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Physico-chemical characterization and water quality index of ground water of Dhanbad town area

Binu Kumari, Mukul R. Mondal, Rajnikant Tiwary and Kausal K. Srivastava

Central Institute of Mining and Fuel Research, Barwa Road, Dhanbad

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ABSTRACT

In this study an attempt has been made to understand the ground water quality of Dhanbad town area in Jharkhand state, India by Physico- chemical characterization and water quality index. For this purpose grab samples were collected from different hand pumps of the Dhanbad town area during the month of December 2012 as per standard method of sampling and analyzed for their physicochemical characteristics. The value of various physicochemical parameters such as Total hardness, Total dissolved solid (TDS), Chloride, Conductivity, Salinity, Total suspended solid (TSS), Dissolved Oxygen (DO), Calcium hardness, Magnesium hardness, Alkalinity and Sulphate have been found to be 1700 mg/l, 966 mg/l, 908.8 mg/l, 1790 µS/cm, 1455 mg/l, 6.9 524 mg/l, 1207.5 mg/l, 173 mg/l , 372 mg/l and 0.674 mg/l respectively. The results shows that 75% of the water samples falls in the category B (Good water) and 25% of the water sample falls in the category C (Poor water) which is mainly due to high TDS and total hardness.

Keywords: Physicochemical parameters, Ground water quality, Contamination, Water Quality Index.

INTRODUCTION

Freshwater is a finite resource, essential for human existence, for agriculture and industry [1]. The quality of water is vital concern for mankind because it directly linked with human health. Changes in local topography and drainage system directly affect both quality and quantity of the ground water. Rapid increase in population and industrialization together has led to the deterioration of quality of water. Presence of active and abandoned coal mines, waste dumps, coal washeries, coking coal plants, thermal power plants, steel plants, cement plants have resulted in significant water pollution. Ground water quality depends on the quality of recharged water, atmospheric precipitation, inland surface water, and subsurface geochemical processes. Water pollution not only affects water quality but also threats human health, economic development, and social prosperity. Therefore, pollution of water resources needs a serious and immediate attention to understand the importance and control of water quality. The present study aims at the assessment of water quality in Dhanbad town area. Water sample were collected from the hand pumps in and around different area of Dhanbad city. Various physical and chemical parameters were determined by using standard methods of APHA [2]. The Dhanbad district is situated in the state of Jharkhand and lies between 23º 37' 3" and 24º 4' North latitude and between 86º6´30" and 86050' East longitude. Dhanbad district shares its boundaries with West Bengal in the eastern and south part Dumka and Giridih district in North and Bokaro district in West. The map of Dhanbad region is shown in fig -1.

