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Physiochemical Assessment of Drinking Water Quality in Kandahar City, Afghanistan

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Abstract:-Drinking water quality is one of the most important aspects affects water consumption in every human community. The water used by humans is never pure, naturally. Natural water contains many physical and chemical pollutants which can endanger human life with different threats. It was so crucial to assess drinking water quality in Kandahar city. People in Kandahar; depend on ground water resources for their daily water needs. This study was conducted to assess the drinking water quality of Kandahar, both physically and chemically. 15 samples were taken from 9 districts of Kandahar City, which almost represent the water of whole city. Samplings were done with coordination of Public Health department of Kandahar. Some of the parameters; such as, Color, Odor, Taste, and Temperature were tested on the sampling site. At the result, the color of sample no.2 was slightly reddish, the taste of sample no. 3, 5 and 11 were slightly bitter, but the Odor of all samples was non-objectionable. Physical parameters; such as, Turbidity, TDS, EC (Electrical conductivity), and color were measured in the lab using several high-tech machines. The results of Turbidity measurement described that sample no.2 and 3 were above the standard regulations of WHO, U.S.EPA, PSDWQ and ANSA. EC results of all samples were over range, which prove the water containing dissolved salts and ions. TDS and Salinity had very close values in each sample. TDS results showed that all the samples were in normal range set by ANSA. Salinity of sample no.3, 4, 5, 7, 8, 11, 12, 13, 14 were over the range of standards set by WHO and EU. Regarding to chemical parameters, only sample no.5 had a pH of 6.2 which is out of the standard range of 6.5-8.5 set by WHO, U.S.EPA, EU, IL, PSDWQ, and ANSA. The rest of the samples were in normal range of pH. Luckily, the drinking water in Kandahar city proved to be in safe condition for the parameters studied in this study. Moreover, the team recommends permanent hardness assessments in some areas of the city and recommends a biological assessment of drinking water quality in Kandahar city.

Background:-Water quality is a vital concern for mankind as it is directly linked with human welfare.

Objective:-With this knowledge, the present study was performed to assess the portability of drinking water in Kandahar city.

Material and Methods:-Water samples from different drinking water sources were collected and analyzed for physio-chemical parameters. This study aimed to assess drinking water quality of Kandahar, physically and chemically. During this study 15 samples were taken from different parts of the city and tested for various physical and chemical parameters.

Findings:-Temperature, color, odor and taste were the physical parameters tested at the field. Temperature was measured by a digital thermometer. Color was measured both visually and by using PtCo units. Taste and Odor were also measured by tasting the samples and smelling them. Some other physical and chemical parameters were tested in water quality lab of Public health department of Kandahar. pH in all samples was in normal range except sample no.5 which had a pH of 6.2. EC was in high level in all the samples and that claims that the water had dissolved salts and ions. TDS and Salinity were high in some samples but not over ranged according to the standard value set by the standard authority of Afghanistan. Chemical parameters in all samples were in safe range. Hardness was the parameter residents of the city are concerned about but as the result of our study, we found that the hardness in some areas are not temporary hardness of CaCO3 but is permanent harness which may be due to the presence of sulfate compounds.

Conclusion:-The physiochemical assessment of water showed that the water quality in Kandahar city is safe.

Keywords:-Water Quality, Sources of Contamination, Physio-Chemical Parameters, Kandahar, Afghanistan.

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I. INTRODUCTION

Water cycle is one of the processes which have both fast and slow bits. Water is above, under and on the surface of earth, which clearly shows that water is being in contact with different materials in different states. Although water is nature's abundant gift but most of it is present in oceans (97%) and in the icebergs in the Polar Regions (2%) which are of no use for utilization and the remaining (1%) of all earth's water, which is available in lake, rivers and underground for utilization(Budhlani and Nagarnaik, 2011). The available data reflects that only 2.5 percent is the available fresh water out of total volume present on earth, most of if locked up in glaciers and depths of ground water aquifers (Kausar et al., 2011). It is obvious that the aquifers located inside the crust and river beds and lakes upon the crust are having different geological make ups which certainly affect the water related to them. Water is a universal solvent; hence, it dissolves almost everything which makes contact with it. While consumed, some of the minerals and compositions dissolved in water are toxic and hazardous for human body.

Despite being harmful in excessive amount, the dissolved substances are indispensable for most of the vital processes in human body. The critical impact of amount-variation has impelled humans to take the issue more seriously. Worldwide there have been so many diseases born from the poor quality of water and Millions of people die annually because of drinking the water which is not safe. For confronting the problem, people have elected several paths because one thing is sure; every human being deserves to have access to safe consumable water, and as a result today there are Water Quality Indexes for every nation, Guidelines for drinking water quality, and more importantly today we have got so many Water quality assessment methods and techniques worldwide.

Water quality assessment is based on assessing three parameters of water; physical, chemical and microbiological. However, all three parameters must be studied and analyzed for a vast understanding of water in any study area; this study is based on two parameters, chemical and physical. Each freshwater body has an individual pattern of physical and chemical characteristics which are determined largely by the climatic, geomorphological and geochemical conditions prevailing in the drainage basin and the underlying aquifer(Meybeck and Helmer, 1996). Thus, this chapter is divided in two main parts. The first part deals with Physical parameters of Water and the second part explains Chemical parameters of Water.

II. MATERIALS AND METHODS

A. Study Area

KandaharCity is the second largest city in Afghanistan with an estimated population of 1225,593in 2015(OCHA, 2015). The province covers an area of (47676 km^2). It is located at 31°37' Latitude North and 65°42' Longitude. It is situated at 1005meters above sea level. It serves as a capital of Kandahar province. Located at the south of the country, it has borders with Zabul Province in the east, Uruzganprovince in the North, Helmand province in the west and with the Balochistan Province of Pakistan in the south. More than four-fifths of the area is made up of flat land (84.5%), whereas nearly a tenth of the province is mountainous or semi mountainous terrain. 7.6% and 6.8% of the area is semi flat.(OCHA, 2015)

B. Climate of Kandahar City

Kandahar has a subtropical arid climate characterized by little precipitation and high variation between summer and winter temperatures. Summers start in mid-May, last until Late-September, and are extremely dry. Temperatures peak in July with a 24-hour daily average of around 31.9 °C (89.4 °F). They are followed by dry autumns from early October to late November, with days still averaging in the 20s °C (above 68 °F) into November, though nights are sharply cooler. Winter begins in December and sees most of its precipitation in the form of rain. Temperatures average 5.1 °C (41.2 °F) in January, although lows can drop well below freezing. They end in early March and are followed by a pleasant spring till late April with temperatures generally in the upper 10s °C to lower 30s °C (65–88 °F) range. Sunny weather dominates year-round, especially in summer, when rainfall is extremely rare. The annual mean temperature is 18.6 °C (65.5 °F).(MRRD, 2006.)

C. Data Collection

The primary data for the assessment is the results of measurements of parameters of water attained at the field and lab.

D. Sampling Procedure

Kandahar is a large city, administratively divided into 12 districts. Majority of the residents in the city depend on ground water sources. People have dug borewellsin almost eachpart of the city privately by themselves. This shows that people generally depend on borewells for drinking and other household water consumption purposes. As the ground water level varies, the depth of the wells also varies in different parts of the city. According to the survey data, the range of the well's depth was from minimum 10 meters to maximum 120 meters (Table 1). The shallow depth of 10 meters is the southern area of the city; whereas, the well with deeper depth 120 meters was in the northern area of the city. The residents have been confronted with water quality issue in some parts of the city. Some complaints are about the hardness of water, and the others complain of the taste and turbidity. Ground water level varies at different parts of the city. Majority of the peoples' complaints are observed where the ground water level is high, near the surface.

