

Water Quality Index (Wqi) Of Some Wells Located In The Region Of Kani Goma And Kanasura In Sulaimani Governorate



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Abstract

A Water Quality Index (WQI) is a useful statistical tool for simplifying, reporting and interpreting complex information obtained from any body of water. A simple number given by any WQI model explains the level of water contamination. This study is carried out by using twelve ecological parameters in evaluating the quality of the ground water for drinking usage, by choosing four sampling sites in Kanasura and Kanigoma district located in Sulaimani city during 15 July, 2013 to 1 September 2013. The sampling was repeated after 15 days and the present study is spread over a period of two months of summer season. The present study aimed to calculate water quality index (WQI) by the analysis of twelve physico-chemical parameters on the basis of Weighted Arithmetic Index in order to assess the suitability of water for drinking purposes and other human uses. These physico-chemical parameters like Electrical Conductivity (EC), Turbidity, pH, Total Dissolved Solids (TDS), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Total Hardness as CaCO_3 , Nitrate ($\text{NO}_3^- \text{N}$), Nitrite, ($\text{NO}_2^- \text{N}$), Sulfate (SO_4^{2-}), Chloride (Cl), and Phosphate ($\text{PO}_4^{3-} \text{P}$). The observed values of these physico-chemical parameters were compared with WHO standards. The results showed that water quality varied from good water to poor water range.

Keywords: ground water, physico-chemical analysis, water quality index (WQI)

1. Introduction

Water is a vital for all aspects of human and ecosystem survival and health. Thus, its quality is also important. Assessment of water quality can be defined as any specific area or specific source can be assessed using physical, chemical and biological parameters. The values of these parameters are harmful for human health if they occurred more than defined limits [1, 2, 3, and 4]. Therefore, the suitability of water sources for human consumption has been described in terms of Water quality index (WQI), which is one of the most effective ways to describe the quality of water. The WQI which was first developed by (Horton, 1965) is basically a

mathematical means of calculating a single value from multiple test results. After that a number of workers developed WQI based on rating water quality parameters, [5]. A Water Quality Index (WQI) is a useful statistical tool for simplifying, reporting and interpreting complex information obtained from any body of water. A simple number given by any WQI model explains the level of water contamination.

Ground water is a resource found under the earth's surface. Most ground water comes from rain and melting snow soaking into the ground. Water fills the spaces between rocks and soils, making an "aquifer" [6]. Groundwater pollution is mainly due to the

process of industrialization and urbanization that has progressively developed over time without any regard for environmental consequences [7].

The present study focus on the Water quality index (WQI) of ground water in some wells in Kani Goma and Kanasura district determined by the physico-chemical properties are compared with data international WHO together with recommended water guidelines for drinking and domestic uses.

2. Materials And Methods

2.1. DESCRIPTION OF THE AREA

Sulaimani city is located NE of Iraq, between latitude $35^{\circ} 31' 26'' - 35^{\circ} 35' 37''$ N and longitude $45^{\circ} 28' 48''$ and $45^{\circ} 22' 10''$ E. Kani Goma and Kanasura are the two villages of Sulaimani city. It is located about 5 km in south- southwest of Sulaimani city. These villages are selected for this study. Its boundaries extend from latitude ($35^{\circ} 31' 31.19''$) N and ($45^{\circ} 22' 57.13''$) East longitude, ($35^{\circ} 32' 13.54''$) N and ($45^{\circ} 23' 17.92''$) East respectively. All of the groundwater samples (W1, W2, W3 and W4) are taken from wells with a depth ranging between (9-35 m) located upon Tanjero Formation. The formation is composed of marly limestone Figure: (2) and sandstone, highly deformed and fractured in the area, which allow to form a secondary porosity. The aquifer yields a good quantity of water in both wet and dry seasons which give about (100-400 gallon/hour) (personal communication with consumer). Tanjero Formation aquifer represents semi-confined aquifer [8] Sewerage System in Sulaimani city discharges the sewage wastewater generally through 6-effluent boxes which are: Sarchinar, Industrial area (city), Albisaka, Qalawa, Wluba and Shekh-Abbas boxes. The system discharges the liquid effluent waste in South-Southwest of Sulaimani City, crossing the valleys until reaching Qiliasan Stream and Tanjero River, except some which are used by agricultural farms before discharging into the river (like Qalawa Sewage), but they also reach surface water by passing through the ground [9].