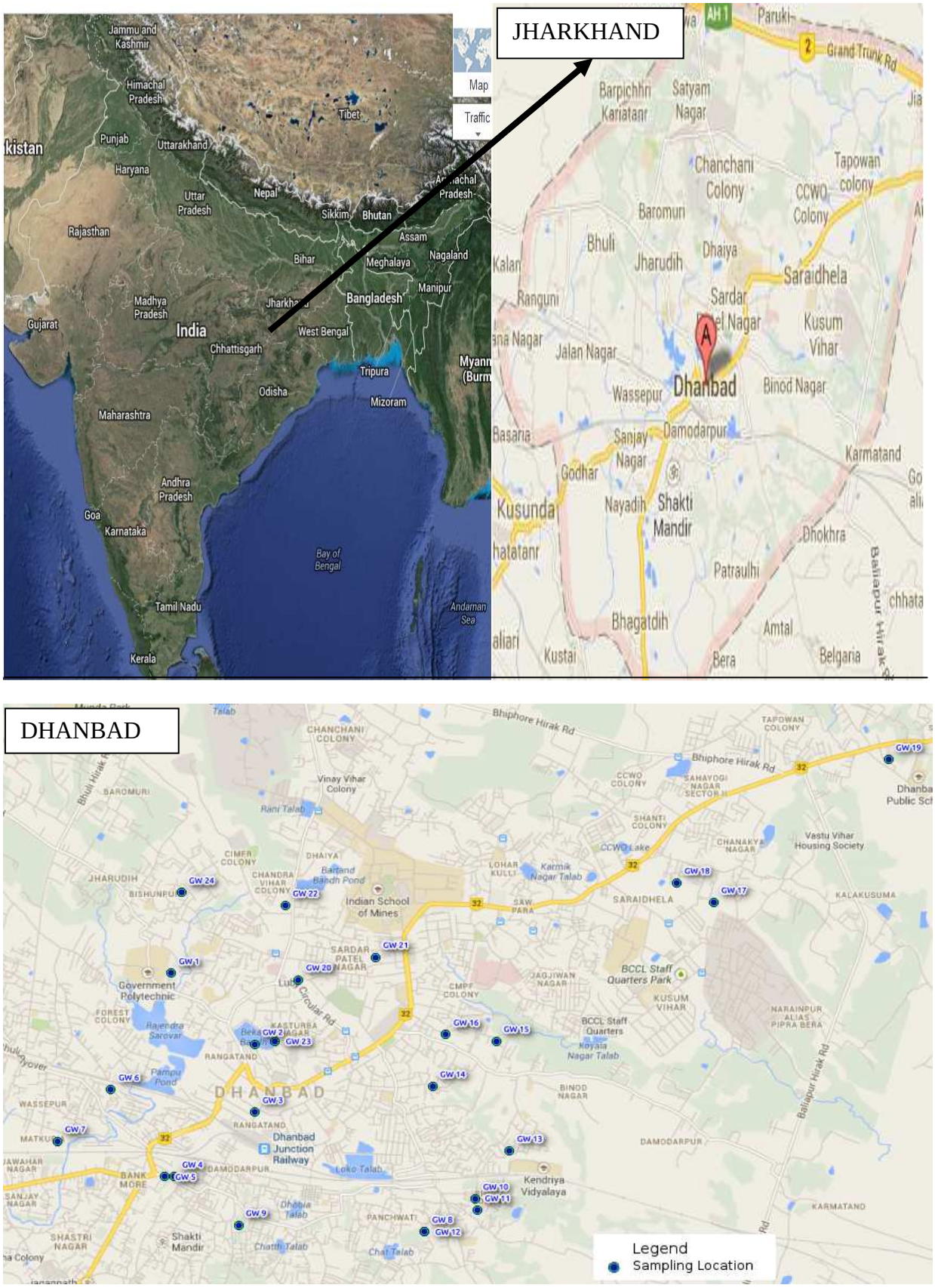

Figure 1: Location Map of Dhanbad Town Area,India

Dhanbad town getting water from Jamadoba. Later on PHED felt a genuine need for more water for growing population of Dhanbad and therefore envisaged ideal scheme for adequate water supply from Maithon Dam. The

first phase under this scheme which has been now commissioned is supplying 1770 cubic meter /hour which is equivalent to approximately 2MGD covering only for about 30% of the population against the requirement of an expected 20 MGD for about 10 lakhs of population of Dhanbad town (JNNURM). The shortage of water is met through surface water, wells, ponds, hand pumps and deep hole boring. All these activities have severely strained the ground aquifers causing depletion in ground water availability. This brings about an acute water crisis especially in summer season. The total population of Dhanbad is 10 lakhs, the requirement of water for whole district is worked out to be 124 MGD i.e. 225 litres/head/day as per IS: 1172/1973 estimation. Now Bureau of Indian Standard has estimated for general water requirement per head is 135l/day. In view of these facts Govt. of India has sanctioned a scheme under Jawaharlal Nehru Urban Renewal Mission (JNNURM) to supply 40 millions litres of water per day by 2039.The scheme yet to be executed by Dhanbad Municipal Corporation (Jawaharlal Nehru National Urban Renewal development plan for Dhanbad, Dhanbad municipal corporation 2007).

MATERIALS AND METHODS

Sampling locations were selected in the residential area and ground water samples were collected from 24 different hand pumps during the month of December 2012 in pre washed plastic containers as per standard sampling methods [3]. Different physicochemical characteristics of water such as pH, TDS, salinity Conductivity had been analyzed at the site using **Kit test r –35** and the remaining parameters like DO, Total hardness, calcium hardness, magnesium hardness, chloride and sulphate have been analysed in the laboratory as per the method described in APHA (1992).