Samples	Name of Sampling Site	Districts	Water source	Bore Depth
WS-1	Agha Sahib Zyarat, Chowni	District-1	Borewell	55 m
WS-2	PashtoonBagh	District-6	Borewell	20 m
WS-3	EthihadMeena, Irazi,	District-3	Borewell	10 m
WS-4	Shikarpur Bazar	District-2	Borewell	20 m
WS-5	Kartha-e-Malimeen	District-10	Borewell	25 m
WS-6	Kala-e-Fasil, Cowk-e-Madad	District-1	Borewell	38 m
WS-7	Aino-Meena	District-11	Borewell	35 m
WS-8	DehKhwaja	District-4	Borewell	28 m
WS-7	Qalacha, Chowni	District-1	Borewell	45m
WS-10	Karez Bazar	District-2	Borewell	30 m
WS-11	MirwiasMeena	District-7	Borewell	30 m
WS-12	Shaheed Street, Bypass Road	District-3	Borewell	28 m
WS-13	Naseran Village, Bypass Road	District-5	Borewell	10 m
WS-14	Taraki Jami, SimanoPul	District-9	Borewell	100 m
WS-15	Alif Area	District-9	Borewell	120 m

Source: Survey Data, 2015

Table 1: Sampling Locations.

The locations for water samples are selected from different areas of the city, based on the peoples' complaints. Table 1 shows the details of sampling. After identifying the locations for sample collection, samples were collected in four days. The sampling sources included both Borewells and hand pumps installed on the wells. All the samples were collected and preserved in one liter sterilized polyethylene bottles. Before taking the sample, water was drained out for 3-4 minutes from every source. The temperature of each sample was measured immediately in sampling site using digital thermometer. Taste, odor and visual color were also checked and noted at the site. Right after the field measurements, the samples were transported to the lab for further analysis in special sample containers. Moreover, the related data was also attained regarding each sample in the sampling forms filled out at the sampling site. The related data in the forms included the location name, GPS addresses, sample source, sampling date and time for each sample.

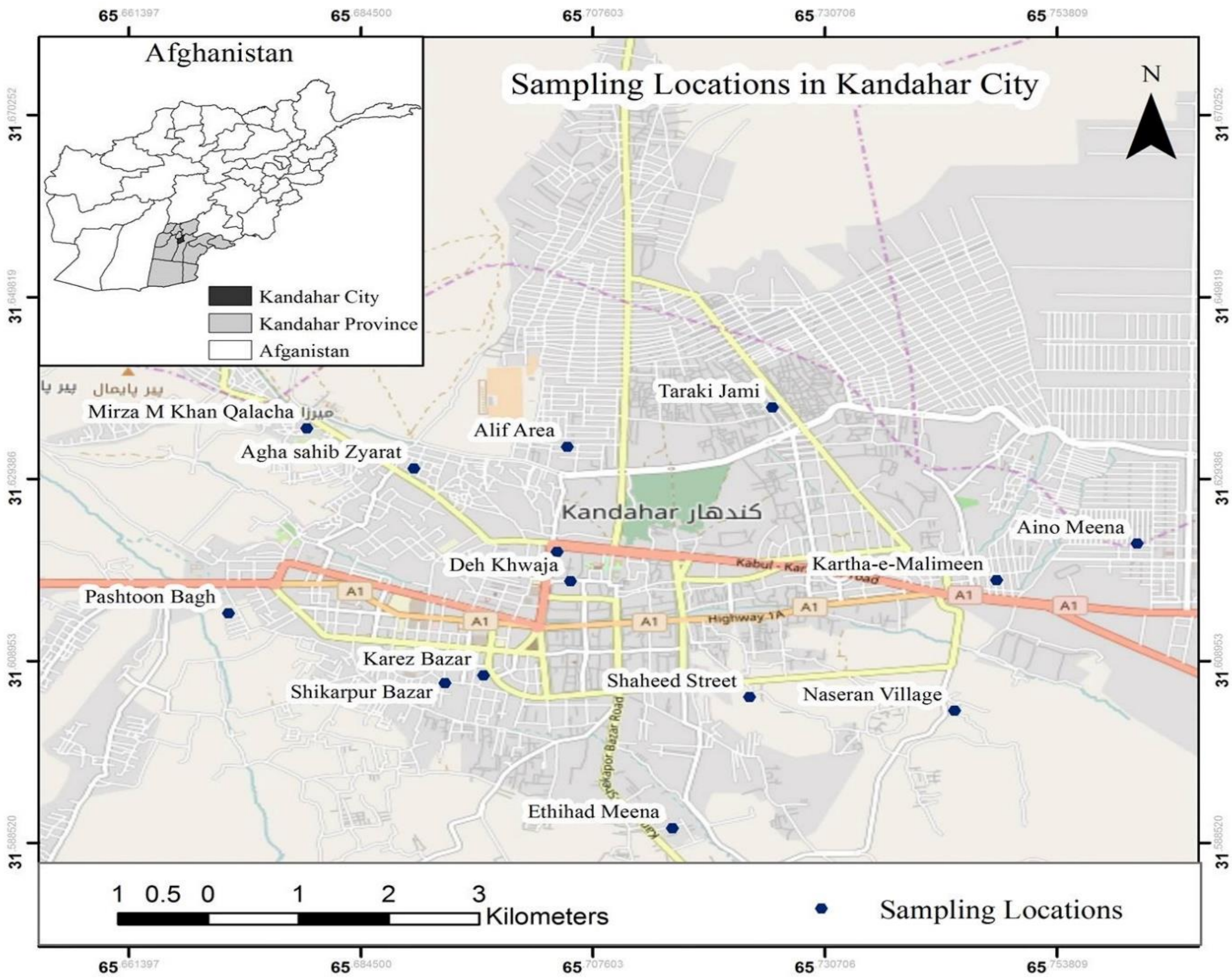

Fig. 1: Map Shows Sampling Location in Kandahar City

E. Measurements of physicochemical parameters

This assessment was conducted to show the physicochemical quality of drinking water in Kandahar city. The measurements were run in two categories of parameters: physical and chemical. Some of physical analyses were carried out at the site whereas the other physical and chemical analyses were executed at the water quality laboratory, Public Health Department of Kandahar city. The physiochemical measurements of each sample were conducted within 24 hours; the sampling was collected.

F. Physical Parameters

Analysis of the physical parameters of water includes assessment of color, taste, odor, turbidity, temperature, electrical conductivity (EC), TDS, and salinity.

G. Physical Analysis of the Water Quality At Site

To avoid the possible changes that take place in the preservation time, measurements of the physical parameters were carried out at the sample siteat the time of sample collection. The measured parameters in the field included: temperature, taste, odor and visual color. Temperature was measured by a digital thermometer (TP 3001). For each sample, as soon the bottle was filled with sample water, the thermometer was inserted to the bottle before closing the cap and held for few seconds to measure the temperature. After the thermometer got stabilized in the sample, the temperature was recorded for each sample. Similarly, the taste, odor and visual color of the water were also checked right at the sampling site.

III. RESULTS AND DISCUSSION

A. Physical Assessment of Drinking Water Quality

Table 4 shows the results of physical parameters in detail for each sample. The physical parameters were tested in the field. The parameters described in this part of the chapter are not tested with any machine. The observation for these parameters was done by the research team by tasting each sample for its taste and odor. The temperature of each sample was checked using a digital thermometer and the color was observed visually.