2.2. WATER SAMPLE COLLECTION AND ANALYSES

Four domestic wells were selected for the studies on ground water located in Kani Goma and Kanasura district within Sulaimani city. The groundwater samples (W1 and W2) were collected in Kanasura district while (W3 and W4) were collected in Kani Goma region. One of the studied wells, (W2) drilled handily upon the aquifer in Kanasura houses with depth of (9 m) figure: (1). The sampling was repeated after 15 days and the present study is spread over a period of two months of summer season (15 July, 2013 to 1 September 2013). Water samples were collected using 1.5 liter polyethylene bottles for physico-chemical analysis after rinsing in laboratory with HCl and distilled water [10]. The collected samples were transported into the laboratory within 24 h of the collection and stored at (2-8) °C if they were not to be analyzed in the laboratory on the same day. The analyses covered physico-chemical parameters of water samples from each borehole. The qualitative analyses were carried out at the Soil Chemistry laboratories of the Faculty of Agricultural Science/ University of Sulaimani. The physical and chemical parameters analyzed were pH, Turbidity, EC, total dissolved solids, Calcium, Magnesium, Total Hardness, Nitrate, Nitrite, Chloride, and Phosphate. The pH was determined using a HANNA pH 211 (microprocessor pH meter) by direct measurement, The turbidity of water sample was determined using portable turbidimeter; model (PHoto Flex Turb.),. The readings were in (NTU) after calibration with turbidity standards. The samples were also analyzed for total dissolved solids (TDS) and Electrical conductivity (EC) using portable EC-meter; model (LF318). Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Nitrates (NO_3^-), Nitrites (NO_2^-), Phosphate (PO_4^{3-}), Sulfate (SO_4^{2-}) and Chloride (Cl^-) of water sample was determined using photoLab spectral instrument model (82362), (2005), WTW company-Germany). Total hardness of water samples analyzed according to [11]

