kathmandu Valley is a bowl shaped, intermontane basin formed in the Lesser Himalayan Midland Zone of the Central Nepal. People of the Kathmandu Valley have been dependent on groundwater sources like dug well, spouts and spring from the ancient time. The demand of groundwater is highly increasing in the valley, due to the uncontrolled population growth and unplanned urbanization. Groundwater, which is water that exists underground (Groundwater Foundation, 2012), and groundwater resources within the Kathmandu basin play the major role for fulfilling the partial demand of water supply. Among groundwater resources, shallow wells are considered as the major source for fulfilling the water demand for domestic purpose (drinking, cooking, washing, irrigation, farming, etc.). Shallow wells, which are driven generally less than the depth of 15 m, are constructed by digging, boring, driving and jetting. As being near to the surface, human activities may consequently pollute this water source over a time and make it unsafe for using without prior treatment. More so, several research findings (UNICEF, 2008; WHO, 2010) have revealed a definite correlation between human socio-economic and industrialization activities to pollution patterns/trends of groundwater. Contamination well can lead to the spread of various water-born diseases. The quality of drinking water is a powerful environmental determinant of health (WHO, 2010).

This study will be another approach for study of hydrogeological condition of the Kathmandu Valley in shallow wells. Precipitation and infiltration are the main recharge agents for the groundwater source. The water

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quality is under intense stress from increasing demand and withdrawal, significant changes in land use pattern, climate change and pollution arising from geological and geochemical environment (Edmunds and Smedley 1996).

The natural groundwater quality isn't always good. The natural quality can vary from one rock type to another and also within aquifers along groundwater flow paths (MacDonald and Calow, 2009). The Kathmandu Valley sediments have been divided into eight different stratigraphic units. (Yoshida and Igarashi, 1984; Yoshida and Gautam, 1988). The oldest is the Lukundol Formation, followed by intermediate gravel deposits such as Chapagaon, Boregaon and Pyanggaon Deposits developed in the course of tilting of the lake due to activation of the Main Boundary Thrust (MBT) towards the southern margin (Sakai, 2001). The younger sediments are in the northern part as the Gokarna Formation, Thimi Formation, Patan Formation and the Recent terrace deposits (Yoshida and Igarashi, 1984). The sediment deposited in different formations directly influences infiltration of water to shallow wells. Gravel and sand are considered as good aquifer with high potential zone for groundwater whereas clay, silt and hard rock as low potential water zone, although water has been extracted from low permeable layers of the Kalimati Formation for domestic purpose in the Kathmandu Valley.

The major river flowing through the southern part of the Kathmandu Valley is the Bagmati Rivdr, Kodku Khola, Nakhu Khola, Godavari Khola, Balkhu Khola, Bosan Khola and the Hanumante Khola. The recharge and discharge interchange within shallow groundwater and drainage according to climate and fluctuation of water table.

Studies on groundwater have been carried out in different parts of the southern Kathmandu; however, no comprehensive study has been conducted on the shallow groundwater quality in the study area. In this study, temperature, pH, EC and dissolved oxygen (physical parameters of water quality) of shallow well waters were determined.

MATERIALS AND METHODS

The Kathmandu Valley extends for about 30 km E-W and 25 km N-S covering the area of 656 sq km. The study area that focuses mainly the southern Kathmandu, is located between latitude 27° 32'34" to 27°49'11" N and longitude 85°11'10" to 85°31'10 E. The study area covers Balambu and the Bagmati River at the north, Chapagaun at the south, Bosan area at the west and Bhaktapur at the east (Fig. 1).

Water quality data collection

Geologically the area lies on the Kathmandu Nappe in the Lesser Himalaya Zone, south of the Great Himalaya Range separated by deep valleys of the Likhu Khola and the Shindu Khola (600 to 1300 m above sea level) (Sakai, 2001). The basin was originated tectonically (Hagen, 1969). Sakai (2001) defined the basin as a piggyback basin lying between the pop-up mountains of the Mahabharat Lekh to the south and the Shivapuri Lekh to the north. Drainage pattern of the Kathmandu Valley is governed by a centripetal drainage system. The area is a subtropical zone which has a mild climate most of the year. The annual mean temperature of the valley is 18.3 °C. During the rainy monsoon season between June and August, 70 to 80% of the total annual precipitation occurs by winds from Bay of Bengal.

Altogether 440 data were collected during both seasons, of which 220 wells water data were collected in dry season and the next 220 data from same wells were collected in rainy season. Data were collected from only shallow dug wells less than 15 m.

Wells in the study area were located in the topographic map from the field study. Longitude, latitude and elevation of each of the wells were taken by GPS (Garmin Colorado 300). Physical water quality parameters like DO, EC, pH and temperature were measured in the field because they showed the unstable behavior with change in surrounding environment. Scientific instruments were used in the field for the purpose of data acquisition like DO Meter (Mettler Toledo SG3-ELK) and EC-pH Meter (Mettler Toledo SG23-SevenGo; DuoTM pH/Conductivity meter). Water Depth Logger was used to measure the water table depth from the ground surface. Various other information like its age, depth, structure and surrounding condition of each well were also noted.