Samples	**Physical Parameters**			
	Color	**Taste**	**Odor**	**Temp (C)**
Samp-1	Clear	Tasteless	Odorless	24.6
Samp-2	Slightly reddish	Tasteless	Odorless	28.6
Samp-3	Clear	Slightly bitter	Odorless	22.0
Samp-4	Clear	Tasteless	Odorless	22.6
Samp-5	Clear	Bitter	Odorless	23.7
Samp-6	Clear	Tasteless	Odorless	23.0
Samp-7	Clear	Tasteless	Odorless	23.0
Samp-8	Clear	Tasteless	Odorless	22.5
Samp-7	Clear	Tasteless	Odorless	23.5
Samp-10	Clear	Tasteless	Odorless	22.0
Samp-11	Clear	Slightly bitter	Odorless	23.0
Samp-12	Clear	Tasteless	Odorless	27.0
Samp-13	Clear	Tasteless	Odorless	28.5
Samp-14	Clear	Tasteless	Odorless	31.0
Samp-15	Clear	Tasteless	Odorless	31.0

Source: Field Survey, 2015

Table 2: Results for Physical Parameters of Drinking Water Quality

B. Physical Assessment of Turbidity, EC, Salinity, TDS and Color

Table 5 shows the results of physical parameters related to turbidity, EC, salinity, TDS and color of the samples. The analyses were conducted in the laboratory. The results of the physical parameters of each sample are compared with the global drinking water quality standards.

Samples	Chemical Parameters				
	Turbidity (NTU)	**EC (µS/cm)**	**TDS (mg/L)**	**Salinity (mg/L)**	**Color (PtCo)**
Samp-1	0.40	520	252	250	5
Samp-2	28.54	440	212	210	200
Samp-3	6.25	1492	743	750	26
Samp-4	0.60	1349	670	670	4
Samp-5	0.47	3215	1648	1670	4
Samp-6	0.30	783	384	380	6
Samp-7	0.14	3001	1538	1560	10
Samp-8	1.95	1152	572	570	1
Samp-7	0.00	465	225	220	1
Samp-10	0.33	833	408	410	3
Samp-11	0.33	2787	1433	1450	11
Samp-12	0.41	1596	799	800	19
Samp-13	0.61	1202	596	600	13
Samp-14	0.59	1331	660	660	14
Samp-15	0.22	679	331	320	7
Water Physical Quality Standards					
WHO	0 - 5	< 250	< 1000	≤ 450	≤ 15
US EPA	0.3- 5	NGVS	< 500	1000	≤ 15
EU	NGVS	< 250	NGVS	≤ 450	NGVS
IL	0 - 25	NGVS	< 500	NGVS	NGVS
PSDWQ	0 - 5	NGVS	< 1000	NGVS	≤ 15
ANSA	5	NGVS	1000 - 2000	NGVS	NGVS

Source: Field Survey, 2015

Table 3: Results for Chemical Parameters of the Drinking Water

Note: US EPA = United States Environmental Protection Agency
EU = European Union
IL = Iranian Legislation
PSDWQ = Pakistan Standards for Drinking Water Quality
ANSA = Afghanistan National Standard Authority
WS= Water Sample

C. Chemical Assessment of Drinking Water Quality

Show the results of chemical parameters of drinking water quality.

Samples	pH	NHO3(mg/L)	Cl (mg/L)	F (mg/L)	Fe (mg/L)
Samp-1	7.12	3.0	0.00	0.35	0.03
Samp-2	7.09	4.7	0.30	0.04	0.07
Samp-3	7.06	3.2	0.00	0.38	0.17
Samp-4	7.12	5.1	0.02	0.53	0.11
Samp-5	6.2	4.6	0.02	0.31	0.11
Samp-6	7.5	8.1	0.03	0.58	0.01
Samp-7	7.9	6.8	0.00	0.89	0.04
Samp-8	6.62	1.2	0.02	0.88	0.30
Samp-7	7.49	2.1	0.01	0.12	0.00
Samp-10	7.26	5.1	0.03	0.20	0.09
Samp-11	6..9	7.9	0.03	0.97	0.04
Samp-12	7.3	3.8	0.06	0.28	0.01
Samp-13	7.3	4.0	0.01	0.76	0.06
Samp-14	7.7	3.5	0.04	0.14	0.03
Samp-15	8.0	7.1	0.02	0.37	0.03
Water Chemical Quality Standards					
WHO	6.5-8.5	11	NGVS	1.5	0.3
U.S.EPA	6.5-8.5	10	NGVS	2	0.3
EU	6.5-8.5	50	NGVS	1.5	0.2
IL	6.5-8.5	45	NGVS	1.7	1
PSDWQ	6.5-8.5	50	0.2-0.5	1.5	NGVS
ANSA	6.5-8.5	50	0.5	1.5	0.3

Source: Field Survey, 2015

Table 4: Results for Chemical Parameters of Drinking Water

Note: US EPA= United States Environmental Protection Agency
EU= European Union
IL= Iranian Legislation
PSDWQ= Pakistan Standards for Drinking Water Quality
ANSA= Afghanistan National Standard Authority
ORP= Oxidation Reduction Potential
NGVS= No Guideline Value Set

Samples	ORP (mV)	Hardness (mg/L) of $CaCO_3$	Ca (mg/L)	Mg (mg/L)	As (mg/L)
Samp-1	200.3	0.29	0.0	0.075	0
Samp-2	226.0	0.57	0.2	0.017	0
Samp-3	121.5	0.85	0.0	0.21	0
Samp-4	237.0	2.50	0.96	0.025	0
Samp-5	245.3	1.55	0.62	0.00	0
Samp-6	150.8	0.47	0.08	0.066	0
Samp-7	174.7	1.05	0.26	0.01	0
Samp-8	207.7	1.82	0.556	0.105	0
Samp-7	224.3	3.93	1.536	0.022	0
Samp-10	223.0	1.49	0.452	0.088	0
Samp-11	243.4	1.11	0.44	0.00	0
Samp-12	190.0	1.80	0.64	0.049	0
Samp-13	202.4	1.23	0.24	0.154	0
Samp-14	184.4	2.91	0.896	0.156	0
Samp-15	187.6	0.70	0.12	0.1	0
Water Chemical Quality Standards					
WHO	(-550)-650	150-500	NGVS	NGVS	0.01
U.S.EPA	NGVS	NGVS	NGVS	NGVS	0.01
EU	NGVS	NGVS	NGVS	NGVS	0.01
IL	NGVS	NGVS	200	30-150	0.05
PSDWQ	NGVS	500	NGVS	NGVS	0.05
ANSA	NGVS	500	NGVS	NGVS	0.05

Source:

Table 5: Chemical Parameters

Note: U.S.EPA = United States Environmental Protection Agency
EU = European Union
IL = Iranian Legislation
PSDWQ = Pakistan Standards for Drinking Water Quality
ANSA = Afghanistan National Standard Authority
ORP = Oxidation Reduction Potential
NGVS = No Guideline Value Set

IV. DISCUSSION

Getting the data and the measurements from various samples enabled the research team to discuss the results of the efforts clearly. This part of the study points out the critical ranges of parameters in any sample which is showing the higher physical, chemical or both contaminations in the water. Besides, the overall Drinking water quality of Kandahar city is also discussed here.

A. Color, Taste and Odor

The color of water samples was not only observed visually but also measured in the laboratory. From the visual observation, it was found that color of only Samp-2was reddish. In contrast to visual observation, the laboratory assessment showed that not only Samp-2 but also Samp-3 and Samp-12 showed objectionable amount of color units. Samp-2, Samp-3 and Samp-12 had color of 200, 26 and 19 PtCo units respectively. Whereas, the standard color units of WHO, U.S.EPA, and PSDWQ are all set as 15 PtCo units for drinking water. Figure 5.1 presents a comparative chart of color measurement. In addition, most of the water samples were found tasteless and odorless. However, only Samp-3, Samp-5 and Samp-11 showed bitter and slightly bitter tastes respectively.

B. Turbidity

Table 5.3 shows that two samples demonstrated turbidities over all the standard ranges. Samp-2 showed 28.54 and Samp-3 showed 6.25 NTUs turbidity. Whereas, the standard range of turbidity of WHO, U.S.EPA, PSDWQ, and ANSA is 5NTUs and the standard range of IL for turbidity is set at 25 NTUs. Comparing the tested samples, it can obviously be claimed that all the water samples collected from different parts of the city had normal range of turbidity, except for Samp-2 and Samp-3. Among these, Samp-2 showed a critical amount of turbidity which is over from all standards. However, the value for Samp-3 falls in normal range as per Iranian legislation standards, but not in normal range as per Afghanistan National Standard Authority.