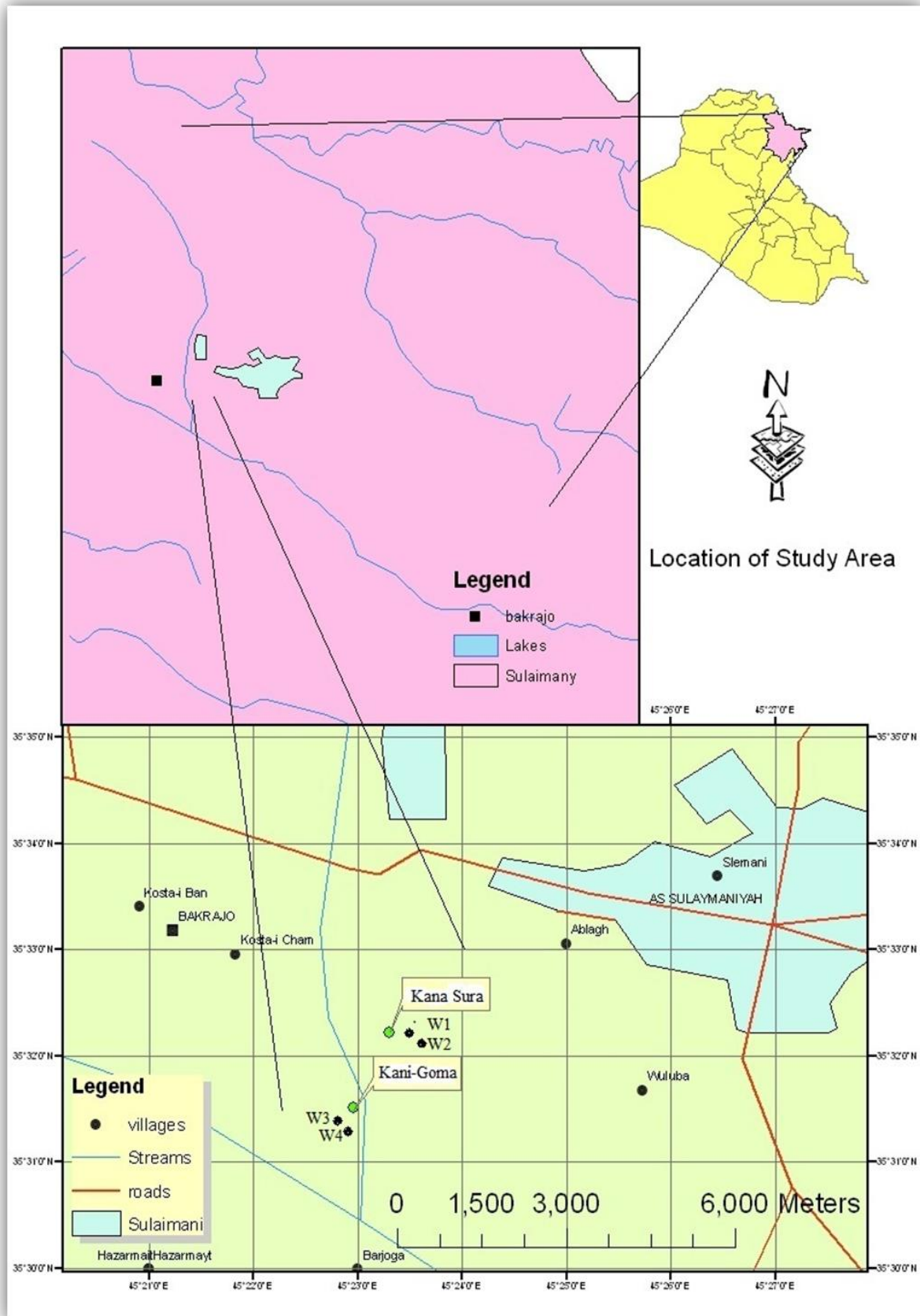


Fig. (1): Location of the experiment, Shows: 1A: Map of Iraq (black bordered) 1B: Map of Sulaimani governorate (Blue bordered) and 1C: Map of experiment location (green circled).

