*Annual Research & Review in Biology*

*18(6): 1-8, 2017; Article no.ARRB.36311*
*ISSN: 2347-565X, NLM ID: 101632869*

# Assessment of Physico-Chemical Characteristics and Trace Metal Contents of Drinking Water Samples of District Tiruchirappalli

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***Authors' contributions***

*This work was carried out in collaboration between both authors. Author CAA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors CAA and ERN managed the analyses of the study and the literature searches. Both authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/ARRB/2017/36311
*Editor(s):*
(1) Olatunde Samuel Dahunsi, Environmental Biotechnologist, Landmark University, Nigeria.
(2) George Perry, Dean and Professor of Biology, University of Texas at San Antonio, USA.
*Reviewers:*
(1) Dorota Porowska, University of Warsaw, Poland.
(2) Ahoussi Kouassi Ernest, University Felix Houphouet Boigny, Côte d'Ivoire.
Complete Peer review History: http://www.sciencedomain.org/review-history/21630

***Original Research Article***

***Received 22nd August 2017***
***Accepted 25th October 2017***
***Published 30th October 2017***

## ABSTRACT

The analytical data of various physico-chemical parameters indicates that some parameters like pH, Hardness, Calcium, Magnesium, Electrical Conductivity, DO, Chloride, Total Alkalinity, Iron are found to be excess than the prescribed limit in some groundwater samples of the study areas. The mean levels (mg $L^{-1}$) of the metals ranged thus; 0.1 (Cd), 0.2 (Pb), 0.2 (As), 0.1 (Ni), 4.8 (Fe), 0.3 (Cr). The objective of this paper is to examine pollution threat, especially to the groundwater resources, around the places of town which is in the south and north of the City which suggest remedial measures that may also be relevant to other industrial area. The changes in the physico-chemical characteristics like temperature, transparency and chemical elements of water such as dissolved oxygen, nitrate and Calcium provide valuable information on the quality of the water, the source (s) of the variations and their impacts on the functions and biodiversity of the reservoir.

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*Keywords: Physico – chemical parameters; trace metals; drinking water; WHO limits; India.*

## 1. INTRODUCTION

Groundwater is an important source but unfortunately prone to contamination by materials deleterious to human health. In many areas of the world, the contamination is so heavy that the water is unfit even for agricultural use. The danger of groundwater pollution or contamination also exists in densely populated areas. Groundwater is a valuable resource that is withdrawn in all parts of the country for a variety of uses groundwater is especially important in a selected number of locations for a specific number of water users, including self supplied domestic, commercial and livestock users in particular. As this resource becomes more contaminated and scarcer, demand for high quality water will continue to grow making groundwater even more valuable and protection more important.

Water is an ordinary substance with extra ordinary qualities. It is the most common material handled by every man, every day, everywhere. It is of vital importance for the support and essential of life not only of man but of all life on earth.

Till a few generations ago water has been taken for granted as a substance available in abundance in nature. It looks utterly strange and ironical that with the great advancement of science and technology which is seen today, the world has come to express great concern about coping with scarcity of good water all over the globe and calls it a ' challenge of the 21$^{st}$ century. It is now one of the Millennium Development Goals to ensure water for people, water for life. The United Nations General Assembly has proclaimed this decade between the year 2016-2017 as a Decade for action to conserve, use and protect world's water resources and make way for providing enough and safe drinking water to the people and make it sustainable for years to come. It would be interesting to explore how this crisis has come about in the present world.

Drinking water plays an important role in the bodily intake of true element by human. Even though some trace elements are essential to man, at elevated levels essential as well as no essential element can cause morphological abnormalities: reduce growth, increase mortality and mutagenic effects [1-3].