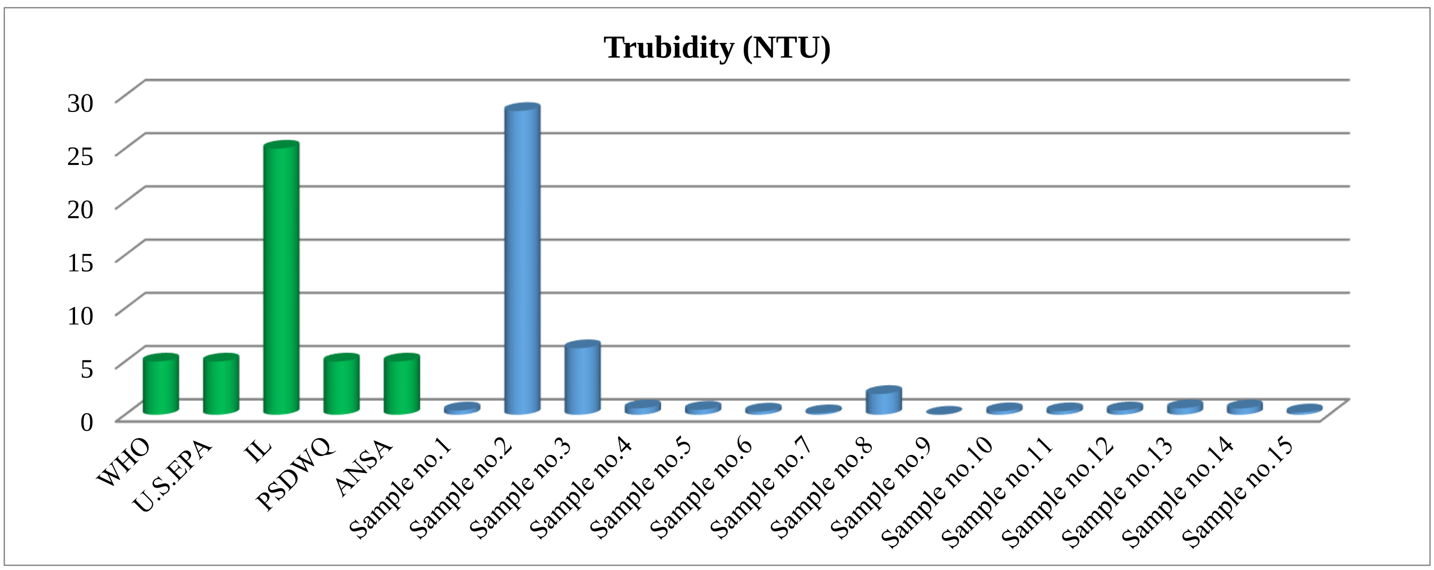

Figure 3: Comparative Chart of Turbidity Measurement

C. Electrical Conductivity (EC)

Tables shows that all 15 samples exhibited over range of Electrical conductivity (EC), compare to the standards. The highest measured EC was the 3215 µS/cm for Samp-5 and the minimum measured EC was 440 µS/cm forSamp-2. The standard range of EC by WHO and EU standards is set at 250 µS/cm. High ranges of EC shows that the water has many dissolved ions in it. The dissolved ions can be either elements of compounds such as salts, sulfates and various carbonate compounds.

D. Total Dissolved Solids (TDSs) and Salinity

Total Dissolved Solids (TDSs) and salinity are closely linked together and show combined effect in water. Results in Table shows that water from samples are in normal range of TDS referring to the ANSA standards of salinity (1000-2000). However, as per the WHO standards (<1000 mg/L), Samp-5

(1648 mg/L), Samp-7 (1538 mg/L) and Samp-11 (1433 mg/L) do not fall in the normal range of TDSs. In the case of salinity, the results of the present study show that Samp-5, Samp-7 and Samp-11 demonstrated high levels of salinity in water. Whereas, the rest of samples showed normal range of salinity. In this study, it was observed that the measured ranges of both TDSs and salinity parameters were close to each other. This is obvious that dissolved salts of different metals have influenced the water to show high ranges of TDSs and salinity. The mutual relationshipof TDSs, salinity, and electric conductivity suggests that these threeparameters should be studied together. For instance, the high levels of EC suggest predict high level of dissolve materials which can create excessive deposits in plumbing fixtures and water pipes.