RESULTS AND DISCUSSION

Physicochemical and biological parameters of water quality of ground water sample of Dhanbad town area have been carried out and overall observation is presented in Table 1.

Table 1: Physico- chemical characterization of ground water of Dhanbad town area

Sl. No.	Sample code	Name of sampling site	pH	Conducti-vity (µS/cm)	Salinity (mg/l)	TSS (mg/l)	TDS (mg/l)	DO (mg/l)	Total hardness (as CaCO3) (mg/l)	Calcium hardness (mg/l) (as CaCO3)	Magnesium hardness (mg/l) (as CaCO3)	Alkalinity (mg/l)	Chloride (mg/l)	Sulphate (mg/l)
1	GW1	Polytechnique campus	7.2	322	155	100	229	5.1	170	84	20.89	13.6	568	0.116
2	GW2	Grewal colony	8.12	815	397	95	659	6.1	390	210	43.74	22	142	0.049
3	GW3	Railway colony Rangatard	7.19	1035	509	100	733	4.1	430	294	33.04	21	205.9	0.674
4	GW4	Bank more near Thana	8.13	737	360	524	624	4.0	350	231	28.91	14	106.5	0.082
5	GW5	Municipal office Bank More	7.64	901	632	110	640	5.2	150	336	42.28	19	241.4	0.082
6	GW6	Washepur near Noorie Masjid	7.44	1273	442	180	902	6.9	340	147	46.89	186	106.5	0.069
7	GW7	Matkuria	7.33	885	437	100	628	5.1	350	231	28.91	372	85.2	0.053
8	GW8	Barmasia	7.39	1257	489	170	892	3.2	480	304.5	42.64	25	397.6	0.065
9	GW9	Gandhi nagar	7.31	1790	671	100	397	3.1	340	178.5	39.24	25	63.9	0.025
10	GW10	Gaguatard	7.42	923	1455	90	655	3.9	630	399.0	56.13	13	305.3	0.094
11	GW11	Tikkiapara	6.41	1185	278	110	841	5.0	118.0	777.0	97.92	14	653.2	0.119
12	GW12	Barmasia	7.39	1257	248	170	892	5.5	130	84	11.17	9.6	21.3	0.102
13	GW13	Chiragora	7.47	1353	1364	180	960	4.3	330	325.5	49.69	21.4	205.9	0.098
14	GW14	Hari mandir campus	6.73	1328	1328	210	943	3.1	550	367.5	44.34	37	156.2	0.049
15	GW15	Telipara	7.18	1364	1353	190	966	5.3	560	252	26.24	36	184.6	0.053
16	GW16	Hirapur near pani tanki	7.27	248	1257	176	346	5.2	600	304.5	71.80	31.6	227.2	0.037
17	GW17	ThanaMore Saraidhela	6.27	278	467	200	298	4.2	380	147	56.61	18.6	120.7	0.004
18	GW18	Near Steel Gate	7.38	1455	605	210	704	3.6	480	325.5	37.54	26.2	149.1	0.074
19	GW19	Near Bhoipur Mandir	6.28	671	933	210	704	3.0	650	210	106.92	41.4	276.9	0.090
20	GW20	Dhaiya Clinic, Dhaiya	7.68	983	656	250	701	5.2	1700	997.5	170.70	28.2	880.4	0.144
21	GW21	Housing colony	6.29	462	529	60	328	5.4	1470	1207.5	63.78	20.0	908.8	0.115
22	GW22	CIMFRCampus outside gate	7.85	644	230	10	451	4.9	650	630	4.86	7.2	390.5	0.041
23	GW23	Bekar Bandh	6.78	1280	398	20	908	3.9	360	315	3.64	21.8	85.2	0.069
24	GW24	Bishunpur near Zila School	6.48	790	323	80	561	6.4	1240	525	173.74	21	369.2	0.049
Indian standards (IS:10500) (mg/l)			6.5-8.5	-	-	-	500	-	300	-	-	-	250	150

