A Comparison of water quality between well and spring samples selected from Soran District, Northern Erbil Governorate, Kurdistan Region – Iraq

M R A Al-Barwary¹, R A Meshabaz¹, N J Hussein¹ and N H Ali¹
¹Dept. Environmental Science, Faculty of Science, University of Zakho, Kurdistan Region – Iraq.

Abstract. Water samples from twenty wells and twenty springs were assessed to determine whether samples from springs and wells have similar concentrations of selected characteristics, including electrical conductivity (EC), total alkalinity (TA), total dissolved solids (TDS), pH, Sulphate (SO₄²⁻), Nitrate (NO₃⁻), total hardness (TH), magnesium (Mg²⁺) and Calcium (Ca²⁺). Comparisons were made between concentrations of chemical and Physical characteristics in water samples from springs and wells within the same aquifer. Samples were collected monthly from the wells and springs during March 2017 to February 2018. The samples were tested for chemical and Physical characteristics according to the standard methods of American Public Health Association. There were significant differences between all data selected from springs and wells except Mg and DO. In addition, no significant difference was found between the mean pH values. The results indicated that the water samples lie within the permissible limits as compared with WHO (World Health Organization) for drinking uses, however some samples of water are without the permissible limit such as EC, TDS, and TH. The spring water samples were found to be better than well water samples. The results showed that eight wells and four springs’ water samples requires treatment for drinking uses.

Keywords: Spring water, well water, Soran Mountain District, Kurdistan region, Iraq.

1. Introduction
Water is one of the most important elements for the existence of life on Earth; though water covered 80% of the surface of earth, the freshwater supply has increasingly become a limiting factor [1]. In Soran town, the most common source of the drinking water for the inhabitants is springs and wells. This is because in the study area, there is lack of water sheds, dams, rivers or lakes. Hence, the springs and wells are the main sources of water available to the village’s community settlement Northern Erbil government, Kurdistan Region, Northern Iraq. These water supplies are important public health issue because they are often vulnerable and may cause microbiological or chemical quality-associated health risks to the water consumers. Therefore, the quality control of natural spring and well water is an area of interest [2]. Several studies indicated that approximately 1 billion people are at the risk of harm of water worldwide; the great majority of these people live in Africa, South Asia and East Asia. Numberless loss of their life annually due to drinking contaminated water [3]. Therefore, Groundwater quality in the location is greatly decided by both natural processes and human activities [4, 5].

Springs’ water, having a natural water quality, are extremely vulnerable to any type of pollution caused by human activities and the influence of the change of climate on the quantity and quality of surface run-off feeding groundwater [6]. Moreover, the quality of these water bodies vary widely depending on the location and environmental factors. Currently, the most essential environmental problems are the contamination of the groundwater and the variety of contaminants that affect water
resources. Naturally, groundwater has an acceptable chemical quality, through the great concentrations of number of constituents can cause problems for water use. The quality of water has been changed by intensive irrigated agricultural discharges into the groundwater. These anthropogenic activities cause serious threat to the groundwater users. The moment that the groundwater is contaminated, its quality cannot be repaired by preventing the pollutants from the sources. Therefore, it becomes imperative to control the quality of the groundwater and to innovate direction and means to protect it [7].

The present work is an attempt to measure the quality of various samples of water from Soran region, northern Erbil, Iraq. The study was carried out to (1) find the water quality of selected twenty springs and twenty wells in Soran district at Arbil governorate, northern Iraq; (2) to analyse the Physical and chemical quality of well and spring water and (3) to find the different concentrations between wells and springs water samples. Little is known about the physical and chemical properties of water of wells and springs water supplied to Soran region and this water is usually consumed without any form of treatment. Chemical and physical characteristics were assessed and the values obtained were compared with the desirable/ permissible values prescribed by WHO [8] guidelines to ensure the quality of springs and wells for domestic uses.

2. Materials and Methods

2.1 The study Sites
The present study was carried out at the Soran District, Erbil Governorate, Kurdistan Region, Northern Iraq. Water samples were collected from various wells and springs, water sources locations are shown in figures (1 and 2) which is a map view of sampling locations of the study area.