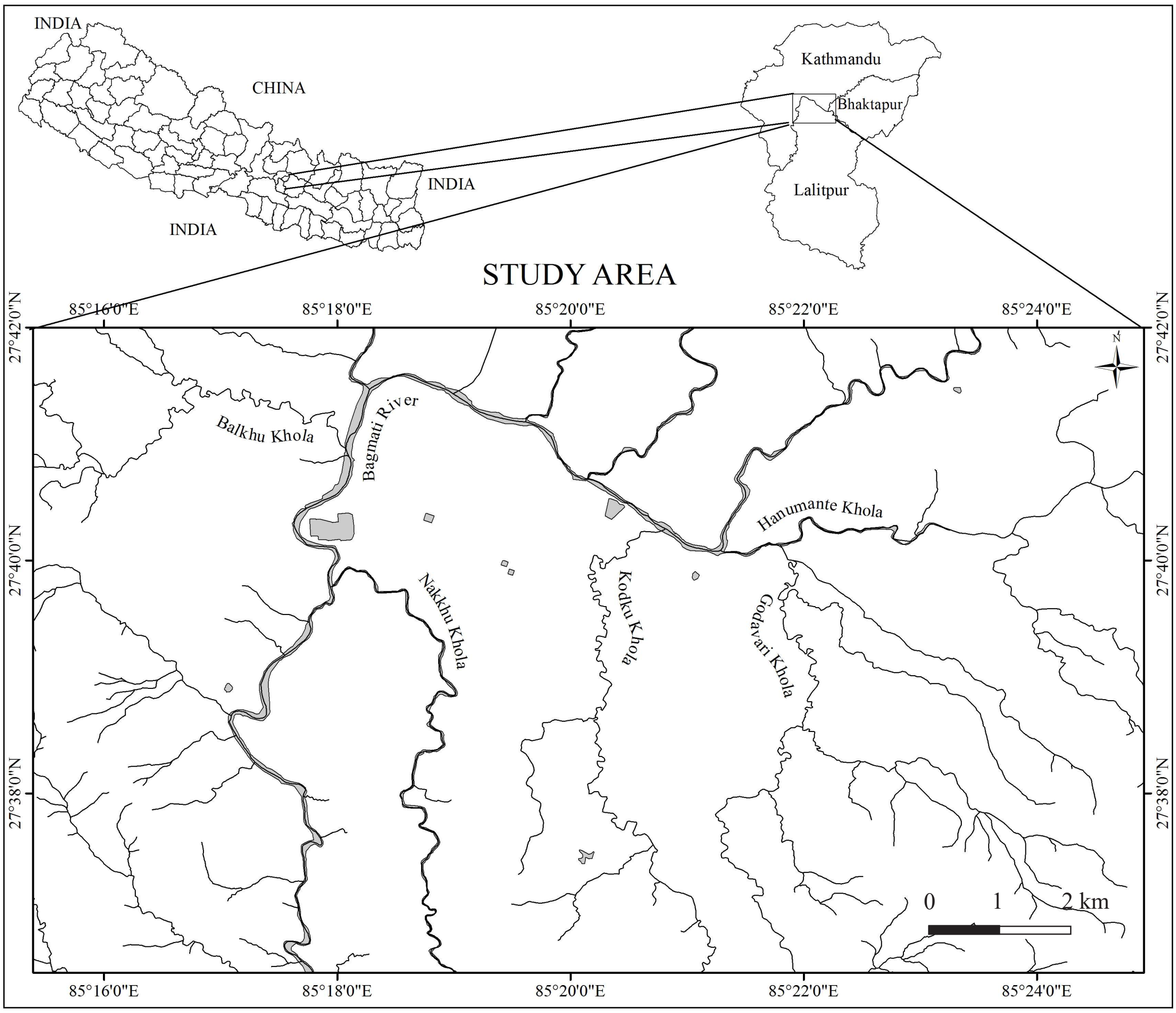

Fig. 1: Location map of study area

Water Quality Index (WQI) map based on physical parameters

Based on different physical water quality parameter measured in study area, a WQI was calculated and a map was prepared. An index is a mean device to reduce a large quantity of data down to the simplest form. It is defined as a technique of rating that provides the composite influence of individual water quality parameter on overall quality of water of that area (Gupta et al., 2015).

Following four steps were followed for calculation of WQI:

i. Assigning weight (w)

In this step the weights for individual parameter were assigned on the scale of 4 to 1 based on their contribution for water quality. For the most important scale of 4 was assigned and for the least important, the scale of 1 was assigned in this study.

ii. Relative weight (W)

Relative weight of each parameter was calculated using the following equation:

$$W = \frac{w}{\sum_{i=1}^{n} w} \quad (1)$$

Where, w is weight of each parameter and n is number of parameters.

iii. Quality Rating Scale (q)

The quality rating scale q for each parameter was determined by dividing the concentration of each parameter to its respective permissible standards and multiplied by 100

$$q = \frac{c}{s} \cdot 100 \quad (2)$$

Where, c is concentration of each measured parameter and s is the maximum allowable level for that parameter.

iv. Sub Index and WQI

To determine the sub index (SI) and WQI, the following equations were used.

$$\text{Sub Index (SI)} = q \times W \quad (3)$$

$$WQI = \sum_{i=1}^{n} SI \quad (4)$$

Where, SI is sub index of each parameter, q is quality rating scale of each parameter and n is number of parameter. Thus, obtained WQI value was described with their respective description value (Table 1).

RESULTS AND DISCUSSIONS

Electrical conductivity (EC) measures the dissolved ionic component in water and hence electrical characteristic. Value ranged from 230–2860 µS/cm with average of 807.66 µS/cm in dry season and 183–3030 µS/cm with average of 765 µS/cm in wet season (Annex Table 1). The water with EC of <1500 µS/cm is considered as potable according to NDWQS (2005). Kalanki and some part of Satdobato in both seasons have values greater than 1500 µS/cm. It can be due to pollution of water. The trend of value of EC in shallow ground water is increasing from the south to the north of the study area. As EC gives an indication of amount of total dissolved substitution in water (Yilmaz and Koc, 2014), high EC can be considered as having more solubility of minerals and other materials.

A pH ranges were 5.67–8.07 in dry season and 5.92–8.3 in wet season (Annex Table 1). Some wells in the Nakhu Khola catchment and the Central Zoo Area had acidic pH value less than 6.5, falling slightly below the guideline limit of 6.5–8.5, thus indicating corrosiveness. However, an average pH of 7.07 in dry season and 7.26 in wet season is recorded. The World Health Organization (WHO, 2010) recommends a pH value of 6.5 or higher for drinking water to prevent corrosion. A pH above 8.0 would be disadvantageous in the treatment and disinfection of drinking water with chlorine (UNICEF, 2008). However, pH values between

Table 1: Relative weight for physical water quality parameter and standards

Parameter	Weight (w)	Relative weight (W)	Allowable Standards
EC	4	0.4	1500 µS/cm (a)
pH	3	0.3	6.5–8.5 (a)
DO	2	0.2	3–8 mg/L (b)
Temperature	1	0.1	20–25^{0} C (c)
Total	14	1	

(a) = Nepal Drinking Water Quality Standards; (b) = European Classification Scheme; (c) = Not stated

Table 2: Water Quality Index Legend

WQI Value	Description
>100	Poor
75–100	Average
< 75	Good

6.5 and 8.5 usually indicate good water quality and this range is typical of most drainage basins of the world (UNEP/GEMS, 2007). The reason for change could be chemical used and pollution in agriculture runoff (EPA, 2012).