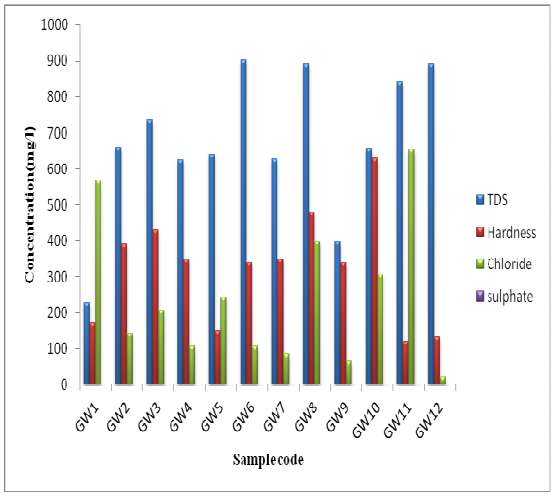

Fig. 2: Concentration (mg/l) of TDS, Hardness, Chloride and Sulphate in ground water sample at different sampling locations

Physicochemical characteristics of ground water of Dhanbad town area

River is a dynamic system. pH is the very vital parameter for river ecosystem or any water bodies. pH greater than 8.5 causes bitter taste of water or soda like taste. Eye irritation and exacerbation of skin disorder is also caused when pH is greater than 11 [4].Highest pH was found in GW4 location. A pH 6.27 and 8.13 was measured at GW17 and GW4 location. Conductivity has been observed to be varied from 248µs/cm to 1790µs/cm. Salinity varies from 155-1455 mg/l with maximum value at GW10.TSS and TDS is an indicator of overall water quality. TSS means suspended solid and TDS means inorganic salt and organic matter in water or water bodies. High concentrations of suspended solids can cause many problems for stream health and aquatic life. High TSS can also cause problems for industrial use, because the solids may clog or scour pipes and machinery.TSS is found to be 10-524mg/l with maximum value at GW4 whereas TDS varies from 229-966mg/l which has been observed above the permissible limit of 500mg/l at all the locations except GW1, GW9, GW16, GW17, GW21 andGW22. Similar to TSS, high concentrations of TDS may also reduce water clarity, contribute to a decrease in photosynthesis, combine with toxic compounds and heavy metals, and lead to an increase in water temperature DO varies from 3.0 to 6.9mg/l. Highest DO value of ground water was observed at GW6 sampling point because aquatic plants present which increases dissolved oxygen concentration. On the other hand GW9 and GW19 were observed to contain lower dissolved oxygen level in comparison to other stations. Hardness varies from 118-1700 mg/l. Hardness mitigates metals toxicity. Hard water can also leave a film on hair, fabrics, and glassware. Hardness of the water is very important in industrial uses, because it forms scale in heat exchange equipment, boilers, and pipes. Some hardness is needed in plumbing systems to prevent corrosion of pipes. Ca hardness is found to be 84-1207.5 mg/l. If the calcium ion concentration in freshwater is below 5mg/L, there is a possibility of oligotrophic condition. Alkalinity has been found to be within the permissible limit of 200mg/l except water sample of GW7 (372 mg/l). Chloride concentration was found to vary from 21.3-908.8 mg/ l. At GW21 station, Chloride concentration was found to be very high (908.8 mg/l) (Table 1). High concentration of chloride gives a salty taste to water.

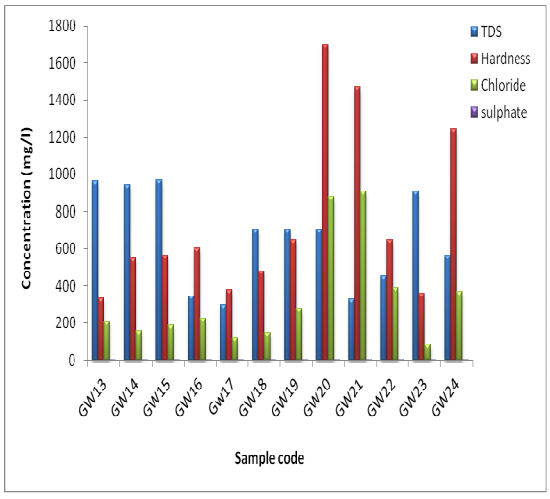

Fig. 3: Concentration (mg/l) of TDS, Hardness, Chloride and Sulphate in ground water sample at different sampling locations