2.2 Data collection
Monthly data samples were collected from 20 wells and 20 springs, which were selected from 20 different areas of Soran District, Erbil Governorate Kurdistan Region, Northern Iraq, from March 2017 to February 2018. The depth of the wells were between 50 and 60 meters. The water samples were collected in clean polythene and sterilized plastic bottles of 2 litres. The samples were brought to the laboratory immediately and kept at 4 °C; then they were analysed in the laboratory for various physio-chemical parameters. The samples were tested for electrical conductivity (EC), pH, turbidity, temperature, total alkalinity (TA), total dissolved solids (TDS), Dissolved oxygen (DO), Sulphate (SO₄²⁻), Nitrate (NO₃⁻), total hardness (TH), Chloride ion (Cl), Calcium (Ca²⁺) and magnesium (Mg²⁺), according to the standard methods of American Public Health Association [9]. The PH, temperature, Electrical conductivity, parameter of the samples were determined in the field at the point of collection of the samples with appropriate instruments of measurement, total hardness (TH) Na₂EDTA Titrimetric Methods digital burette EPA-O.S. 19 Calcium (Ca²⁺) Na₂EDTA Titrimetric Methods digital burette EPA-O.S. 19.Magnesium (Mg²⁺) Na₂EDTA Titrimetric Methods digital burette EPA-O.S. 19.Chloride AgNO₃ Titrimetric Methods digital burette EPA-O.S. 21.
Figure 1. a map view of sampling locations of the study area.

Figure 2. a map view of sampling locations of the study area.

2.3 Data analysis
The recorded data were analysed using Past3 software program (PAleontological Statistics, Version 3.17). In addition; the summary statistics was obtained from Past3 software program [10] Residual plots confirmed by a Shapiro-Wilk normality test showed that all data to be parametric. Therefore, they were analysed using Analysis of variance (ANOVA) test followed by a two-sample parametric test by using Tukey’s pairwise test for post hoc comparisons.

3. Results and Discussion
The mean ± standard error of mean values of the physio-chemical analysis of wells and springs in the study area are shown in table 1. There were significant differences between all data selected from springs and wells except Mg and DO.
Table 1. Mean ± SEM values of the physio-chemical analysis of wells and springs in the Soran region of Kurdistan, Iraq

| Data             | Wells         | Springs       | P-value |
|------------------|---------------|---------------|---------|
| TDS (mg/l)       | 639.2 ± 74.5  | 345.3 ± 39.7  | 0.001   |
| DO (mg/l)        | 6.6 ± 0.2     | 7.0 ± 0.1     | 0.210   |
| TH (mg/l)        | 487 ± 35      | 393 ± 38      | 0.070   |
| Ca (mg/l)        | 403 ± 31      | 305 ± 32      | 0.030   |
| Mg (mg/l)        | 84 ± 5        | 89 ± 6        | 0.490   |
| Cl (mg/l)        | 95.8 ± 15     | 38.1 ± 5      | 0.001   |
| Alkalinity (mg/l)| 378 ± 22      | 254 ± 26      | 0.010   |
| Nitrate (mg/l)   | 3.3 ± 0.3     | 2.3 ± 0.3     | 0.050   |
| Sulphate (mg/l)  | 66.0 ± 9      | 32.6 ± 6      | 0.010   |

Total Dissolved Solids (TDS) in mg/l: In the present study, in table (1) the Mean ± SD values of TDS in wells and springs water samples sites were (639.2± 74.5) and (345.3± 39.7) mg/l respectively. TDS showed significant variations at (p < 0.001) among the water sources. The well water samples have the highest TDS values than the spring water source. High TDS in well water sample may be due to the surface run-off from the cultivated fields which might have increased the concentration of ions [11]. Most values of well water samples were without the standard limits of drinking water quality set by [3] (500 mg/l) the studied springs and wells exhibit monthly variation in (TDS) along the study periods table 2.