The DO ranges from 0.09 to 9.1 mg/L in dry season. In wet season it ranges from 0.19 to 7.9 mg/L (Annex Table 1). Areas like Katunje, Balkot, Lubu, Thaiba, Sunakothi and Kalanki had low DO often less than 2 mg/L. Except some few wells of Chobhar, Gwarko and Godavari where DO values range greater than 4, in almost all remaining wells, DO ranges from 2 to 4 mg/L in wet season. In dry season, DO of well water ranges from 0.09 to 2 mg/L in Balambu, Katunje and upstream of the Godavari Khola. The average DO values of the study area are 2.19 mg/L and 2.38 mg/L in dry season and in wet season, respectively (Annex Table 1). Inorganic reductants such as hydrogen sulphide, ammonia, nitrate and ferrous ions tend to decrease oxygen in water. Microbiological activities also consume oxygen creating the reduction of DO in water. Photosynthesis also influences the amount of DO in shallow aquifer.

Temperature is integral part to determine water quality. Various factors like sunlight, atmosphere, turbidity, mixing from other sources affect the temperature of shallow water. The temperature value ranges from 15.3 to 25.5°C in dry season and it seems to increase in wet season from 19.6 to 27.3°C showing same trend of distribution. Temperature value of the wells water are distributed heterogeneously in the study area. These suggest that the groundwater temperature is generally ambient and good for consumers who prefer cool to warm water and for the specific reason of water quality; since, bears negative impact on water quality by enhancing the growth of micro-organisms which may increase taste, odour, colour and corrosion problems (UNICEF, 2008). Therefore, it is important that groundwater temperature is not too high in order not to have microbial proliferation. Temperature affects biological, chemical and physical activities in the water (Yilmaz and Koc, 2014). Besides, increase in temperature of water decreases solubility of gases such as O_2, CO_2, N_2 and CH_4 (Yilmaz and Koc, 2014).

The WQI map prepared in GIS from the physical data of well water shows good categories of water in some part of Balambu, Central Zoo and almost all wells of upstream of rivers except the Hanumante Khola and the Thaiba Area while average in downstream of all rivers with poor category of water in some area like Kalanki and Satdobato in dry season (Annex Table 1; Figs. 2 and 3). Same pattern is observed in the wet season with minor changes in poor water only in Kalanki area, and Satdobato well waters change to average from poor water quality.

CONCLUSIONS

Temperature, pH, EC, and DO of groundwater of dug wells of the southern part of the Kathmandu Valley area were studied. Temperature values can be considered as being ambient relative to the geographical region and not too bad in terms of supporting microbial growth. Average pH is slightly basic with wells in some areas like the Hanumante Khola, and the north western part are acidic in nature indicating corrosion problems. Electrical conductivity values are average, hence from the EC values, the groundwater of this study area can be said to have average salt concentration and good for domestic and crop production but for drinking, other factors like chemical and biological parametersof the groundwater will have to be studied. DO values, further give mixed result to the freshness of the water, implying yet again low to high organic presence. Most of parameters with few exceptions clearly fell below WHO international best standards for water quality and NDWQS. The WQI maps prepared for two seasons show little variation of physical water quality parameters. Therefore, from results of this study, the groundwater in the study area can be regarded as being of good quality for household purpose and agriculture purposes with reference to the parameters under consideration, although requiring little treatment of pH especially in the Nakhu Khola, EC in some wells of the Kalanki Area, and DO in the upstream part of almost all the river area. However, further studies with reference to the chemical and microbial analyses will have to be done to have a broader picture of this water quality.