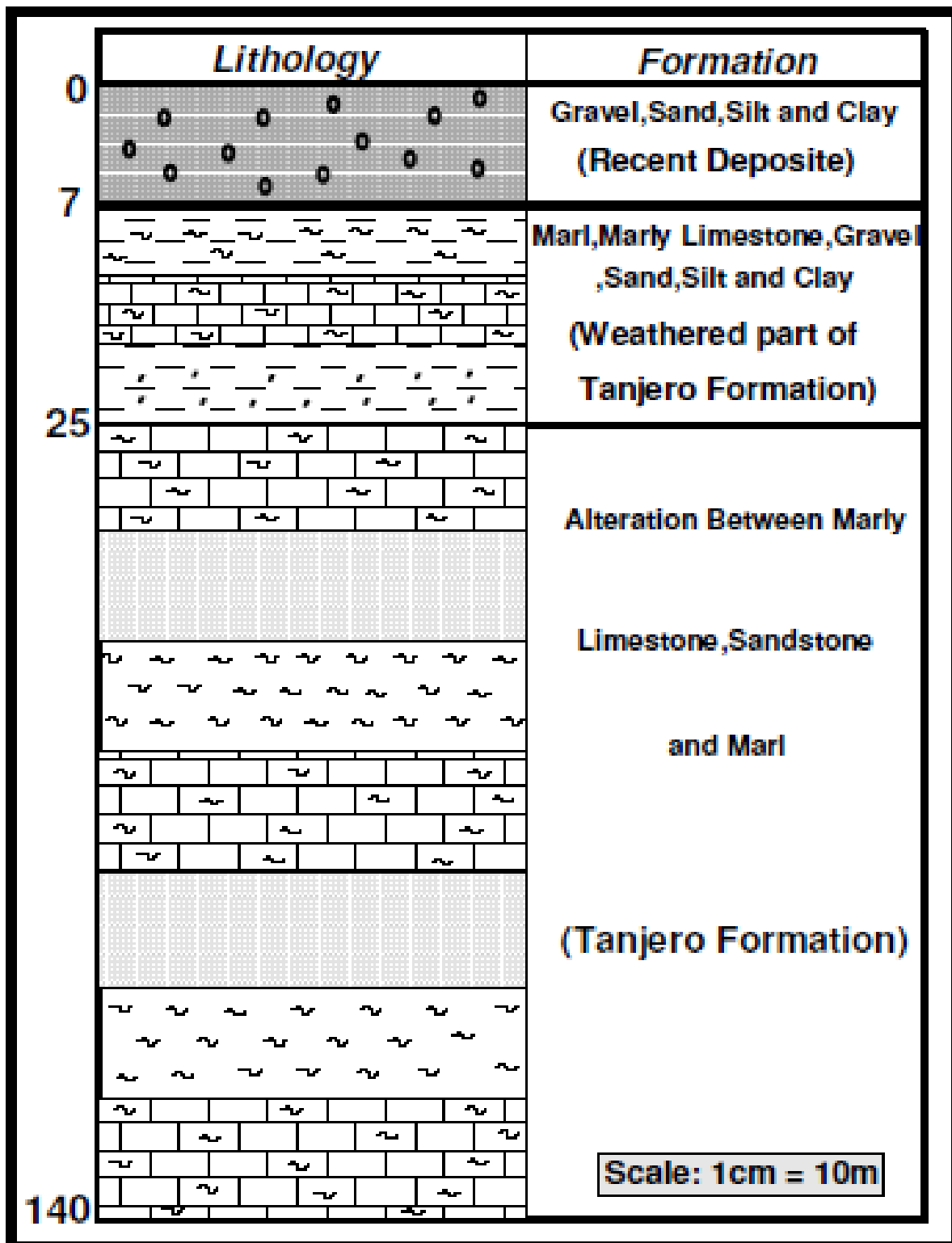


Fig. (2): Stratigraphic succession of a well in Kani-Goma and Kanasura area(From Drilling Well Sector/Sulaimani).

3. CALCULATING OF WATER QUALITY INDEX (WQI)

In this study, for the calculation of water quality index, twelve important parameters were chosen. In the formulation of WQI, the importance of various parameters depends on the intended use of water; here, water quality parameters are studied from the point of view of suitability for human consumption. The water quality index has been calculated by using the standards of drinking water quality recommended by the world Health Organization [12]. The Water Quality Index (WQI) was calculated using the Weighted Arithmetic Index method. The quality rating (Q_i) scale for each parameter was calculated by using this expression:

$$Q_i = [C_i / S_i] \times 100$$

While, the quality rating for pH or DO (Q_{pH}, Q_{DO}) was calculated on the basis of,

$$Q_{pH} = [C_i - V_i / S_i - V_i] \times 100$$

Where,

- Q_i = the quality rating,
- C_i = value of the water quality parameter obtained from the laboratory analysis,
- S_i = value of the water quality parameter obtained from recommended WHO or Iraqi standard of corresponding parameter,
- V_i = the ideal value which is considered as 7 for pH.

Then, after calculating the **quality rating** scale (Q_i), the Relative (unit) weight (W_i) was calculated by a value inversely proportional to the recommended standard (S_i) for the corresponding parameter using the following expression;

$$W_i = 1/S_i$$

Where,

- W_i = Relative (unit) weight for nth parameter
- S_i = Standard permissible value for nth parameter
- I = Proportionality constant.

Finally, the overall Water Quality Index (WQI) was calculated by aggregating the quality rating (Q_i) with unit weight (W_i) linearly:

$$WQI = \sum Q_i W_i / \sum W_i$$

Table (1): Water quality index (WQI) range and type of water can be classified according [13]

Water Quality Index levels	Description
< 50	Excellent water
50-100	Good water
100-200	Poor water
200- 300	Very poor water
>300	Water unsuitable for drinking purposes

4. Results and Discussion

Water quality index of the ground water sample are established on important various physico-chemical parameters for four sites, from Kani Goma and Kanasura villages within Sulaimani city. The values of various physico-chemical parameters for calculation of water quality index are presented in Table (2). The WQI and overall WQI of all the samples taken were calculated according to the procedure explained above. WQI indicates the quality of water in terms of index number which represents overall quality of water for any intended uses. On the basis of the WQI, The

water quality index obtained for ground water samples in different sites through two months are 100.22, 81.56, 100.71, and 100.18 respectively Table (3, 4, 5, and 6), The results obtained on WQI for the different sampling sites were found to fall under the class from good water (50 - 100) class at the sample site of W2, to poor water (100 - 200) class at the sample sites of W1, W3, and W4. Table (1). Those index values revealed that the status of the ground water samples was suitable for human uses in all sampling locations according to WHO guideline standards [14].