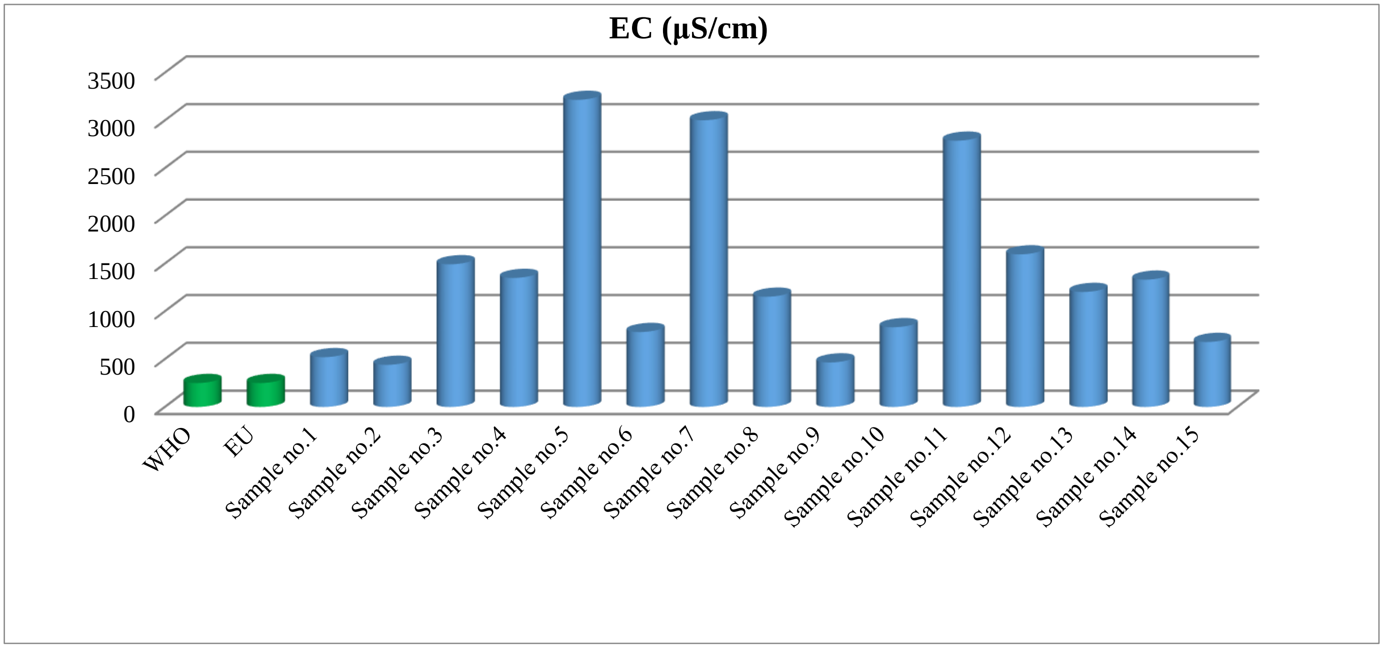

Figure 4: Comparative Chart of EC Measurement

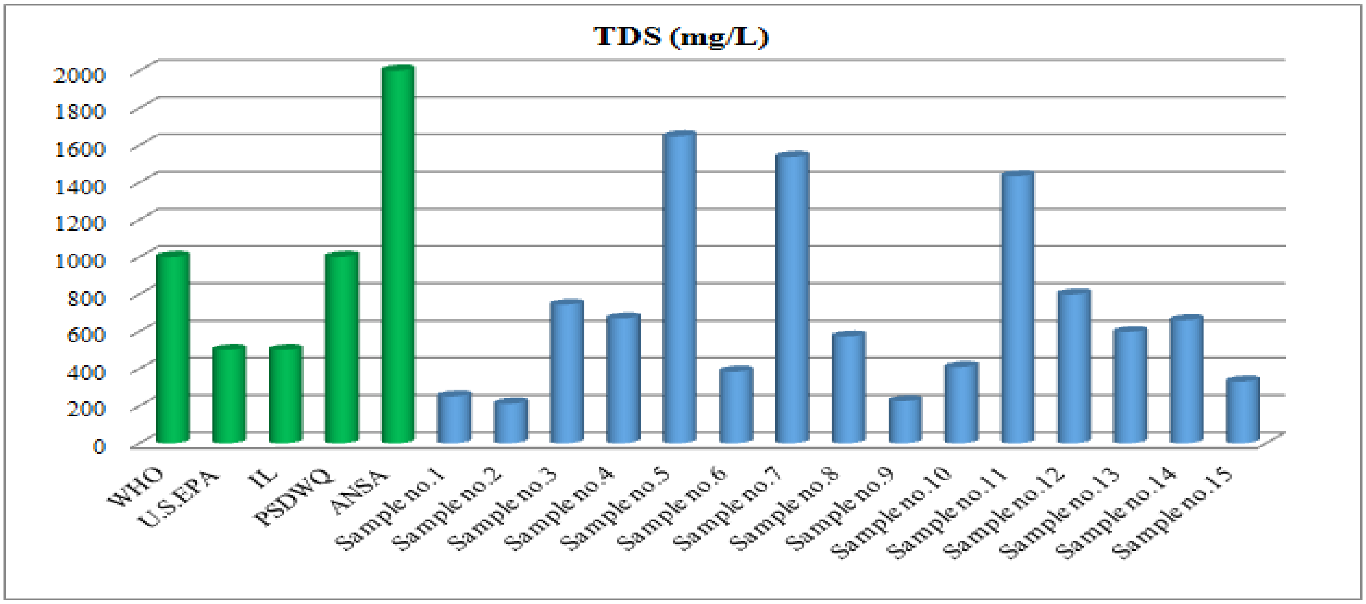

Figure 5: Competitive Chart of TDS Measurement.

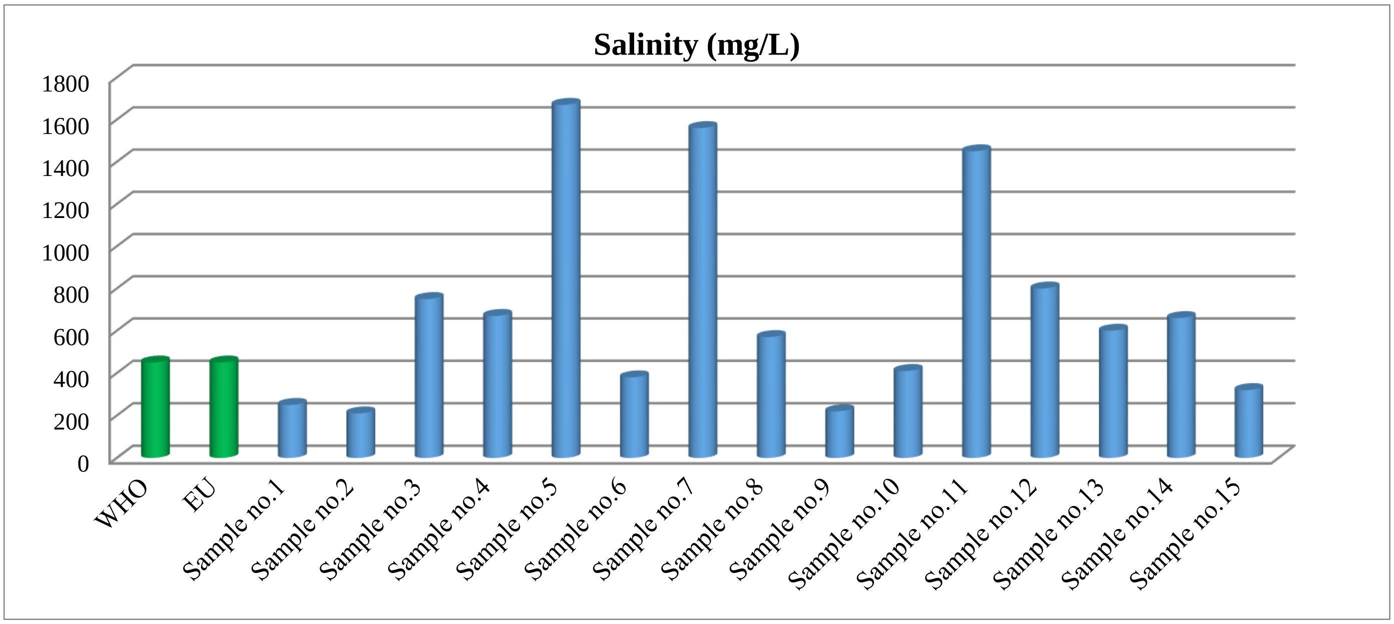

Figure 6: Comparative Chart of Salinity Measurement

E. Chemical Parameters

Further understanding of the drinking water quality in Kandahar city influenced the team to measure some chemical parameters beside the physical parameters. Table 5.4 shows all the results of measured parameters. From the attained results we can observe that except sample no.5 all the rest were in normal range of pH. Sample no.5 had a pH of 6.2, which proves that the water is below the standard national and global ranges and is acidic. The ORP (redox) values of all the samples declare that the water in all samples were neither oxidizing, nor de-oxidizing. Finally, the team can admit that except the pH of sample no.5 the rest of the samples were all in safe chemical state. However, the water in few areas such as the locations of sample no.5, an 7 are apparently hard, but it seems that the hardness in those water is not due to the presence of Calcium and Magnesium. The calcium and magnesium ranges were very low in all the samples and it is likely possible that the hardness in the mentioned area is permanent hardness, which occurs because of the presence of sulfates of calcium and magnesium and during this study sulfates were not measured. All parameters will be discussed in detail.

F. PH

The pH of all the samples were measured using a standard pH meter, specified in chapter 4. The results of all water samples showed that all the samples were in normal range of pH. Only one sample showed slightly acidic characteristic with a pH of 6.2; See table 5.4.

The standard range of pH according to all national and international water quality standards are between 6.5 and 8.5. In general, water with a low pH (< 6.5) could be acidic, soft, and corrosive. Therefore, the water could leach metal ions such as: iron, manganese, copper, lead, and zinc from the aquifer, plumbing fixtures, and piping. Therefore, water with a low pH could contain elevated levels of toxic metals, cause premature damage to metal piping, and have associated aesthetic problems such as a metallic or sour taste, staining of laundry, and the characteristic "blue-green" staining of sinks and drains.

Water with a pH > 8.5 could indicate that the water is hard. Hard water does not pose a health risk, but can cause aesthetic problems. These problems include: Formation of a "scale" or precipitate on piping and fixtures causing water pressures and interior diameter of piping to decrease; Causes an alkali taste to the water and can make coffee taste bitter; Formation of a scale or deposit on dishes, utensils, and laundry basins; Difficulty in getting soaps and detergents to foam and formation of insoluble precipitates on clothing, etc.; and Decreases efficiency of electric water heaters.Typically these problems are encountered when the hardness exceeds 100 to 200 milligram (mg) $CaCO_3$/liter (L).