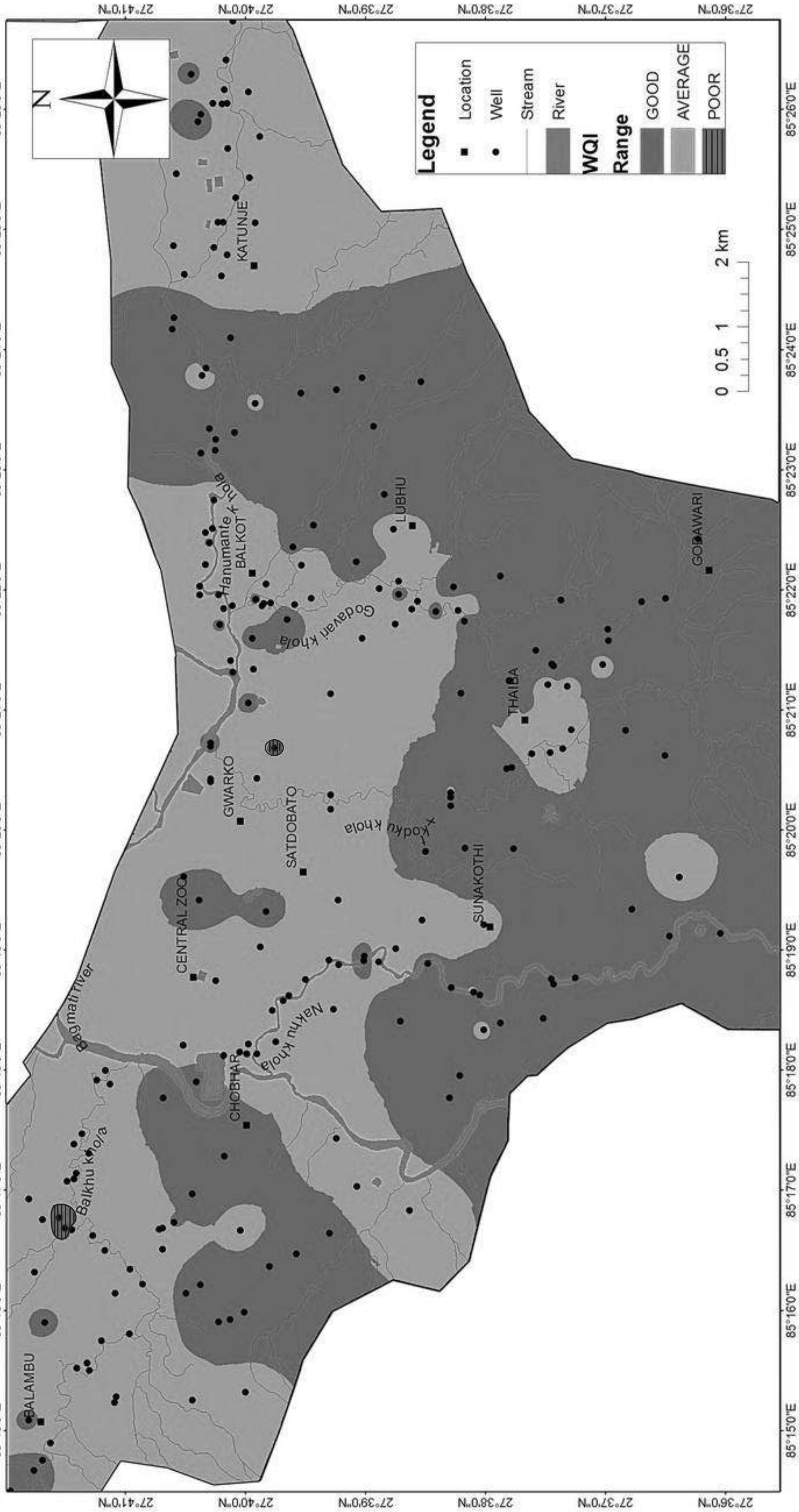

Fig. 2: WQI map of dry season of study area

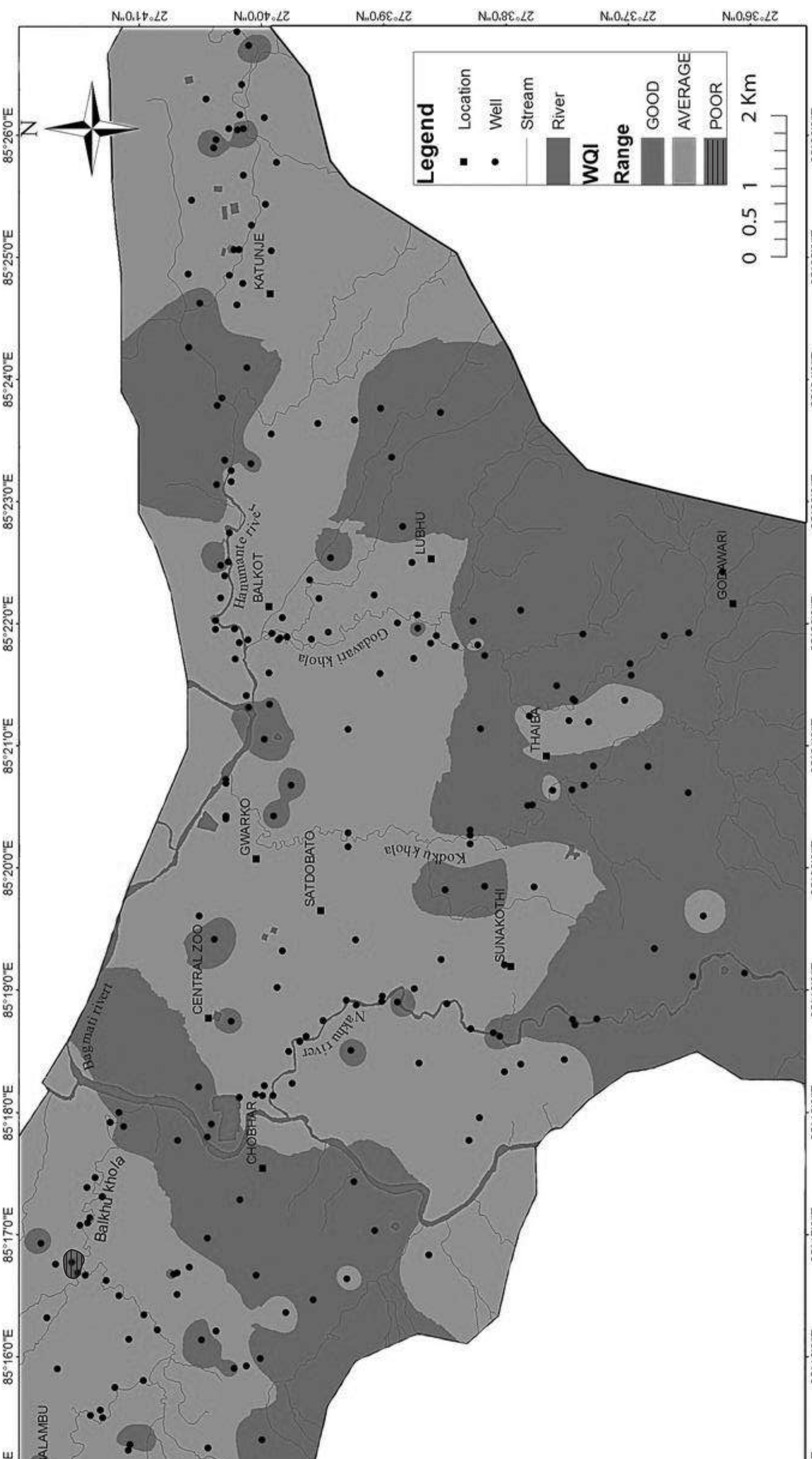

Fig. 3: WQI map of wet season of study area

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ANNEX

Annex Table 1: Physical parameters and WQI data of dry and wet seasons

S. N.	Well No.	Dry Season Data						Wet Season Data					
		EC (µS/cm)	pH	DO (mg/L)	Temp. (^{0}C)	WQI	Description	EC (µS/cm)	pH	DO (mg/L)	Temp. (^{0}C)	WQI	Description
1	HW1	1382	7.16	1.54	19.1	91	Average	623	7.61	3.29	22.8	63	Good
2	HW2	1059	6.95	0.55	20.1	87	Average	1221	7.36	0.98	22.4	91	Average
3	HW3	1142	6.8	3.31	19.2	71	Good	769	6.73	3	21.0	76	Average
4	HW4	576	7.56	1.13	18.6	76	Average	551	6.83	2.97	22.2	72	Good
5	HW5	1023	6.97	1.81	20.2	83	Average	1671	7.42	3	23.7	96	Average
6	HW6	982	6.65	0.97	20.1	85	Average	889	7.25	4.1	22.6	69	Good
7	HW7	1217	5.67	0.7	19.7	97	Average	1334	5.92	0.59	23.8	99	Average
8	HW8	604	6.95	2.31	19.6	73	Good	935	7.3	2.13	23.3	83	Average
9	HW9	746	7.2	2.13	19.4	77	Average	252	7.85	4.88	24.5	62	Good
10	HW10	571	6.75	1.05	20.7	77	Average	627	6.96	0.55	20.7	79	Average
11	HW11	852	7.26	1.94	18.8	79	Average	591	7.52	2.45	22.7	75	Average
12	HW12	1023	6.89	4.67	18.9	71	Good	745	6.94	3.83	22.2	65	Good
13	HW13	549	7.03	2.21	19.4	72	Good	915	7.34	1.05	22.5	85	Average
14	HW14	609	6.72	1.57	19.5	76	Average	520	7.06	2.56	22.8	73	Good
15	HW15	670	7.37	1.25	19.6	78	Average	662	7.2	2.93	22.3	74	Good
16	HW16	553	7.03	1.79	19.6	74	Good	801	7.22	3.16	24.2	66	Good
17	HW17	630	6.77	2.56	20.0	74	Good	1006	7.33	3.79	23.8	72	Good
18	HW18	812	6.96	3.61	19.2	65	Good	849	6.73	3.88	22.9	68	Good
19	HW19	661	6.65	1.26	18.9	77	Average	681	7.16	2.38	22.0	76	Average
20	HW20	627	6.76	0.67	18.4	78	Average	613	7.14	3.17	23.1	62	Good
21	HW21	921	6.61	2.56	18.8	79	Average	2158	7.61	1.32	24.7	111	Poor
22	HW22	855	6.85	1.12	18.1	81	Average	1736	6.98	1.78	22.1	99	Average
23	HW23	1512	6.9	1.91	19.0	92	Average	699	7.84	1.28	23.5	83	Average