Dhanbad town and its adjoining area are not in prominent of any river hence lands open to sky are the only option left to receive rainwater for recharging ground water through percolation but builders are increasingly occupying lands which were once open to sky and other intending settlers for high rise apartments, buildings and colonies. As such an open land in and around Dhanbad is shrinking, so in rainy season reduced area of land are available to receive rain water resulting in adequate recharging of ground water. Intermittent, untimely and insufficient monsoon rains do not recharge the ground water adequately causing depletion in ground water which ultimately lowers the water level especially in summer. Mining process surrounding the Dhanbad town is also one of the most important factors for depletion of ground water. The water level which is already gone down because of reasons stated above is further going down due to excessive withdrawal of ground water. Consequently many surface water wells get dried up with not a drop of water especially in summer seasons.

Water Quality Index (WQI):

Water quality index is an important tool for getting an idea about the quality of water for drinking purpose. One of the most effective ways to communicate information regarding water quality trends to policy makers and the general public or citizens is with indices [5].Five physicochemical parameters viz. pH, TDS, Total hardness, Chloride and Sulphate have been taken for calculating water quality index. The quality index does not show exact degree of pollution, rather it is used to assess water quality trends for the management purpose. Mishra et al 2008. Recommended water quality criteria [6-9] for drinking purpose is given in Table 2.The Water Quality Index (WQI) is a very useful and efficient method for assessing the quality of water [10]. An index value of <50= Excellent, 50 - 100= Good, 100 - 200= Poor, 200 - 300= Very poor and >300= Unfit for drinking. To determine the suitability of the groundwater for drinking purposes, WQI has been computed from the following formula:

Procedure for calculating WQI is as follows:

$$Wi = \frac{wi}{\sum_{i=1}^{n} wi} \qquad (i)$$

Where wi is the weight of each parameters and n is the number of parameters. Calculated unit weight and quality rating (q_i) values are given in table.

Then, quality rating (q_i) for each parameter was determined by dividing its concentration in each sample by respective Indian standard followed by BIS 1991 and the result was multiplied by100, mentioned in equation (ii). Next, quality rating qi is determined as follows:

$$q_i = (Ci / Si) X 100 \qquad (ii)$$

Where,

Ci = Concentration of each parameter in each water sample and Si = Indian drinking water standard for each parameter

For WQI analysis, sub index SIi was first determined for each parameter by multiplying its unit weight (Wi) with quality retting (qi), equation (iii).

$$SI_i = Wi \, . \, qi \qquad (iii)$$

SI_i = Subindex of ith parameter.

Then quality index is calculated by the following no (iv) equation.

$$WQI = \sum SI_i \qquad (iv)$$

WQI for ground water of Dhanbad town area is given in Table 2 according to above mentioned procedure.

Table 2: Water quality index of ground water of Dhanbad town area

Sl. No.	Sample code	Name of sampling site	Water Quality Index
1	GW1	Polytechnique campus	86.6
2	GW2	Grewal colony	77.2
3	GW3	Railway colony Rangatard	82.60
4	GW4	Bank more near Thana	71.7
5	GW5	Munical office Bank More	72.2
6	GW6	Washepur near Noorie Masjid	76.04
7	GW7	Matkuria	67.05
8	GW8	Barmasia	105.1
9	GW9	Gandhi nagar	58.7
10	GW10	Gaguatard	98.2
11	GW11	Tikkiapara	104.4
12	GW12	Barmasia	59.4
13	GW13	Chiragora	85.2
14	GW14	Hari mandir campus	87.7
15	GW15	Telipara	92.8
16	GW16	Hirapur near pani tanki	81.8
17	Gw17	ThanaMore Saraidhela	58.4
18	GW18	Near Steel Gate	80.2
19	GW19	Near Bhoipur Mandir	93.6
20	GW20	Dhaiya Clinic, Dhaiya	193.9
21	GW21	Housing colony	170.8
22	GW22	CIMFR Campus outside gate	102.1
23	GW23	Bekar Bandh	72.9
24	GW24	Bishunpur near Zila School	124.3
		Drinkinng water Standard(IS:10500)	

The water quality classification according to quality index is shown in Table 3 and Figure 4 reflects the graphical variation.