## 2. MATERIALS AND METHODS

Bore and well water samples were collected near Tiruchirappalli Tamil Nadu in two litre polythene bottles. The sampling bottles were thoroughly pre-cleaned with 50% $HNO_3$ (Nitric acid) followed by triple washing with double distilled water. The data were subjected to statistical analysis (SPSS version 16.0). Further, the data was compared with national and international standards of water quality WHO (World Health Organization); TNPCB (Tamil Nadu Pollution Control Board). In order to assess the groundwater chemistry, a total of 50 representative groundwater samples were collected from dug and bore wells which are being extensively used for drinking and other irrigation purposes. The groundwater samples were collected in a well cleaned 1000 ml polyethylene bottles. pH and electrical conductance were measured in the field by using multi parameter. Ca and Mg were determined titrimetrically using standard EDTA, and chloride was determined by silver nitrate titration (Volgel, 1968). Carbonate and bicarbonate were estimated with standard sulphuric acid and sulphate was determined gravimetrically by precipitating BaSO4 from BaCl2. Na and K by Elico flame photometer (APHA, 1996). The samples were analyzed for physico-chemical parameters (pH, EC), major cations (Ca, Mg, Na, K), major anions (CO3, HCO3, SO4, Cl), and minor anion (NO3, F) as per standard procedures and the results in ppm value are given in Table 1. For the drinking water purposes, World Health Organization (WHO) standard limit was used to demarcate sample suitability. Their attributes are added and analyzed in ArcGIS software. Spatial analysis tools were used for the preparation of interpolation map. The maps were interpolated by using inverse distance methods for the spatial distribution map preparation.

The water samples were immediately brought to the laboratory for estimation of water quality parameters (pH, electrical conductivity, total solids, total dissolved solids, total suspended solids, dissolved oxygen, BOD, COD, total hardness, calcium, magnesiun, chloride, alkalinty, acidity, fluoride, sulphate, nitrate, silicate, total nitrogen, sodium, potassium, phosphorus, mercury and total organic carbon, which were analysed according to the methods mentioned in APHA and labeled thus: WW7 - Well water (from Agriculture area) and RW8 -

Rock water (from mountain), RW4 - Rain water (from earth Surface), RW5 - Rain water (from Iron Metal roof), BH6 - Bore house water, UD1 - Upper division water (from Lake), LD2 - Lower division water (from same lake), RW3, - Rain water(from Asbestos roof),ND-Not Deduted, NF-Not Found.

The following physic-chemical properties were determined immediately after sampling: Temperature, pH, Conductivity, Taste & odour, Chloride, Magnesium, Calcium, Total hardness, DO, Nitrate, oil and grease, pH was measured with a meter (Hanna instruments, model 8621) and conductivity measured with a JSI model 33 conductivity meter after standardizing with KCl and NaCl solutions. Various standard methods [4]. For the metal analysis, the water samples were acidified with nitric acid. A 100 $cm^3$ aliquot of the sample was digested with $HNO_3$ in a beaker at 120℃ until a clear solution was obtained [5]. All the sample were then stored at 40℃ in the refrigerator prior to analysis.

The samples were analyzed for As, Ni, Fe, Co Cr, Cd, Pb, and Zn by analyzing by used of Perkin Elmer model 306 atomic absorption spectrophotometer. Then standard deviation and coefficient of variation (%) Means, of all the value were calculated.

## 3. RESULTS AND DISCUSSION

Water has been classified on the basis of hardness as follows [6]: water having 0-75 mg Calcium $L^{-1}$ as soft. The Values 75-150 mg Calcium $L^{-1}$ as hard while samples having total hardness of over 300 mg Calcium $L^{-1}$. The temperature of the sample ranged from 24.3℃ to 27.4℃, pH was in the range of 7.3 to 8.2 while conductivity ranged from 310 to 461 mhos/cm (Table 1). The highest desirable level for pH is within the range of 7.0-8.5 [7]. The degree of hardness of the water was low and this might encourage the dissolution of heavy metals [8]. The agricultural activities of the area where the samples were taken did not alter the pH of the water samples. This may explain the presence of most of the metals in the water samples and the high level of conductivity [9]. Based on these, the water samples in this study fell under soft water. The present result compared with the result on ground and surface water samples. The total concentration of divalent metal ions (primarily Ca and Mg) expressed in mg $L^{-1}$ of equivalent $CaCO_3$ is termed total hardness of water. Mg and Ca are the range of 0.4 – 7.3 mg $L^{-1}$ (mean; 3.6 mg/l) and 3.4-3.0 mg $L^{-1}$ (mean, 17.4 mg $L^{-1}$) respectively. These metals fell within the maximum acceptable limit by WHO. The presence of appreciable concentration of Ca and Mg were consistent with the level of hardness because higher values of Ca and Mg were consistent with total hardness.