24	HW24	1468	7.17	1.75	18.3	91	Average	784	7.22	1.14	23.6	82	Average
25	HW25	1160	7.05	0.55	19.9	89	Average	228	7.61	1.98	23.8	70	Good
26	HW26	1546	6.95	0.54	19.3	96	Average	481	7.7	3.72	23.5	62	Good
27	HW27	571	7.69	1.08	19.5	78	Average	934	8.05	1.54	20.7	87	Average
28	HW28	804	7.61	0.68	18.9	83	Average	839	7.03	2.05	22.3	80	Average
29	HW29	824	6.88	1.85	19.8	79	Average	620	7.51	3.88	22.2	64	Good
30	HW30	816	7.12	2.5	20.4	78	Average	401	7.34	2.88	25.3	71	Good
31	HW31	374	7.01	1.53	19.3	71	Good	663	7.27	2.73	22.3	75	Average
32	HW32	713	6.79	1.04	18.0	78	Average	861	7.57	0.5	24.6	87	Average
33	HW33	838	7.16	1.32	21.0	81	Average	828	7.52	1.03	20.7	83	Average
34	HW34	813	7.32	1.03	20.3	81	Average	1481	7.34	2.5	23.8	93	Average
35	HW35	915	7.07	0.4	19.6	84	Average	866	7.51	1.05	24.1	85	Average
36	HW36	666	7.37	0.47	19.3	80	Average	857	7.27	1.72	23.1	82	Average
37	HW37	1206	7.13	0.33	19.3	90	Average	1682	7.35	3.33	21.6	83	Average
38	HW38	1806	7.25	3.72	19.9	85	Average	565	8.13	6.24	19.9	72	Good
39	HW39	770	7.27	3.58	19.4	64	Good	1120	7.67	4.87	19.6	76	Average
40	HW40	1210	7.3	3.44	18.8	72	Good	1011	7.72	4.89	19.8	74	Good
41	HW41	778	7.22	3.53	19.9	64	Good	952	7.7	2.34	23.3	84	Average
42	HW42	1373	7.18	2.58	19.4	88	Average	718	7.15	1.45	23.9	80	Average
43	HW43	724	6.75	0.78	22.1	81	Average	555	7.26	6.18	20.8	67	Good
44	HW44	505	7.09	2.25	19.5	71	Good	1056	7.33	4.27	22.8	73	Good
45	HW45	1144	7.55	6.25	19.6	79	Average	1884	7.67	4.8	23.7	93	Average
46	HW46	340	7.33	2.37	19.6	68	Good	437	7.52	1.49	22.8	75	Average
47	HW47	397	7.07	0.74	18.7	73	Good	1569	7.31	2.26	23.6	95	Average
48	HW48	962	7.14	3.79	18.7	68	Good	514	7.4	0.82	26.4	79	Average
49	HW49	669	6.84	1.71	19.8	76	Average	540	6.8	1.69	20.5	74	Good
50	HW50	332	6.63	1.38	18.9	70	Good	674	7.1	2.58	22.4	75	Average
51	HW51	627	6.84	3.26	19.9	60	Good	612	7.14	2.68	24.7	75	Average
52	NW1	608	7.05	3	20.3	72	Good	666	6.92	1.03	21.6	79	Average
53	NW2	629	6.8	1.35	18.7	76	Average	940	7.4	2.52	23.5	82	Average