G. Nitrate

Nitrate (NO_3) is a naturally occurring form of nitrogen found in soil. Nitrogen is essential to all life. Most crop plants require large quantities to sustain high yields. The formation of nitrates is an integral part of the nitrogen cycle in our environment. In moderate amounts, nitrate is a harmless constituent of food and water. Plants use nitrates from the soil to satisfy nutrient requirements and may accumulate nitrate in their leaves and stems. Due to its high mobility, nitrate also can leach into groundwater. If people or animals drink water high in nitrate, it may cause methemoglobinemia

(Methemoglobinemia is a blood disorder in which an abnormal amount of methemoglobin ,a form of hemoglobin , is produced. Hemoglobin is the molecule in red blood cells that distributes oxygen to the body. Methemoglobin cannot release oxygen).

During this study, all 15 samples were tested for the accurate amount of Nitrate in the water. As table 5.4 denotes the results of nitrate measurements in the ground water of Kandahar city, it can be observed that all the samples were in the normal range of all standards. Figure 5.6 shows the comparative chart of Nitrate measurement.

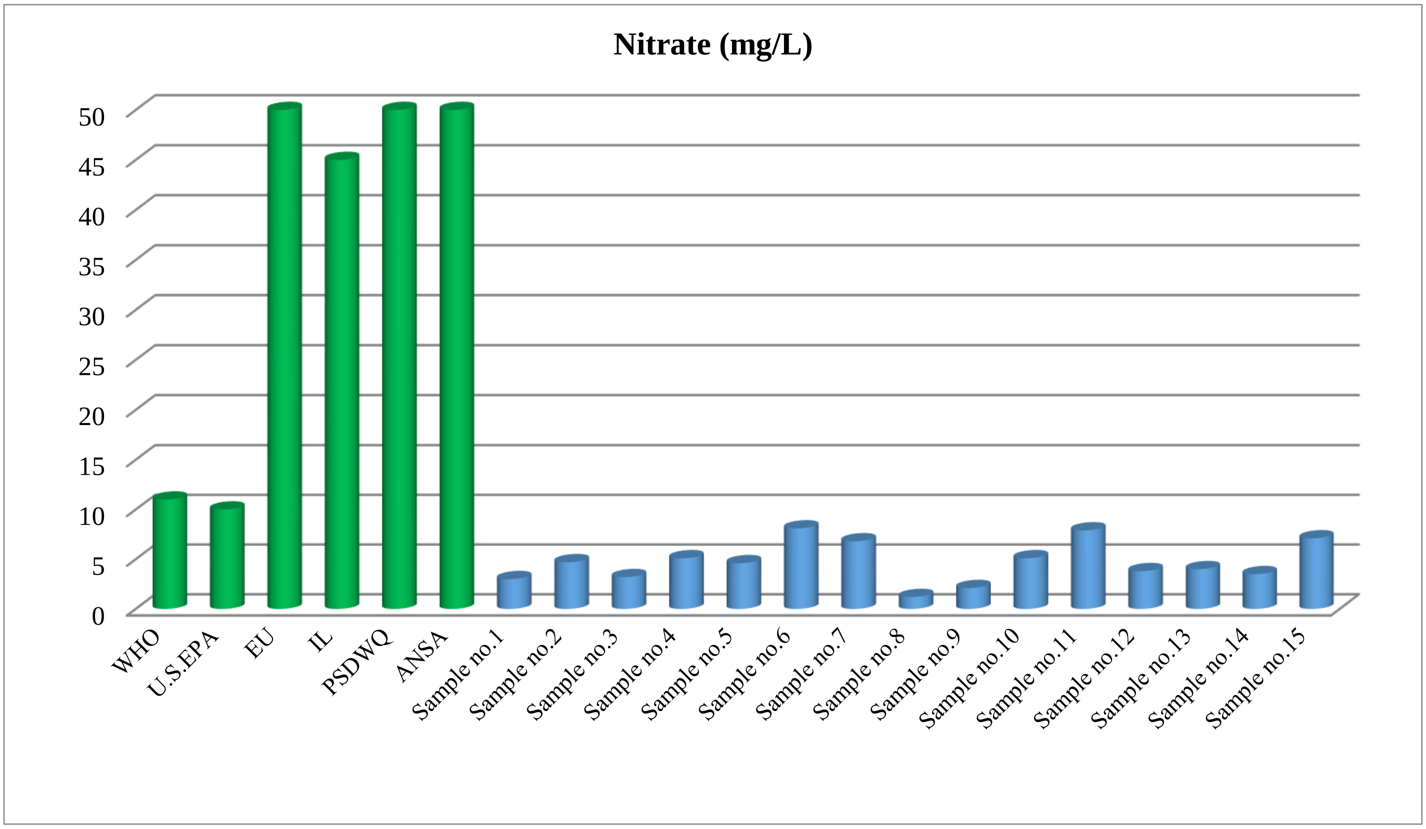

Figure 7: Comparative Chart of Nitrate Measurement

H. Chlorine

Another chemical parameter tested for the assessment of drinking water quality in Kandahar was Chlorine. Chlorine is a chemical that is used to disinfect water prior to it being discharged into the distribution system. It is used to ensure water quality is maintained from the water source to the point of consumption. When chlorine is fed into the water, it reacts with any iron, manganese, or hydrogen sulfide that may be present. If any chlorine remains (residual), it will then react with organic materials, including bacteria. In order to ensure that water is sufficiently treated through the whole distribution system, an excess of chlorine is usually added. This amount is usually adjusted to make sure there is enough chlorine available to completely react withall organics present.

The water consumed by the residents in the city is not treated with chlorine, because the residents accept the water to be safe for they pump it out from wells. Although the chlorination isn't taking place, the team analyzed water samples for chlorine content. Some amount of chlorine is dissolved in water due to the presence of various compounds and the occurrence of continuous reactions in water. The results shown in Table 5.4 denote that all the samples were in the safe range of total chlorine content. The standard ranges for chlorine is 0.2 - 0.5 mg/L and the samples were in much lower level. Figure 5.7 shows the comparative chart for chlorine measurement.