Dissolved oxygen (DO) in mg/l: The oxygen content of natural waters varies with salinity, temperature, turbulence and atmospheric pressure. The solubility of oxygen decreases as temperature and salinity increase [12]. In the present study, in table (1) Mean ± SD values of concentration of (DO) in well and spring water samples were (6.6 ± 0.2) and (7.0 ± 0.1) (mg/l) respectively. (DO) showed significant variations at (p < 0.210), among the water sources, the low DO concentration in well water may be attributed to increased decomposition of organic material from the closely situated surrounding crop. The permissible limit of the DO in drinking water should be ≥6 mg/L [13].

Total Hardness (TH) in mg/l as CaCO3. In the present study in table (1) the Mean ± SD values of total hardness in well and spring water samples were (487 ± 35) and (393 ± 38) mg/l respectively. (TH) showed significant variations at (p < 0.070), among the water sources. These high values of total hardness may be due to the addition of magnesium and calcium salts. The permissible limits of (TH) in potable water ranged within 300 mg/l as given by (WHO) for drinking water. Hardness values of the most well and spring water samples were exceeding the permissible limit of 300 mg/l as CaCO3, but all the value were within maximum limit value 500mg/l. Hardness values exceeding 500 mg/l, are generally unsuitable for domestic purposes without treatment. Similar results reported by [14]. Table (2) shows that well water have the highest monthly variation in (TH). This is probably due to the variation in the feeding source.

Calcium in mg/l as CaCO3: In table (1), the Mean ± SD values of calcium in well and spring water samples collected from the study area were (403 ± 31) and (305 ± 32) mg/l respectively. Calcium content is very common in groundwater, because they are available in most of the rocks, abundantly and also due to its higher solubility. All the concentration of Ca²⁺ were exceeding the standard values of WHO (75 mg/L) and US-EPA (75-100 mg/L). In this study are significantly higher than those reported by [15]. Table (2) shows a significant variation in calcium hardness along the study period.
Magnesium Mg\(^{2+}\) in mg/l: the Mean ± SD values of Mg\(^{2+}\) in the investigated well and spring water samples in table (1) were (84 ± 5) to (89 ± 6) mg/l respectively, they have in significant difference at (p < 0.490). Most of the sites of spring and well water samples exceeded the permissible limit. The maximum permissible limit of Mg\(^{2+}\) concentration of drinking water is specified as 100 mg/l. Table (2) show a detectable variation in hardness along the study period. This is probably due to the variation of the geological formation at each spring site. The studied wells and springs shows monthly variation in magnesium hardness along the study periods (table 2).

Chloride ion (Cl) in mg/l: in table (1) In present study, the Mean ± SD values of chlorides in well and spring water samples were (95.8 ± 15) and (38.1 ± 5) mg/l respectively. The permissible limit of chloride in drinking water is 250 mg/L as given by [8]. The chloride value recorded in spring and well water samples were within the permissible levels of chloride for safe drinking water set by WHO (250 mg/l). Similar results reported by [12]. The studied springs and wells exhibit significant variation in chloride along the study periods (table 2).

Total alkalinity (TA) in mg/l: in table (1), the mean ± SEM values of total alkalinity in spring and well water samples were (378 ± 22) and (254 ± 26) mg/l respectively. There was a significant difference at (P<0.01). High concentration of total alkalinity might be due to the presence of bicarbonates, the desired limit and the maximum permissible limit for alkalinity in drinking water is 200 and 600 mg/L respectively set by [13]. The present study’s results showed that total alkalinity of both spring and well water samples were within the permissible limit. Similar results reported by [16]. All the springs and wells exhibit significant seasonal variation in Alkalinity (Table 2).

Nitrates (NO\(_3\)\(^-\)) in mg/l: in table (1) in the present study the Mean ± SD values of NO\(_3\)\(^-\) in well and spring water sampling locations were (3.3 ± 0.3) and (2.3 ± 0.3) mg/l respectively. They have a significant difference at p<0.050. The presence of nitrates in a water sample may be due to excessive application of inorganic fertilizers, plants and animal decomposition and leaching of wastewater. All sites of spring and well water concentration were found within the desirable limit value of 45 mg/l set by WHO [8].