54	NW3	978	7.16	1.63	20.2	83	Average	867	7.35	1.92	21.8	81	Average
55	NW4	856	7.24	1.04	18.4	81	Average	856	7.21	1.91	22.6	81	Average
56	NW5	745	7.03	2	19	77	Average	937	7.94	2.51	24.6	85	Average
57	NW6	1058	6.92	1.34	20.3	85	Average	870	7.02	1.03	24.9	85	Average
58	NW7	1068	7.33	1.21	19.4	86	Average	895	7.53	2.34	24	82	Average
59	NW8	1131	7.26	1.71	19.2	85	Average	1540	7.72	2.9	23	94	Average
60	NW9	950	7.28	0.68	20.6	85	Average	501	7.4	1.39	24.1	76	Average
61	NW10	635	6.99	1.84	20.4	76	Average	938	7.46	1.19	22.5	85	Average
62	NW11	320	7.81	4.6	19.8	60	Good	827	7.25	3.57	24.1	67	Good
63	NW12	1052	7.03	1.26	18.9	85	Average	443	7.02	1	23.7	75	Average
64	NW13	464	7.04	0.6	19	75	Average	472	7.51	1.23	24.4	77	Average
65	NW14	458	7.34	0.8	19.3	74	Good	373	7.41	1.01	24.3	75	Average
66	NW15	401	7.46	1.09	20.2	73	Good	299	7.46	0.19	22.5	75	Average
67	NW16	452	7.45	0.5	19.8	76	Average	300	7.12	1.11	22.6	72	Good
68	NW17	345	7.14	0.55	19.2	72	Good	244	6.96	1.61	21.6	69	Good
69	NW18	264	6.99	2.79	19.5	65	Good	300	7.35	4.31	23.1	59	Good
70	NW19	370	7.39	4.2	18.2	57	Good	340	7.09	3.2	23.4	56	Good
71	NW20	396	7.73	3.45	19.1	58	Good	303	7.52	2.74	23.1	69	Good
72	NW21	242	7.09	5.7	20.9	59	Good	286	7.62	2.15	25.1	72	Good
73	NW22	371	7.37	2.76	19.7	68	Good	291	7.4	5.05	23.4	60	Good
74	NW23	335	7.26	5.4	18.7	60	Good	1186	6.18	2.05	21.1	89	Average
75	NW24	979	6.05	3.19	20.2	71	Good	704	6.8	5.34	20.4	68	Good
76	NW25	659	6.47	5.51	20.8	68	Good	698	6.6	2.15	20.3	77	Average
77	NW26	629	6.57	2.53	21.1	75	Average	1202	7.17	3.02	23.1	73	Good
78	NW27	1122	6.91	1.53	20.4	86	Average	1167	7.56	5.23	22.1	78	Average
79	NW28	1305	7.26	2.9	20.7	87	Average	520	7.67	5.75	19.9	66	Good
80	NW29	1083	6.67	4.04	18.3	71	Good	1028	6.39	1.6	22.2	86	Average
81	NW30	625	6.84	1.52	19.1	76	Average	951	6.53	1.8	22.5	84	Average
82	NW31	1025	6.97	1.4	20.6	85	Average	1132	6.72	0.8	23	90	Average
83	NW32	1035	6.49	0.5	17.8	87	Average	1238	6.88	1.2	22	90	Average
84	NW33	812	6.85	2.32	19.6	78	Average	916	6.48	0.5	22.8	87	Average
85	NW34	1257	7.38	3.54	19.9	74	Good	827	6.75	7.9	23.5	78	Average
86	NW35	720	6.78	4.04	19	64	Good	556	6.58	0.7	25.3	80	Average
87	NW36	574	7.69	7.36	18.2	71	Good	1091	7.15	2.3	22.2	84	Average
88	NW37	1071	7.07	3.35	18.2	69	Good	332	6.11	0.4	25.2	79	Average
89	NW38	511	6.24	0.55	19	78	Average	498	6.41	1.3	23.7	77	Average
90	NW39	479	6.66	5.15	18	62	Good	209	6.63	1.1	22	70	Good
91	NW40	484	8.07	0.55	18.9	79	Average	566	6.61	0.9	24.7	79	Average
92	NW41	581	6.46	0.3	24.2	81	Average	996	6.56	2	22	84	Average
93	NW42	743	6.64	0.56	21	82	Average	731	6.45	1.8	20.8	79	Average
94	NW43	865	6.6	1.42	18.4	81	Average	327	7.21	5.3	24.7	62	Good
95	NW44	297	7.32	6.33	21.4	63	Good	905	7.81	4	25.3	73	Good
96	NW45	1169	6.72	0.95	20.7	89	Average	874	6.96	6.7	21.3	75	Average
97	BW1	992	7.33	1.78	19.5	83	Average	859	7.83	3.64	23.3	70	Good
98	BW2	1694	7.07	3.03	18.7	81	Average	942	7.2	1.3	23.7	85	Average
99	BW4	896	7.2	2.17	20.3	80	Average	1184	7.09	1.36	22.8	89	Average
100	BW5	553	7.54	1.56	20.6	76	Average	886	7.4	1.22	23.9	84	Average
101	BW6	1544	6.95	3.46	19.8	79	Average	1335	6.8	2	21.7	90	Average
102	BW7	1174	6.78	1.7	20	87	Average	837	7.09	2	23.8	81	Average
103	BW8	1401	6.66	1.3	18.6	92	Average	785	6.82	2.8	24.9	79	Average
104	BW9	2860	7.03	0.37	20.3	124	Poor	3030	7.35	1.95	23.3	125	Poor
105	BW10	2140	6.63	0.38	19.6	109	Poor	2040	6.91	1.3	23.9	107	Poor
106	BW11	1661	6.63	1.04	19.8	98	Average	859	6.9	0.8	24.2	85	Average
107	BW12	583	6.68	0.5	19.9	78	Average	579	7.41	2.94	25.2	75	Average
108	BW13	797	6.68	0.7	19.9	82	Average	685	6.73	0.9	23.5	81	Average
109	BW14	689	7.38	1.28	18.5	78	Average	589	7.31	0.33	24	81	Average