Extensive abstraction of groundwater for irrigation purposes in the central part of the study area has given rise to a groundwater trough. This area also shows larger annual fluctuations in groundwater levels. The persistence of groundwater trough even after the recharge season indicates over-exploitation condition in that part. But for this, groundwater levels in the area generally follow the surface topography.

The quality of groundwater is generally quite fresh in the hills and slope regions, while it is slightly brackish in the plains and valleys. An analysis of temporal changes in groundwater quality indicates that it is dependent on geomorphology, rock-water interaction as well anthropogenic activities. In a year having adequate rainfall, the groundwater in the hilly area, having slopes more than 1 percent, generally shows a sharp increase in TDS after recharge, while majority of the wells located in the plains show a decrease. The Tiruchirappallii district forms part of the upland plateau with many hills and undulating plain. The structural hills, pediments and valley fills in the district have wide variation in the weathering and fracturing pattern, which controls the groundwater recharge and storage.

Chloride was in the range of 1-30 mg $L^{-1}$(mean, 10.6 mg $L^{-1}$). Samples from low division and rock have highest chloride content that those from other source. High chloride content impacts taste and could cause corrosion [7].

Dissolved oxygen ranged from 7.4 to 18 .2 mg $L^{-1}$. The dissolved oxygen concentration of the samples showed that the samples were oxygen – rich although, rain water obtained from asbestos roof had the lowest value. The values were not highly varied. This is depicted by the value of CV (%), 33.25. The nitrate values ranged between 0.07 and 6.61 mg $L^{-1}$. The results showed that all samples have low nitrate values. Nitrate in natural waters can be traced to percolating nitrate from sources such as decaying plant and animal materials, agricultural fertilizers, domestic sewage [6].

Drinking water contains more than 50 mg/l nitrate can cause methamoglobinemia in infants [10]. The level and range of the elements in the water sample are shown in Table 2. The distribution diagram of each metal was prepared to evaluate the variability of each metal contents (Fig. 1). In all the samples, the mean level of all the elements was below the WHO limts. The range of Fe, Cr, Cd, Pb, and As, were 3.3-6.1, ND-0.2, 0.1-0.3 and ND-0.2 mg $L^{-1}$ Co and Zn were not detected. The concentration range of the metal indicate a lack of uniform distribution of metal within the water sample, however same variations of this magnitude have also been reported by other workers [11-13]. The variation observed were probably due to various factors such as trace metal contents of all the soil and crops, geographical location, fertilizers and fungicides applied in the area, environmental pollutions due to automobile emissions, industrial effects, other agricultural activities and weathering of rocks.

### 3.1 Graphs: Trace Metal Content (mg $L^{-1}$) of Water Samples

Graphical Clustered Colum Variations Range of Trace Metal Water Samples.