Sulphate (SO\(_4\)\(^{3-}\)) in mg/l: in present investigation the Mean ± SD values of (SO\(_4\)\(^{3-}\)) in well and spring water samples were (66.0 ± 9) and (32.6 ± 6) mg/l respectively. They have a significant difference at p< 0.010, Sulphate may come into spring and well water by anthropogenic additions in the form of Sulphate fertilizers or industrial. The sulphate concentration of spring and well water samples for all locations lie within the permissible limits of [17] (250 mg/L).

Turbidity NTU: water turbidity is also a parameter of potable water quality in this study in figure 3, the value of well and spring water were (3.75) and (3.17) NTU respectively. Increased turbidity in spring waters, because springs do not allow for sediment to settle to the spring bottom, rather the current carries sediment downstream. All the spring and well water samples were below the permissible limit set by WHO [8].

![Figure 3](image_url)
Temperature °C: in figure 4, in the present study the values of water temperature of spring and well water were (19.1 °C) and (15 °C) respectively. In spring water temperature is lesser than wells temperature due to the impact of winter freeze on springs temperature, as well as the geologic strata had impacted the spring water temperature, as it was significantly colder and impacted by the subsurface geology for length time, During spring and winter season. All the samples were below the permissible limit prescribed by [8]. Also monthly variation was noticed at each spring and well (table 2). This ensures the nearby feeding sources.

**Figure 4.** The mean ± SEM temperature values of wells and springs water in °C in the study areas.
Table 2. The mean monthly of the physio-chemical parameters of wells and springs