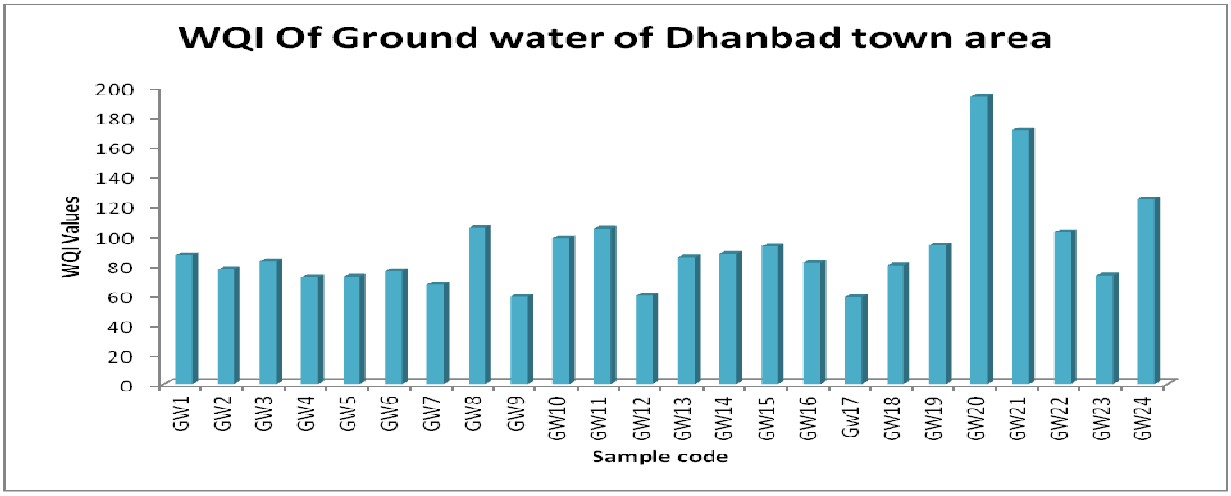

Fig. 4: WQI for various ground water sampling location of the study area

The water quality classification is done according to the water quality index so obtained which is shown in the Table 3.

Table 3: Water quality index of various ground water sampling location of the study area

WQI value	Water quality	Category	% of water sample
< 50	Excellent	**A**	0.0
50 -100	Good water	**B**	75 (approx)
100 - 200	Poor Water	**C**	25 (approx)
200 - 300	Very Poor water	**D**	0.0
> 300	Water unsuitable for drinking	**E**	0.0

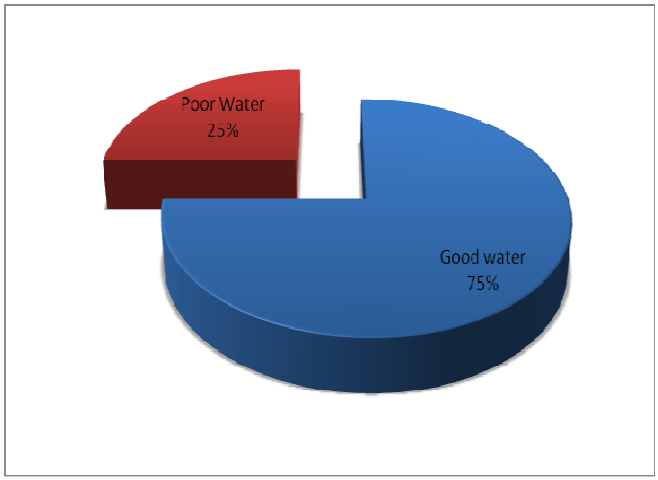

Fig. 5: WQI Categories of samples (%)

The results shows that 75% of the water samples falls in the category B (Good Water) and 25% of the water sample falls in the category C (Poor Water) which is mainly due to high TDS and Total hardness.

CONCLUSION

The analytical results of water sample shows that physicochemical parameters like total hardness, total dissolved solids and chloride have been observed above the permissible limit with the value ranging between 1700 mg/l, 966 mg/l and 908.8 mg/l respectively. WQI Value shows that 75% of the water samples falls in the category B (good water) and 25% of the water sample falls in the category C (poor water) which is mainly due to high TDS and total hardness.

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