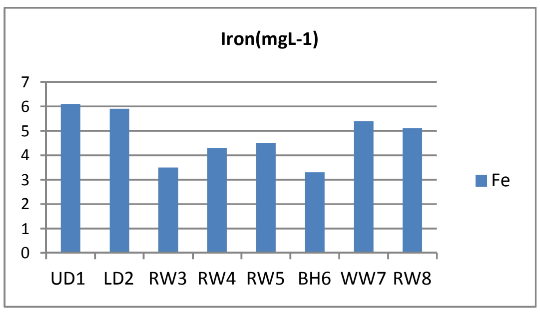


**Fig. 1. Determination of iron water samples 1-8**

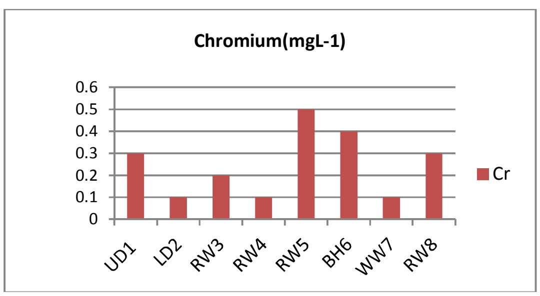


**Fig. 2. Determination of chromium water samples 1-8**

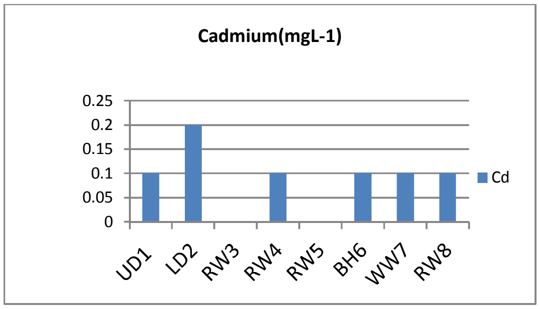


**Fig. 3. Determination of cadmium water samples 1-8**

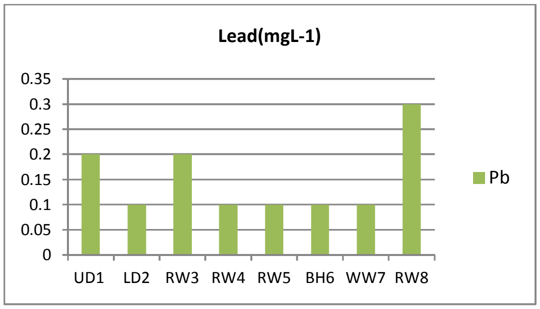


**Fig. 4. Determination of lead water samples 1-8**

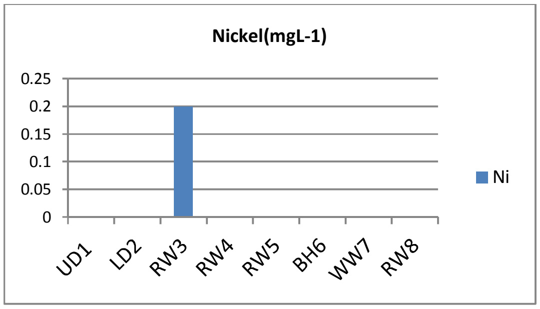


**Fig. 5. Determination of nickel water samples 1-8**

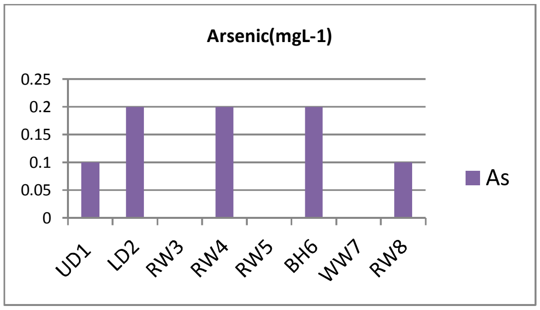


**Fig. 6. Determination of arsenic water samples 1-8**

**Table 1. Values of physico chemical parameters**

| Para meter | WHO standard BIS 10500: 1991 | UD1 | LD2 | RW3 | RW4 | RW5 | BH6 | WW7 | RW8 | Min | X (Mean) | Max | SD | CV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temp ℃ | - | 25.2 | 25.8 | 24.8 | 24.3 | 24.3 | 27.4 | 7 | 24.8 | 24.3 | 25.5 | 27.4 | 1.19 | 4.67 |
| pH | 6.5 to 8.5 | 7.4 | 7.4 | 7.6 | 7.3 | 7.3 | 7.6 | 7.4 | 8.2 | 7.3 | 7.5 | 8.2 | 0.3 | 3.94 |
| Conductivity (mhos/cm) | 657 | 324 | 461 | 310 | 420 | 328 | 380 | 315 | 405 | 310 | 367 | 461 | 56.79 | 15.44 |
| Chloride (mg $L^{-1}$) | 250 | 6.8 | 24.8 | 1 | 1.9 | 2.1 | 7.2 | 10.3 | 30.7 | 1 | 10.6 | 30.7 | 11.16 | 105.28 |
| Magnesium (mg $L^{-1}$) | 30 | 6.2 | 7.3 | 0.8 | 0.9 | 0.4 | 6 | 1.2 | 5.8 | 0.4 | 3.6 | 7.3 | 2.98 | 83.36 |
| Calcium (mg $L^{-1}$) | 75 | 12 | 28.6 | 3.4 | 4.8 | 4.7 | 30.3 | 25.7 | 30 | 3.4 | 17.4 | 30 | 12.33 | 70.76 |
| Total hardness (ppm) | 200 | 57.6 | 42.5 | 40.7 | 43.4 | 41.7 | 38.8 | 48.1 | 61.3 | 38.8 | 48.8 | 61.3 | 8.33 | 17.82 |
| DO ($mgL^{-1}$) | 78 | 10.7 | 8.77 | 8.6 | 7.4 | 9.2 | 11.2 | 15.2 | 18.2 | 7.4 | 11.2 | 18.2 | 3.71 | 33.25 |
| Nitrate (mg $L^{-1}$) | 45 | 1.08 | 1.02 | 0.9 | 0.07 | 0.21 | 0.43 | 1.01 | 6.6 | 0.07 | 1.3 | 6.61 | 1.3 | 165.93 |