110	BW15	1145	7.11	0.11	18.4	89	Average	865	7.51	0.69	24	86	Average
111	BW16	714	7.47	0.47	18.4	80	Average	523	7.53	0.98	24.3	78	Average
112	BW17	1127	6.98	1.97	20.1	85	Average	385	8.3	2.74	24.5	77	Average
113	BW18	577	7.14	0.59	20.6	78	Average	622	7.1	1.83	23	77	Average
114	BW19	1005	7.46	2.63	18.9	81	Average	814	8.04	2.34	23.5	84	Average
115	BW20	1071	7.39	0.47	18.6	87	Average	531	8.05	1.66	22.3	79	Average
116	BW21	781	7.03	1.14	19.1	80	Average	635	7.66	0.43	22.6	82	Average
117	BW22	661	7.33	2.55	19	74	Good	603	7.81	1.67	23.5	79	Average
118	BW23	661	7.37	2.97	19.5	73	Good	568	7.8	1.9	24.6	79	Average
119	BW24	576	6.31	1.36	20.7	78	Average	521	6.58	3.9	24.7	63	Good
120	BW25	605	7.42	0.57	20.8	79	Average	697	7.62	0.36	23.4	83	Average
121	BW26	999	6.9	2.97	19.9	80	Average	661	7.01	2.22	24.6	77	Average
122	BW27	867	7.56	5.37	19.4	71	Good	938	7.46	1.74	23.6	84	Average
123	BW28	404	6.96	0.59	19.4	74	Good	533	7.46	2.87	23.9	73	Good
124	BW29	467	6.94	1.21	19.2	73	Good	453	7.63	1.35	27.3	78	Average
125	BW30	708	6.87	0.98	19.9	79	Average	774	6.92	2.6	24	78	Average
126	BW31	339	6.72	5.72	17.1	60	Good	708	6.6	2	21	78	Average
127	BW32	1408	6.7	1.48	19.5	92	Average	893	7.45	4.7	25.1	73	Good
128	BW33	886	7.26	1.88	18.3	80	Average	481	7.65	4	23.8	63	Good
129	BW34	521	7.32	3.23	21.8	60	Good	313	7.16	4.7	23.7	60	Good
130	BW35	935	6.68	1.07	17.9	83	Average	415	6.7	1.9	22.3	72	Good
131	BW36	618	6.92	1.55	17.6	75	Average	489	7.81	3.1	25.5	63	Good
132	BW37	602	7.32	1.25	17.5	75	Average	496	6.83	1.1	24.4	77	Average
133	BW38	365	6.76	2.65	19.3	68	Good	659	6.84	3.4	22.8	63	Good
134	BW39	444	7.23	0.35	18.4	75	Average	346	7.11	3.5	26.3	59	Good
135	BW40	934	7.19	6.29	19.4	74	Good	1382	6.74	0.9	23.3	95	Average
136	BW41	804	6.68	5.51	17.4	69	Good	382	7.35	2.8	25.2	71	Good
137	BW42	496	6.87	1.24	19.2	74	Good	572	6.88	4.2	22.7	63	Good
138	BW43	950	6.75	1.4	18.3	82	Average	386	6.97	1.8	25.2	73	Good
139	BW44	312	6.68	2.16	17.8	67	Good	899	6.95	2.9	23.3	80	Average
140	BW45	1005	7.26	2.95	19.2	80	Average	992	7.44	2.31	23.1	84	Average
141	BW46	1316	6.95	1.18	17.3	89	Average	1145	6.99	1.44	21.9	87	Average
142	BW47	1001	6.76	2.25	18.2	81	Average	928	6.76	3.4	20.2	67	Good
143	BW48	1011	6.55	4.23	21.1	72	Good	1135	7	3	24.1	84	Average
144	BW49	446	7.42	5.94	18.7	64	Good	554	7.21	3.95	22.4	62	Good
145	BW50	501	6.76	4.75	18.5	61	Good	456	6.4	2.1	22.3	74	Good
146	BW51	1152	7.04	1.06	20	88	Average	1075	6.86	0.8	23.6	89	Average
147	BW52	762	6.79	0.5	17.5	80	Average	284	6.71	0.8	21.6	72	Good
148	BW53	1221	6.78	0.87	18.9	89	Average	1211	6.9	1	23.8	91	Average
149	BW54	671	7.11	2.21	19.7	75	Average	214	7.44	3.8	26.2	57	Good
150	BW55	787	6.63	1.45	17.8	79	Average	914	6.84	1.9	23.2	82	Average
151	GW1	1222	7.13	2.47	19	85	Average	856	7.1	2.85	21.3	78	Average
152	GW2	2090	7.16	1.7	20.4	105	Poor	1575	7.49	2.91	21.9	93	Average
153	GW3	498	7.04	1.68	15.3	71	Good	599	6.96	1.34	24.5	78	Average
154	GW4	810	7.03	2.5	17.5	76	Average	923	7.46	1.86	24.4	84	Average
155	GW5	840	7.31	2.45	17.5	77	Average	815	7.49	1.92	24.2	82	Average
156	GW6	608	7.17	0.71	18	77	Average	515	7.09	1.51	23.5	76	Average
157	GW7	441	7.06	3.77	24	60	Good	779	7.41	1.33	21.3	81	Average
158	GW8	620	7.23	0.62	17.4	77	Average	1099	7.2	1.25	22	87	Average
159	GW9	1525	7.68	2.06	19.8	94	Average	876	7.32	0.79	23.6	85	Average
160	GW10	944	7.22	0.72	16.9	83	Average	809	7.4	0.98	23.7	83	Average
161	GW11	741	7.23	1.22	16.8	78	Average	848	7.54	3.03	25.2	68	Good
162	GW12	932	7.66	5.04	17	71	Good	725	7.64	2.86	25.6	79	Average
163	GW13	747	7.41	1.11	15.3	78	Average	697	7.47	0.77	24.6	82	Average
164	GW14	838	7.33	2.26	15.4	76	Average	405	7.7	2.13	25.2	75	Average
165	GW15	512	7.3	1.3	17.5	73	Good	550	7.13	1.01	22.3	77	Average