The pH values ranged (7.09 – 7.16) which are within the normal values as show in table 3 which summarized the guidelines of drinking water (WHO, Standards) . The pH values of the studied water was ranging between the minimum values of 7.09 in (W2) While, the maximum value was 7.16 in (W1) (Table: 2). The pH value of most investigation lies in the alkaline side of neutrality, the obtained value of pH are considered as a usual condition because, generally in Iraq Kurdistan region the pH of water characterized by shift towards the alkaline side of neutrality due to the geological formation of the area which composed mainly of CaCO_3 [15] and [16].

The values of specific conductance for the studied water ranged from (923.43 to 1082.09) $\mu\text{S}\cdot\text{cm}^{-1}$ at (W3 and W2) (Table: 2). The minimum electrical conductivity value was observed at (W3) while the maximum value was recorded at (W2). The highest values of (EC) were observed in W2, because water wells in this area are generally near sewage system, and effluents are likely to contribute ions to groundwater, also the anthropogenic activities are higher in this district. However, electrical conductivity values more than 500 $\mu\text{S}\cdot\text{cm}^{-1}$ in a given aquatic system considered to be hard water [17]. The wide range over the studied period probably related to the differences in climate lithology, and geological

formation. Electrical conductivity (EC) is an indirect measure of water salinity, and one of the most common and convenient methods used to test water. Electrical conductivity is significantly affected by the temperature, so all results should be normalized to a standard temperature of 25°C. The EC is also strongly dependent upon the ionic composition of water.

From results the turbidity of the water sample ranged between (0.41 to 0.84 NTU). The higher value of turbidity was observed in (W3), while the lower value of turbidity was observed in (W1). The turbidity values obtained at all sites were lower than the WHO standard of 5 NTU. Presence of suspended particles and other materials are usually responsible for high turbidity values. Soil particles may have found their way into the wells from the unstable side walls thereby increasing turbidity of the water.

The total dissolved solids (TDS) which ranged from (904.50 to 1095.50) mg L^{-1} at (W3 and W2) the water samples in (W3) were above the WHO Standards while, in (W2) lower than the WHO Standards. The palatability of water with a total dissolved solids (TDS) level of less than about 600 mg L^{-1} is generally considered to be good; drinking-water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg L^{-1} .

The concentrations of calcium and magnesium of the studied water were ranged between (114 to 133) mg L^{-1} and (75.4 to 81.5) mg L^{-1} respectively (Table: 2). The lowest value of calcium concentration was observed at (W3) While, the highest value was recorded at (W2). This is possibly due to the degree of ability of cations to precipitate as carbonate compounds [18], or various bicarbonate and carbonate compounds, originating from dissolution of sedimentary rocks. One possible adverse effect from ingesting high

concentrations of calcium for long periods of time may be an increased risk of kidney stones. The presence of calcium in water decreases the toxicity of many metals to aquatic life [19]. The minimum magnesium concentration was measured at (W4) while, the maximum value was observed at (W2). Comparing the present calcium and magnesium values to the guideline values recommended by WHO standard for water quality standards, the calcium and magnesium values of all studied water during the studied period were above the desirable levels.

Total Hardness concentrations of the studied water area ranged from 582.44 mg L⁻¹ as CaCO₃ at (W4), to 667.47 mg L⁻¹ as CaCO₃ at (W2). The hardness of water samples may be due to leaching of Ca and Mg ions into the groundwater [20]. The hardness of water samples at all locations was higher than the desirable concentrations for domestic water consumption recommended by WHO standard hence unfit for use as potable water. Hardness caused by calcium and magnesium is usually indicated by precipitation of soap scum and the need for excess use of soap to achieve cleaning. Consumers are likely to notice changes in hardness [21]. High concentration of total hardness in drinking water (above 500 mg L⁻¹) has negative effect on health by causing many diseases associated with kidney [22].