| Oil & grease | 0.01 | NF | NF | NF | NF | NF | NF | NF | NF | NF | NF | NF | NF | NF |

*WW7 - Well water(from Agriculture area) and RW8 - Rock water(from mountain), RW4 - Rain water (from earth Surface), RW5 - Rain water (from Iron Metal roof), BH6 - Bore house water, UD1 -Upper division water(from Lake), LD2 - Lower division water (from same lake), RW3, - Rain water (from Asbestos roof), ND- Not Deduted, NF-Not Found*

**Table 2. Trace metal content (mg $L^{-1}$) of water sample**

| Parameter | WHO standard IS BIS 10500:1991 | UD1 | LD2 | RW3 | RW4 | RW5 | BH6 | WW7 | RW8 | Min | X (Mean) | Max | SD | CV% |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fe | 0.3 | 6.1 | 5.9 | 3.5 | 4.3 | 4.5 | 3.3 | 5.4 | 5.1 | 3.3 | 4.8 | 6.1 | 1.04 | 21.8 |
| Cr | 0.05 | 0.3 | 0.1 | 0.2 | 0.1 | 0.5 | 0.4 | 0.1 | 0.3 | 0.1 | 0.3 | 0.5 | 0.15 | 60.5 |
| Cd | 0.01 | 0.1 | 0.2 | -- | 0.1 | -- | 0.1 | 0.1 | 0.1 | -- | 0.1 | 0.2 | 0.04 | 35.0 |
| Pb | 0.05 | 0.2 | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.3 | 0.1 | 0.2 | 0.3 | 0.07 | 45.8 |
| As | 0.05 | 0.1 | 0.2 | -- | 0.2 | -- | 0.2 | -- | 0.1 | -- | 0.2 | 0.2 | 0.06 | 38.5 |
| Ni | 0.05 | -- | -- | 0.2 | -- | -- | -- | -- | -- | -- | 0.1 | 0.2 | 0.06 | 43.3 |
| Co | 0.05 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Zn | 5 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |

*WW7 - Well water (from Agriculture area) and RW8 - Rock water (from mountain), RW4 - Rain water (from earth Surface), RW5 - Rain water (from Iron Metal roof), BH6 - Bore house water, UD1 -Upper division water (from Lake), LD2 - Lower division water (from same lake), RW3, - Rain water (from Asbestos roof), ND-Not Deduted, NF-Not Found*

### 3.2 Graphs: Physico Chemical Parameters of Samples

Graphical Clustered Colum Variations Range of Physico Chemical Water Samples.