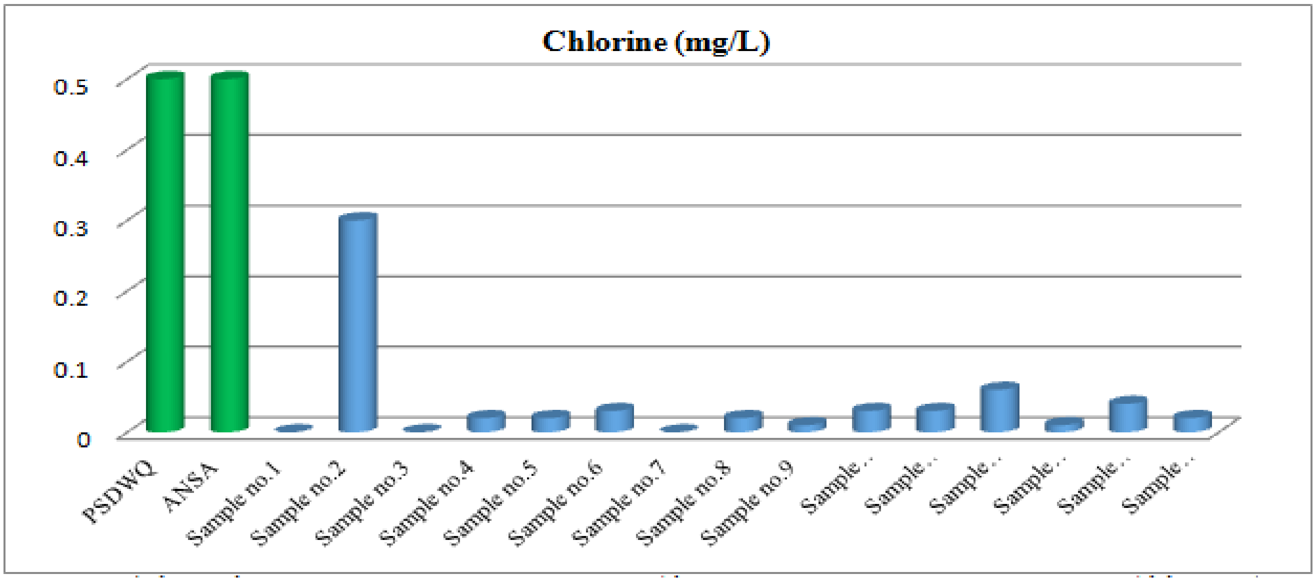

Figure 8: Comparative Chart of Chlorine Measurement

I. Fluoride

Fluoride compounds are salts that form when the element, fluorine, combines with minerals in soil or rocks. Some fluoride compounds, such as sodium fluoride and fluorosilicates, dissolve easily into ground water as it moves through gaps and pore spaces between rocks. Most water supplies contain some naturally occurring fluoride. Fluoride also enters drinking water in discharge from fertilizer or aluminum factories. Also, many communities add fluoride to their drinking water to promote dental health.Exposure to excessive consumption of fluoride over a lifetime may lead to increased likelihood of bone fractures in adults, and may result in effects on bone leading to pain and tenderness. Children aged 8 years and younger exposed to excessive amounts of fluoride have an increased chance of developing pits in the tooth enamel, along with a range of cosmetic effects to teeth. Hence, during this study fluoride was also a parameter of interest for drinking water quality assessment of Kandahar. Table 5.4 shows that all the samples were at a safe level of Fluoride content. Figure 5.8 denotes the comparative chart of Fluoride measurement.

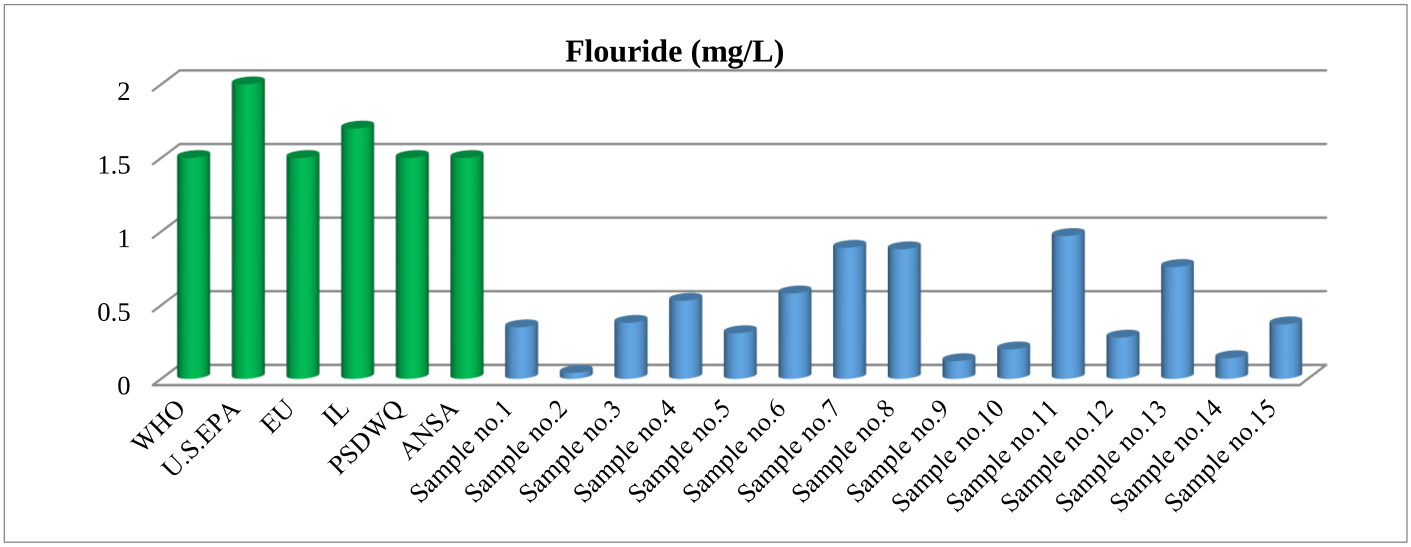

Figure 9: Comparative Chart of Fluoride Measurement

J. Total Iron

Iron is a common water problem faced by consumers. The maximum contaminant levels (MCL) for iron and manganese are 0.3 milligrams per liter (mg/l). When iron is present above the maximum contaminant levels (MCL), this usually results in discolored water, laundry, and plumbing fixtures. It is seldom considered to be a health risk in drinking water.

Iron is often found in water because of the large amount of iron present in the soil, sediment, and bedrock. It is also found in water because corrosive water will pick up iron from pipes. Clothing washed in water containing excessive iron may become stained a brownish color. The taste of beverages may also be affected by iron.

Well water is usually clear and colorless. However, when water containing colorless, dissolved iron is allowed to stand in a container or comes in contact with a sink or bathtub, these minerals combine with oxygen from the air and will oxidize, forming reddish-brown particles that stick to fixtures or are suspended in the water. The reddish particles formed by iron are commonly called rust. These impurities can give a metallic taste to water or to food.

The rusty or brown stains on plumbing fixtures, fabrics, dishes, and utensils cannot be removed by soaps or detergents. Bleaches and alkaline builders (often sodium phosphate) can make the stains worse. Over time, iron deposits can build up in pressure tanks, water heaters, and pipelines, reducing the quantity and pressure of the water system.

Ferrous is the type of iron often called "clear water iron" since it is not visible in poured water. It is found in water which contains little oxygen, such as water from deep wells or groundwater. The total iron content was measured for all samples in Kandahar city during this study. The results can be easily observed in Table 5.4, where it shows that all the water samples proved to contain the normal range of iron. Figure 5.9 shows comparative chart of Total Iron measurement.

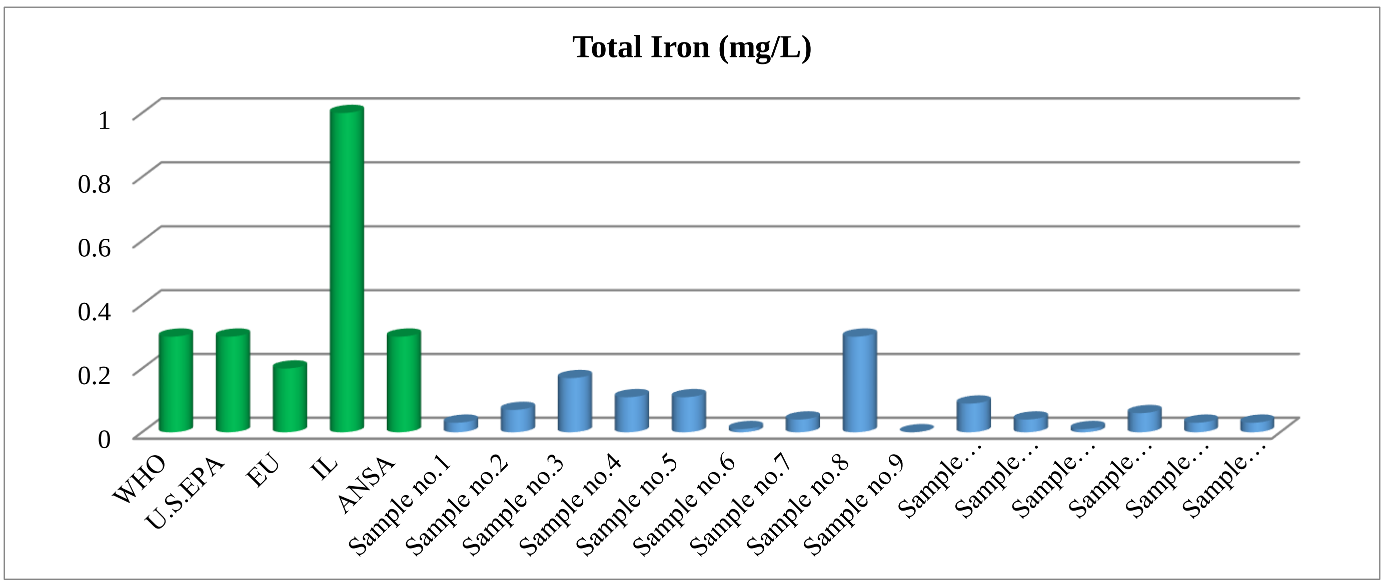

Figure 10: Comparative Chart of Total Iron Measurement

K. Total Hardness, Calcium and Magnesium

There are two types of hardness in water, temporary hardness and permanent hardness. Temporary hard water is high in dissolved minerals, both calcium and magnesium. As water moves through soil and rock, it dissolves small amounts of these naturally-occurring minerals and carries them into the ground water supply. Water is a great solvent for calcium and magnesium, so if the minerals are present in the soil around your well and its water supply, youcan end up with hard water.