| Data Source | Time: Months | P value |
|-------------|--------------|---------|
| TDS (mg/l)  | Jan  | Feb | Mar | Apr | May | Jun | Jul  | Aug | Sep | Oct | Nov | Dec |
| Well        | 678. | 712. | 617. | 622. | 650. | 626. | 627. | 617. | 649. | 613. | 615. | 639. |
|             | 5 ± 5 | 7 ± 7 | 3 ± 3 | 0 ± 0 | 9 ± 5 | 5 ± 5 | 8 ± 8 | 5 ± 0 | 8 ± 0 | 8 ± 0 | 8 ± 0 | 8 ± 0 |
| Spring      | 351. | 360. | 337. | 349. | 349. | 349. | 343. | 353. | 336. | 337. | 338. | 341. |
|             | ± 40 | 7 ± 14 | 45 ± 6 | 6 ± 1 | 5 ± 1 | 1 ± 8 | 3 ± 3 | 4 ± 5 | 3 ± 4 | 5 ± 4 | 5 ± 4 | 5 ± 4 |
| DO (mg/l)   | 6.7 ± 0.2 | 6.8 ± 0.2 | 6.6 ± 0.2 | 6.7 ± 0.2 | 6.6 ± 0.2 | 6.5 ± 0.2 | 6.5 ± 0.2 | 6.5 ± 0.2 | 6.5 ± 0.2 | 6.5 ± 0.2 | 6.5 ± 0.2 | 6.5 ± 0.2 |
| Well        | 381. | 476. | 473. | 484. | 482. | 491. | 491. | 493. | 492. | 494. | 496. | 489. |
|             | 4 ± 1 | 2 ± 3 | 6 ± 2 | 2 ± 5 | 5 ± 8 | 7 ± 7 | 7 ± 3 | 4 ± 3 | 3 ± 2 | 3 ± 2 | 3 ± 2 | 3 ± 2 |
| Spring      | 381. | 369. | 383. | 395. | 398. | 396. | 401. | 400. | 401. | 402. | 396. | 393. |
|             | ± 36 | 37 ± 1 | 37 ± 3 | 37 ± 2 | 37 ± 0 | 37 ± 3 | 37 ± 0 | 37 ± 3 | 37 ± 0 | 37 ± 3 | 37 ± 0 | 37 ± 3 |
| Ca (mg/l)   | 406. | 412. | 290. | 390. | 395. | 406. | 422. | 424. | 416. | 426. | 426. | 418. |
| Well        | 8 ± 1 | 7 ± 7 | 9 ± 9 | 7 ± 7 | 4 ± 4 | 3 ± 7 | 0 ± 7 | 0 ± 6 | 6 ± 1 | 1 ± 5 | 1 ± 5 | 1 ± 5 |
|             | 34 ± 3 | 33 ± 2 | 32 ± 3 | 31 ± 3 | 31 ± 3 | 33 ± 3 | 34 ± 3 | 35 ± 3 | 33 ± 3 | 32 ± 3 | 32 ± 3 | 32 ± 3 |
| Spring      | 309. | 308. | 221. | 292. | 300. | 304. | 309. | 318. | 314. | 319. | 320. | 334. |
|             | 5 ± 5 | 6 ± 9 | 6 ± 9 | 1 ± 1 | 4 ± 9 | 9 ± 9 | 6 ± 3 | 6 ± 3 | 2 ± 2 | 3 ± 1 | 3 ± 1 | 3 ± 1 |
| Mg (mg/l)   | 76.1 | 63.2 | 182. | 18.2 | 83.4 | 85.1 | 71.1 | 67.7 | 71.7 | 72.0 | 59.5 | 69.5 |
| Well        | ± 9 | ± 4 | 7 ± 20 | ± 9 | ± 8 | ± 7 | ± 5 | ± 12 | ± 4 | ± 4 | ± 4 | ± 6 |
|             | ± 5 | ± 6 | 2 ± 29 | ± 5 | ± 8 | ± 15 | ± 5 | ± 15 | ± 5 | ± 5 | ± 5 | ± 7 |
| Cl (mg/l)   | 88.7 | 79.8 | 90.5 | 98.9 | 102. | 97.6 | 99.8 | 100. | 98.9 | 97.2 | 99.1 | 94.7 |
| Well        | ± 14 | ± 13 | ± 15 | ± 15 | ± 15 | ± 14 | ± 16 | ± 15 | ± 15 | ± 15 | ± 15 | ± 15 |
|             | ± 5 | ± 5 | ± 5 | ± 5 | ± 5 | ± 5 | ± 5 | ± 5 | ± 5 | ± 5 | ± 5 | ± 5 |
| Alkali (mg/l) | 388. | 395. | 373. | 383. | 375. | 378. | 372. | 369. | 370. | 373. | 373. | 375. |
| Well        | 0 ± 6 | 9 ± 4 | 8 ± 3 | 8 ± 9 | 5 ± 5 | 9 ± 1 | 8 ± 8 | 5 ± 8 | 5 ± 8 | 5 ± 8 | 5 ± 8 | 5 ± 8 |
|             | 23 | 23 | 22 | 22 | 23 | 22 | 22 | 23 | 23 | 23 | 23 | 23 |
This is probably due to the increase of runoff in this season. WHO fall within the recommended limit weathering of plagioclase feldspar in sediments. Reaction of Carbon dioxide, pH values were changed by the existence of inorganic and organic solutes collectively with the reaction of Carbon dioxide, The general increase of pH in a sedimentary terrain is related to weathering of plagioclase feldspar in sediments. All the water samples analysed have concentration of well and spring water samples. It is obvious that pH increases in winter.