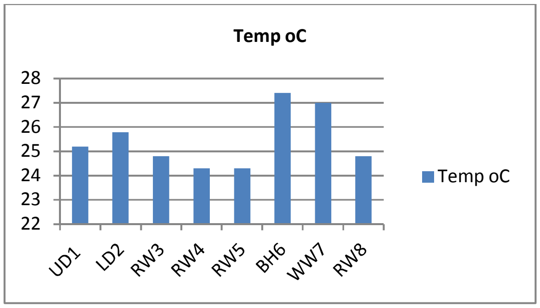


**Fig. 7. Determination of Temp $^{o}$c water samples 1-8**

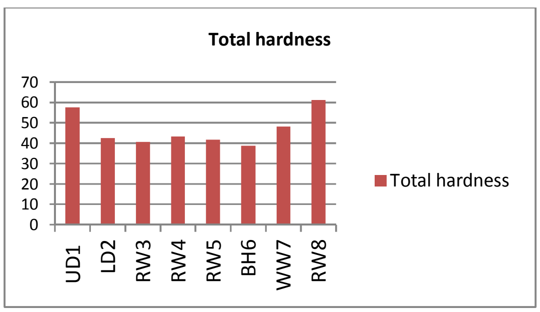


**Fig. 8. Determination of Total hardness water samples 1-8**

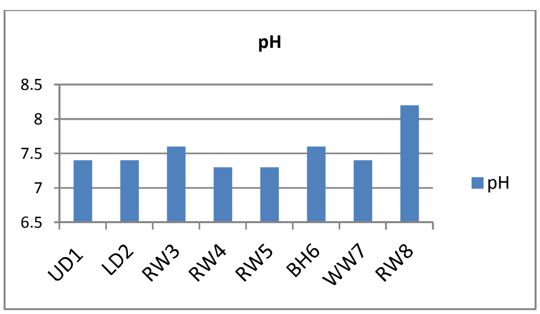


**Fig. 9. Determination of pH water samples 1-8**

The total weekly intake of Pb and Cd through food, water and air established by WHO. Although the metal contents were below these levels,the total weekly intake of these metals above tolerance levels [7]. The level of Co and Zn were higher than the values for this study [3].