166	GW16	951	7.57	0.5	19	86	Average	331	7.26	1.74	22.9	71	Good
167	GW17	422	7.11	1.24	17.6	71	Good	325	6.96	1.27	23.5	72	Good
168	GW18	459	6.88	0.82	18	73	Good	346	7.72	1.01	24	76	Average
169	GW19	406	7.16	0.6	17.9	73	Good	405	7.63	1.53	24	75	Average
170	GW20	428	7.33	4.55	21.1	61	Good	409	7.6	2.11	24.5	74	Good
171	GW21	400	7.47	1.04	19.1	73	Good	340	7.8	2.94	22.5	70	Good
172	GW22	464	7.47	2.56	16.2	69	Good	322	7.27	1.81	23.6	71	Good
173	GW23	418	7.14	3.62	17.2	56	Good	350	7.53	2.97	23.2	69	Good
174	GW24	369	7.48	3.97	19.7	58	Good	362	7.43	1.24	23.4	74	Good
175	GW25	398	7.22	5.78	16.5	61	Good	299	7.67	5.21	19.6	60	Good
176	GW26	303	7.03	4.51	19.6	57	Good	776	7.85	3	23.6	80	Average
177	GW27	1675	7.09	1.45	19.9	97	Average	972	7.66	1.36	24.1	87	Average
178	GW28	1197	7.07	0.77	21.2	90	Average	474	7.5	4.1	22.7	62	Good
179	GW29	400	7.48	2.58	20.2	70	Good	752	7.38	3.13	20.3	63	Good
180	GW30	471	7.46	6.36	19.5	66	Good	591	7.85	3.68	22.7	65	Good
181	GW31	526	7.63	2.78	20.6	73	Good	440	7.56	3.41	25.3	61	Good
182	GW32	359	7.24	5.55	19.5	61	Good	1050	7.22	2.38	22.6	84	Average
183	GW33	1004	6.95	2.73	19.3	80	Average	741	7.43	2.44	22.9	78	Average
184	GW34	853	7.14	2.45	19.9	78	Average	866	7.7	1.91	24.1	84	Average
185	GW35	846	7.18	2.05	19.6	79	Average	1382	7.37	0.97	24.8	95	Average
186	GW36	1268	7.06	1.3	19.3	89	Average	960	7.55	1.43	24	86	Average
187	GW37	470	7.16	2.2	21.5	72	Good	742	7.74	3.77	25.7	69	Good
188	GW38	734	7.2	3.85	20.1	64	Good	829	8.16	5.17	25.7	77	Average
189	GW39	1007	7.13	1.29	21.3	85	Average	425	6.9	0.96	24.6	76	Average
190	GW40	528	6.8	3.7	19.5	59	Good	685	7.42	0.22	24.5	83	Average
191	GW41	946	7.09	0.72	21.2	85	Average	344	7.12	2.18	23.4	70	Good
192	GW42	399	6.95	3.05	19.4	55	Good	590	7.48	3.12	24.1	62	Good
193	GW43	497	7.53	1.63	19	74	Good	856	7.9	5.29	20.9	74	Good
194	GW44	848	7.5	5.13	18.6	70	Good	428	7.31	2.38	24.1	72	Good
195	GW45	468	6.74	2.56	21.3	71	Good	1072	7.55	5.04	20	75	Average
196	KW1	1054	7.53	5.4	15.9	73	Good	1279	7.44	1.15	22.5	92	Average
197	KW2	1021	7.57	5.45	15.9	73	Good	1568	7.47	1.27	23.8	98	Average
198	KW3	1840	6.71	0.31	16	102	Poor	1187	7.59	1.06	24.8	92	Average
199	KW4	977	7.18	0.86	17.3	83	Average	872	7.33	1.5	22.5	83	Average
200	KW5	847	7.27	0.42	18.2	83	Average	1142	7.13	1.21	22.1	88	Average
201	KW6	1092	6.86	1.31	19.7	86	Average	945	7.29	0.42	23.3	87	Average
202	KW7	804	7.16	0.57	16.2	80	Average	371	8.06	3.63	24.9	63	Good
203	KW8	528	7.66	0.09	15.9	77	Average	516	6.95	2.83	24.2	73	Good
204	KW9	320	7.13	1.06	15.5	69	Good	1204	7.39	0.5	22	92	Average
205	KW10	416	7.03	0.9	16.8	72	Good	421	7.61	2.64	23.7	72	Good
206	KW11	455	7.07	0.5	17.8	74	Good	432	7.32	2.15	23.3	73	Good
207	KW12	294	7.03	1.35	17.2	68	Good	796	7.09	2.85	21	77	Average
208	KW13	999	6.62	1.43	18.6	83	Average	468	6.81	2.15	21.2	72	Good
209	KW14	568	7.89	0.82	17.5	78	Average	312	7.15	1.29	21.4	71	Good
210	KW15	570	7.05	0.47	17.8	76	Average	375	7.86	1.94	23	74	Good
211	KW16	511	8.03	9.1	20.8	77	Average	183	6.6	1.22	21.6	69	Good
212	KW17	267	7.2	2.46	19	66	Good	347	6.51	2	21.3	71	Good
213	KW18	230	6.16	3.68	22	57	Good	894	7.35	4.45	23.2	71	Good
214	KW19	1336	7.04	1.22	19.9	91	Average	933	7.56	4.84	22.7	73	Good
215	KW20	1869	7.11	0.41	18.5	103	Poor	1269	7.25	2.37	22.8	88	Average
216	KW21	1022	6.77	4.14	18.9	70	Good	512	7.29	5.16	20.2	63	Good
217	KW22	404	7.16	6.49	18.6	63	Good	860	6.44	4.39	20.1	69	Good
218	KW23	845	6.54	5.24	19.2	70	Good	371	8.06	3.63	24.9	63	Good