|    | Spring | Well     | Nitrate (mg/l) | Spring | Well     | Sulfate (mg/l) | EC (µs/cm) | pH | Well     | Spring | Well     | Turbidity (NTU) | Temp (°C) |
|----|--------|----------|----------------|--------|----------|---------------|------------|----|----------|--------|----------|--------------|-----------|
|    | 26 ±  | 9 ±     | 3.4 ±          | 2.3 ±  | 0.3 ±    | 67.5 ± 10     | 0.5 ± 10   | 7.2 ±| 0.1 ±    | 7.3 ±  | 0.1 ±    | 3.4 ±         | 18.9 ±    |
|    | 26    | 26      | 3.6 ±          | 2.6 ±  | 0.3 ±    | 70.2 ± 11     | 3.1 ± 11   | 7.1 ±| 0.1 ±    | 7.3 ±  | 0.1 ±    | 3.2 ±         | 18.7 ±    |
|    | 26    | 26      | 3.5 ±          | 2.2 ±  | 0.3 ±    | 61.8 ± 9      | 3 ± 9      | 7.2 ±| 0.1 ±    | 7.3 ±  | 0.1 ±    | 4 ±          | 19.0 ±    |
|    | 26    | 26      | 3.4 ±          | 2.0 ±  | 0.3 ±    | 67.0 ± 9      | 3.3 ± 9    | 7.4 ±| 0.1 ±    | 7.4 ±  | 0.1 ±    | 4.0 ±         | 19.1 ±    |
|    | 26    | 26      | 3.2 ±          | 2.1 ±  | 0.3 ±    | 63.2 ± 9      | 3.8 ± 9    | 7.4 ±| 0.1 ±    | 7.4 ±  | 0.1 ±    | 3.9 ±         | 19.2 ±    |
|    | 26    | 26      | 3.1 ±          | 2.2 ±  | 0.3 ±    | 66.2 ± 10     | 3 ± 10     | 7.5 ±| 0.1 ±    | 7.4 ±  | 0.1 ±    | 3.8 ±         | 19.1 ±    |
|    | 26    | 26      | 3.0 ±          | 2.3 ±  | 0.3 ±    | 67.3 ± 9      | 3.8 ± 9    | 7.6 ±| 0.1 ±    | 7.4 ±  | 0.1 ±    | 3.8 ±         | 19.1 ±    |
|    | 26    | 26      | 2.9 ±          | 2.4 ±  | 0.3 ±    | 67.5 ± 9      | 3.8 ± 9    | 7.7 ±| 0.1 ±    | 7.5 ±  | 0.1 ±    | 3.7 ±         | 19.1 ±    |

pH; the pH concentration of well and spring water samples were (7.2) and (7.3) respectively. pH values were changed by the existence of inorganic and organic solutes collectively with the reaction of Carbon dioxide. The general increase of pH in a sedimentary terrain is related to weathering of plagioclase feldspar in sediments. All the water samples analysed have concentration fall within the recommended limit (6.5-8.5) standard set by the WHO. Similar results reported by WHO [18]. The monthly variation in pH is shown in table 2. It is obvious that pH increases in winter. This is probably due to the increase of runoff in this season.
The pH value of wells and springs in the Soran region of Kurdistan, Iraq.

Conductivity (EC) µs/cm: In the study area, in figure 6, the values of EC in well and spring water were (998.6) and (538.3) µs/cm, respectively. In the present study observed Large differences between the conductivity values of spring and well water, high water mineralization indicates High conductivity geological nature of soil formations were factors that influence variations in conductivity [19]. Most values obtained in sampling sites in well water were without the standard value of drinking water quality which is 1000 µs/cm, [8]. The spring water samples were found to be better than well water samples. Similar results reported by [20].

4. Conclusion
The physical and chemical characteristics of well and spring water sources used by villagers of Soran district have been measured. The results of chemical and physical analysis showed considerable variation. Some spring and well water samples significant differences of TDS, EC and TH. This may be due to different soil textures. Most of well water needed treatment for drinking uses due to total hardness and TDS which present in a desirable level but most of spring water was found within the safe level for drinking. Form the findings, it was found that the concentration of TDS, EC, TH, Ca$^{2+}$, and Mg$^{2+}$ were higher than the permissible levels for drinking uses set by WHO [8]. Four spring water
samples needed treatment for drinking uses. But eight wells water needed treatment, the rest sites of well and spring were found within the safe limit for dirking and other domestic uses. Results showed that were different between samples from springs and wells for most properties.