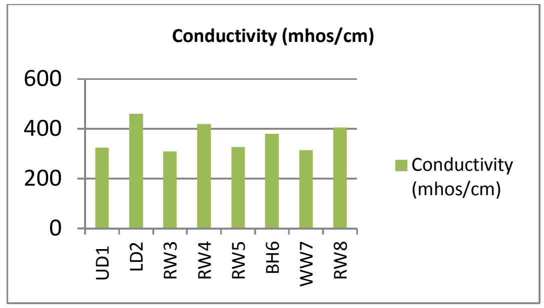


**Fig. 10. Determination of conductivity water sample 1-8**

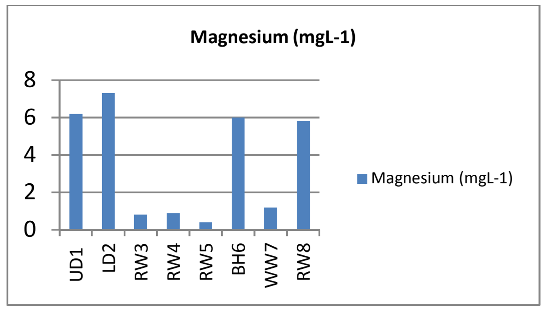


**Fig. 11. Determination of magnesium water samples 1-8**

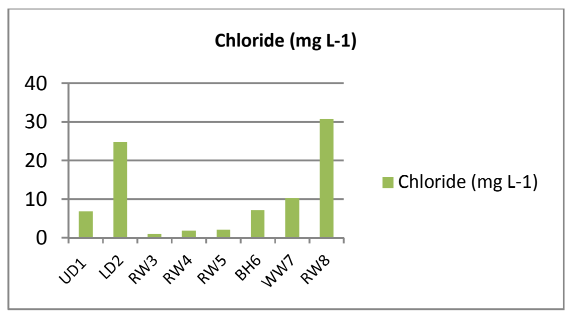


**Fig. 12. Determination of chloride water samples1-8**

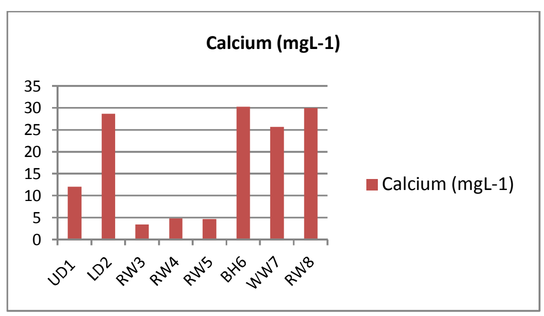


**Fig. 13. Determination of calcium water sample 1-8**

**Table 3. Comparative present study among countries**

| Element | Present study | Nigeria | Pakistan | USA | Norway | Britain |
|---|---|---|---|---|---|---|
| Fe | 3.3-6.1 | - | 0-0.04 | - | - | - |
| Cr | 0.10.5 | 0.12-0.11 | 0-4.10 | - | - | 0.4-0.15 |
| Cd | ND-0.20 | 0.05-0.06 | 0-1.12 | - | <0.25 | 0-0.06 |
| Pb | 0.1-0.2 | 0.21-0.44 | 0.6-4.20 | 0.83 | <0.35 | 0-0.07 |
| As | 0.0-0.2 | 0.24-1.30 | - | - | - | 0.04-0.05 |
| Ni | ND-0.2 | 0.44-1.10 | 0.12 | - | <0.15 | 0.08-0.17 |
| Co | ND | - | - | - | - | - |
| Zn | ND | - | 0.1-4.3 | - | 50.9 | 0.12-3.81 |

*ND-Not Deduted*

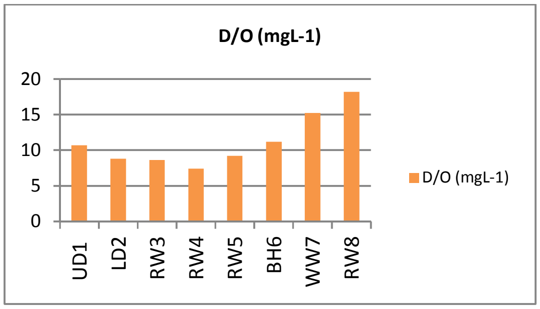


**Fig. 14. Determination of D/O water samples 1-8**

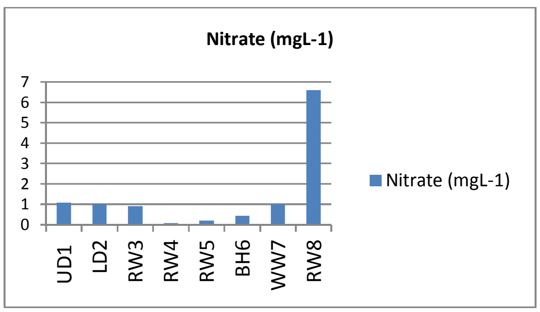


**Fig. 15. Determination of nitrate water samples 1-8**

## 4. CONCLUSION

The physiochemical analysis of well water and bore well water indicate that some of the parameters were found to be exceed the permissible limits, which were could be described to seepage of treated waste water into ground water factors such as availability and solubility of fluoride minerals, velocity of flowing water, pH, Calcium, bicarbonate ions, high fluoride of drinking water was reported [14].

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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