Nitrates and nitrites had their values ranging from (6.6 to 14.3) mg L⁻¹ and from (0.01 to 0.02) mg L⁻¹ respectively (Table: 2). High nitrate concentrations in groundwater samples (W2) in Kanasura district may result from a leakage of sewage wastewater of Albisaka, Qalawa and Chwar-Chra effluents. Sample (W4) in Kani-Goma well also shows a high nitrate concentration, may be a result of continuous recharge of sewage effluents to Kani-Goma well. It has been established that 10 mg L⁻¹ of nitrate-nitrogen as the maximum

contamination level allowed in drinking water and maximum tolerable limit of 50 mg L⁻¹. Water sample W2 had nitrate concentration level higher than these limits, hence unfit for consumption. Low nitrite concentrations in these groundwater sample sites may be due to denitrification resulting from the increase in organic substances [23].

Nitrites are relatively short-lived because they are quickly converted into nitrates by bacteria which exist in the air. Water with nitrite levels exceeding 1.0 mg L⁻¹ should not be consumed by humans let alone given to babies. The good news is nitrates are not usually harmful to healthy adults or older children. However, drinking water high in nitrates does threaten infants under the age of six months. Their stomach acid isn't strong enough to kill certain types of bacteria capable of converting nitrates to harmful nitrites. Nitrites bind hemoglobin in the blood, preventing oxygen from getting to the rest of the body; the baby may lose its natural color and turn blue. "Blue baby syndrome" or methemoglobinemia simply causes suffocation [24]. Nitrate concentrations in groundwater are typically less than 10 ppm, but can exceed that in areas of concentrated human sources [25]. Much of the scientific literatures suggest that nitrate levels in groundwater have been generally increasing over time, unless there has been a change in local land use practices [26]. Areas influenced by substantial human activity had higher nitrate concentrations than pristine areas [27].

PO₄³⁻ which ranged from (0.4 to 0.5) mg L⁻¹, the highest phosphate concentration level was 0.5 mg L⁻¹ at (W1, W 3 and W 4), which may result from the direct effect of sewage effluents. In addition to sewage wastewater, agricultural contaminants (fertilizers and pesticides), [23], [28]. PO₄³⁻ is relatively high, in groundwater in the urban area associated with municipal wastewater. Too much phosphate can cause health problems, such as

kidney damage and osteoporosis, Phosphate shortages can also occur. Detergents, soaps and anthropogenic substances represent the main sources of phosphate [23].

In this investigation the minimum recorded concentrations of SO_4^{2-} was 73 mg L^{-1} at (W3), while the maximum levels observed was 120 mg L^{-1} at (W2). High sulfate concentration in sample (W2) reflects the effect of sewage of industrial area on the groundwater of surrounding area. High sulfate concentration in water of Kanasura and Kani-Goma districts indicates that sewage effluents of Albisaka, Qalawa and Chwar Chra recharge and mixed with groundwater system of these areas. Although, the observed levels were generally lower than the 250 mg L^{-1} established by the WHO, standard for drinking water. Sulfate concentrations normally vary between 10 mg L^{-1} and 80 mg L^{-1} in most surface waters, although they may reach thousands of milligrams per liter near industrial discharges. The presence of sulfate in drinking-water can cause noticeable taste, and very high levels might cause a laxative effect in unaccustomed consumers.

Chloride ion in the studied water was within the range (66 to 103) mg L^{-1} . The lowest value 66 mg L^{-1} was recorded at (W1) while, the highest value 103 mg L^{-1} was observed at (W2). Chloride concentration in water sample of Kanasura well (W2) shows higher value than other groundwater samples. This may result from seepage of sewage wastewater from Chwar Chra and Kanasura sewage effluent to groundwater system of the Kanasura area. According to (WHO, standard) all the studied water samples during this investigation were within the desirable levels. Chlorides in water are more of a taste than a health concern, although high concentrations may be harmful to people with heart or kidney problems [19]. Excessive chloride concentrations increase rates of corrosion of metals in the distribution system, depending on the alkalinity of the water. This can lead to increased concentrations of metals in the supply. No health-based guideline value is proposed for chloride in drinking-water. However, chloride concentrations in excess of about 250 mg/l can give rise to detectable taste in water [21].