5. References

[1] Dagim Abera Shigut, Geremew Liknew, Dejene D. Irge, Tanweer Ahmad 2017: Assessment of physico-chemical quality of borehole and spring water sources supplied to Robe Town, Oromia region, *Ethiopia. Appl Water Sci* 7:155–164

[2] Noëlia Carbó, Javier López Carrero, F. Javier García-Castillo, Isabel Tormos Estela Olivas, Elisa Folch, Miguel Alcañiz Fillol, Juan Soto, Ramón Martínez-Máñez ID and M. Carmen Martínez-Bisbal: 2018. Quantitative Determination of Spring Water Quality Parameters via Electronic Tongue. *Sensors* 2018, 18, 40

[3] WHO (World Health Organization) 2006: Guidelines for drinking water quality. First Addendum to 3rd edn ,Voume 1. Geneva

[4] Andrade E, Palacio HAQ, Souza IH, Leao RA, Guerreio MJ 2008: Land use effects in groundwater composition of an alluvial aquifer by multivariate techniques. *Environ Res* 106:170–177

[5] Devic G, Djordjevic D, Sakan S 2014: Natural and anthropogenic factors affecting the groundwater quality in Serbia. *Sci Total Environ* **468–469**:933–942

[6] Saad E., Saad I., Houri K., Jaghror H., Hamman C., Zidane L., Douira A., Fadli M. 2011. Physico-chemical Approach to the main water sources of the Middle Atlas piedmont Beni Mellal (MOROCCO), Vol. 3, n° 110605, ISSN 2111- 4706, P.5

[7] Bairu GA, Nata T, Elias J 2011: Application of water quality index to assess suitability of groundwater quality for drinking purposes in Hantebet watershed, Tigray, Northern Ethiopia. *J Food and Agri Sci* 1(1):22–30

[8] WHO (World Health Organization) 2009: World health organization global frame work for sanitation and water supply

[9] APHA American Public Health Association: 1999. Standard methods for the examination of water and waste water 20th ed by American public health association, American water works association water environment federation united states of America

[10] Folk.uio.no. 2016. Past 3.x – the Past of the Future. [Online] Available at: http://folk.uio.no/ohammer/past/ [Accessed 9 Mar. 2018]

[11] Dhanaji G Kanase, Shagufta A Shaikh, Pramod N Jagadale. 2016: Physico-Chemical Analysis of Drinking Water Samples of Different Places in Kadegaon Tahsil, Maharashtra. *Advances in Applied Science Research*, 7:41-44

[12] Abdulhalim Zaryab, Ali Reza Noori, Kai Wegerich, Bjørn Kløve 2017. Assessment of water quality and quantity trends in Kabul aquifers with an outline for future drinking water supplies. *Central Asian Journal of Water Research* 3: 3-11

[13] WHO (World Health Organization) 2008: Guideline of drinking water quality .3rd. Vol. I, Recommendation, printed in China by sun fungi

[14] UB Gawai and SS Nandre 2017: Physico Chemical Study of Ground Water from Katwan Region in Sakri Tehsil (MS) *Journal of Chemical and Pharmaceutical Research*, 9: 20-23

[15] Marian P. Berndt, Brian G. Katz, Bruce D. Lindsey, Ann F. Ardis 2005.Comparison of Water Chemistry in spring and Well Samples from Selected Carbonate Aquifers in the United States, Scientific investigation report, 5160-74-81

[16] Kilwake J. Wanjala, Mwakio Tole, Musundi Sammy 2017: Assessment of Water Quality in Boreholes and Wells in Waa Location, Kwale County – Kenya. *Journal of Scientific and Engineering Research*, 4 261–277

[17] WHO (World Health Organization) 1993. Drinking Water Standards and Health Advisories Office of Water U.S. Environmental Protection Agency Washington, DC
[18] Anbarasu K. and G. Anbuselvan. 2017: Physico-chemical parameter analysis of water in Musiri Taluk, Tamil Nadu, India. *World News of Natural Sciences* 6 36-43

[19] Lebrahimi, M. Fekhaoui, A. Bellaouchou, M. Elabidi3, L. Tahri 2018: Assessment of groundwater quality in Khouribga region, Morocco, *J. Mater. Environ. Sci.*, 9 161-171

[20] Zidi, C., A. Jamrah, L. Al-Issaï 2017. Assessment of Groundwater Quality in Al-Buraimi, Sultanate of Oman, *JMES*, 8, 1266-1276