Table (2): Physiochemical parameter values for all sampling studied area in 15 July, to 1 September 2013.

Parameters	Units	Locations			
		W1	W2	W3	W4
Depth of well (d)	m	35	9	19	23
pH	7.16	7.09	7.14	7.13
Turbidity	NTU	0.41	0.60	0.84	0.45
Electrical Conductivity (EC)	$\mu\text{S.cm}^{-1}$	981.28	1082.09	923.43	990.66
Total dissolved solids (TDS)	mg L^{-1}	954.75	1095.50	904.50	962.66
Calcium (Ca^{2+})	mg L^{-1}	115	133	114	109
Magnesium (Mg^{2+})	mg L^{-1}	79.2	81.5	80	75.4
Total Hardness (T.H)	mg L^{-1}	613.06	667.47	613.85	582.44
Chloride (Cl^-)	mg L^{-1}	66	103	84	89
Sulfate (SO_4^{2-})	mg L^{-1}	90	120	73	99
Phosphate (PO_4^{3-}P)	mg L^{-1}	0.50	0.40	0.50	0.50
Nitrate ($\text{NO}_3^- \text{N}$)	mg L^{-1}	8.60	14.3	6.6	9.2
Nitrite ($\text{NO}_2^- \text{N}$)	mg L^{-1}	0.01	0.02	0.02	0.02

Table (3): Calculation of water quality index in Location (1).

Parameter	Observed Value (Ci)	Standard Value(Si)	Relative weight(Wi)	Quality rating (Qi)	Qi Wi
pH	7.16	8.5	0.1176	10.67	1.25
Turbidity (NTU)	0.41	5	0.2	8.20	1.64
Electrical Conductivity ($\mu\text{S.cm}^{-1}$)	981.28	300	0.00333333	327.09	1.09
Total dissolved solids (mg.L^{-1})	954.75	1000	0.001	95.48	0.09
Calcium (mg.L^{-1})	115	75	0.013333	153.33	2.04
Magnesium (mg.L^{-1})	79.20	50	0.02	158.40	3.17
Total Hardness (mg.L^{-1})	613.06	500	0.002	122.61	0.25
Chloride (mg.L^{-1})	66	250	0.004	26.40	0.11
Sulfate (mg.l^{-1})	90	250	0.004	36	0.14
Nitrate (as NO_3^-) (mg.L^{-1})	8.60	50	0.02	17.20	0.34
Nitrite (as NO_2^-) (mg.L^{-1})	0.01	3	0.33333	0.33	0.11
Phosphate (mg.L^{-1})	0.50	0.4	2.5	125	312.50
			$\Sigma \text{Wi} = 3.22$		$\Sigma \text{Qi Wi} = 322.73$
Overall WQI = $\Sigma \text{Qi Wi} / \Sigma \text{Wi} = 100.22$					

Table (4): Calculation of water quality index in Location (2)

Parameter	Observed Value (Ci)	Standard Value(Si)	Relative weight(Wi)	Quality rating (Qi)	Qi Wi
pH	7.09	8.5	0.1176	6	0.71
Turbidity (NTU)	0.60	5	0.2	12	2.40
Electrical Conductivity ($\mu\text{S.cm}^{-1}$)	1082.09	300	0.00333333	360.97	0.87
Total dissolved solids (mg.L^{-1})	1095.50	1000	0.001	109.55	0.11
Calcium (mg.L^{-1})	133	75	0.013333	177.33	2.36
Magnesium (mg.L^{-1})	81.50	50	0.02	163	3.26
Total Hardness (mg.L^{-1})	667.47	500	0.002	133.49	0.27
Chloride (mg.L^{-1})	103	250	0.004	412	1.65
Sulfate (mg.L^{-1})	120	250	0.004	48	0.19
Nitrate (as NO_3^-) (mg.L^{-1})	14.30	50	0.02	28.60	0.57
Nitrite (as NO_2^-) (mg.L^{-1})	0.02	3	0.3333	0.67	0.22
Phosphate (mg.L^{-1})	0.40	0.4	2.50	100	250
			$\Sigma \text{Wi} = 3.22$		$\Sigma \text{Qi Wi} = 262.61$
Overall WQI = $\Sigma \text{Qi Wi} / \Sigma \text{Wi} = 81.56$					

Table (5): Calculation of water quality index in Location (3).

Parameter	Observed Value (Ci)	Standard Value(Si)	Relative weight(Wi)	Quality rating (Qi)	Qi Wi
pH	7.14	8.5	0.1176	9.33	1.09
Turbidity (NTU)	0.84	5	0.2	16.80	3.36
Electrical Conductivity ($\mu\text{S.cm}^{-1}$)	923.43	300	0.00333333	307.81	1.03
Total dissolved solids (mg.L^{-1})	904.50	1000	0.001	90.45	0.09
Calcium (mg.L^{-1})	114	75	0.013333	152	2.03
Magnesium (mg.L^{-1})	80	50	0.02	160	3.20
Total Hardness (mg.L^{-1})	613.85	500	0.002	122.77	0.25
Chloride (mg.L^{-1})	84	250	0.004	33.60	0.13
Sulfate (mg.L^{-1})	73	250	0.004	29.20	0.12
Nitrate (as NO_3^-) (mg.L^{-1})	6.60	50	0.02	13.20	0.26
Nitrite (as NO_2^-) (mg.L^{-1})	0.02	3	0.33333	0.67	0.22
Phosphate (mg.L^{-1})	0.50	0.4	2.5	125	312.50
			$\Sigma \text{Wi} = 3.22$		$\Sigma \text{Qi Wi} = 324.28$
Overall WQI = $\Sigma \text{Qi Wi} / \Sigma \text{Wi} = 100.71$					

Table (6): Calculation of water quality index in Location (4)

Parameter	Observed Value (Ci)	Standard Value(Si)	Relative weight(Wi)	Quality rating (Qi)	Qi Wi
pH	7.13	8.5	0.1176	8.67	1.02
Turbidity (NTU)	0.45	5	0.2	9	1.80
Electrical Conductivity ($\mu\text{S.cm}^{-1}$)	990.66	300	0.00333333	330.22	1.10
Total dissolved solids (mg.L^{-1})	962.66	1000	0.001	96.27	0.09
Calcium (mg.L^{-1})	109	75	0.013333	145.33	1.94
Magnesium (mg.L^{-1})	75.40	50	0.02	150.80	3.01
Total Hardness (mg.L^{-1})	582.44	500	0.002	116.49	0.23
Chloride (mg.L^{-1})	89	250	0.004	35.60	0.14
Sulfate (mg.L^{-1})	99	250	0.004	39.60	0.16
Nitrate (as NO_3^-) (mg.L^{-1})	9.20	50	0.02	18.40	0.37
Nitrite (as NO_2^-) (mg.L^{-1})	0.02	3	0.33333	0.67	0.22
Phosphate (mg.L^{-1})	0.50	0.4	2.5	125	312.50
			$\Sigma \text{Wi} = 3.22$		$\Sigma \text{Qi Wi} = 322.58$
Overall WQI = $\Sigma \text{Qi Wi} / \Sigma \text{Wi} = 100.18$					

Conclusion

Application of Water Quality Index (WQI) in this study has been found useful in assessing the overall quality of water and to get rid of judgment on quality of the water. This method appears to be more systematic and gives comparative evaluation of the water quality of sampling stations. It is also helpful for public to understand the quality of water as well as being a useful tool in many ways in the field of water quality management. The water quality index obtained for ground water samples in different sites through two months are 100.22, 81.56, 100.71, and 100.18 respectively. The results obtained on WQI for the different sampling sites were found to fall under the class from good water (50 - 100) class at the sample site of W2, to poor water (100 - 200) class at the sample sites of W1, W3, and W4. Those index values revealed that the status of the ground water samples was suitable for human uses in all sampling locations according to WHO guideline standards

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