Hard water interferes with almost every cleaning task, from doing the laundry to washing dishes to taking a shower. Clothes can look dingy and feel rough and scratchy. Dishes and glasses get spotted and a film may build up on shower doors, bathtubs, sinks and faucets. Washing your hair in hard water may leave it feeling sticky and dull. Finally, hard water can cause a residue to build-up in pipes that can lower water pressure throughout the house.

Hard water can be a nuisance due to the mineral buildup on plumbing fixtures and poor soap and detergent performance. It often causes aesthetic problems, such as an alkali taste to the water that makes coffee taste bitter; build-up of scale on pipes and fixtures than can lead to lower water pressure; build-up of deposits on dishes, utensils and laundry basins; difficulty in getting soap and detergent to foam; and lowered efficiency of electric water heaters.

Measured hardness, calcium and magnesium in all 15 samples of water in Kandahar city proved that all the samples were in much lower range of hardness, while this can also be understood from the pH of all samples. Table 5.4 contains the results of measurement of Hardness, calcium and magnesium. Figure 5.10, 5.11, and 5.12 shows comparative charts of hardness, calcium and magnesium measurements, respectively.

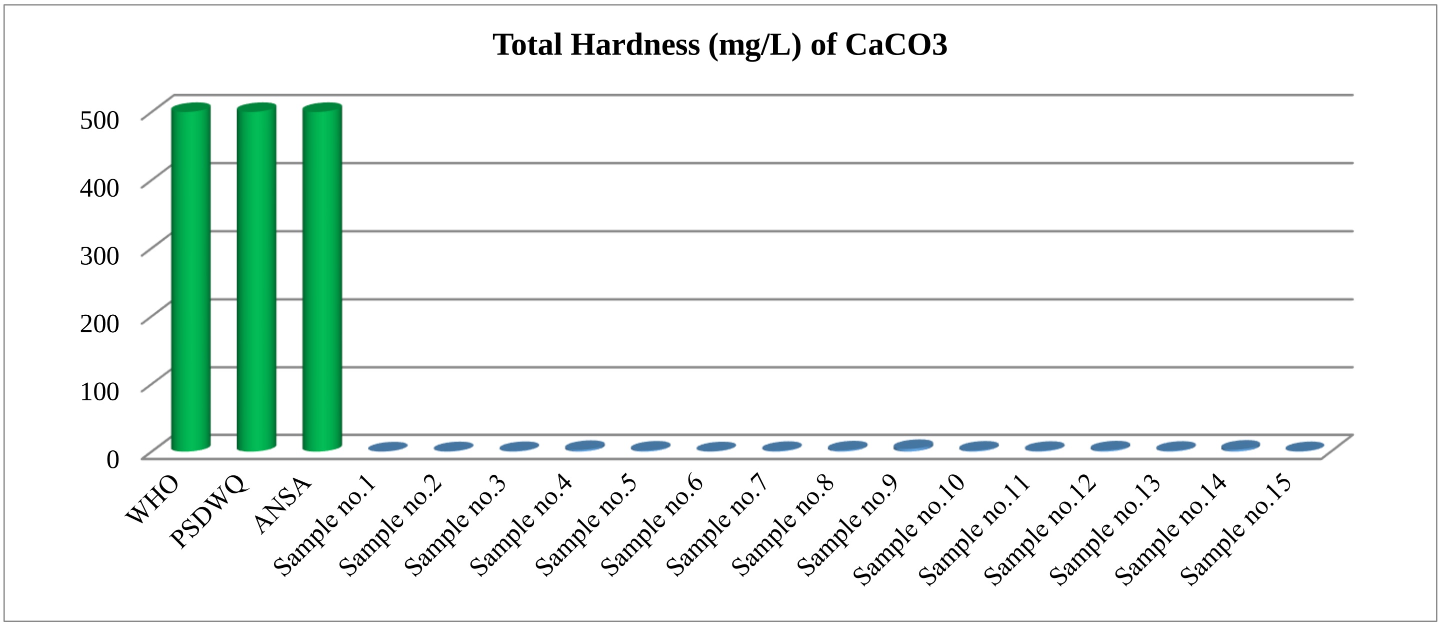

Figure 11: Comparative Chart of Total Hardness Measurement

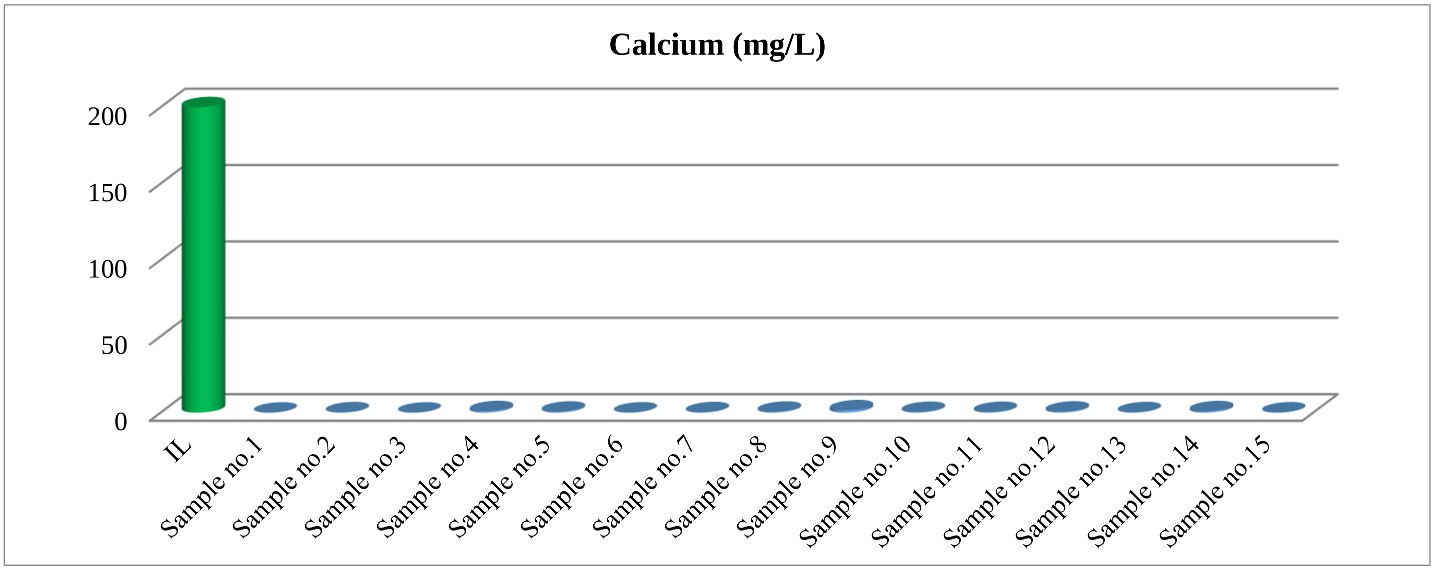

Figure 12: Comparative Chart of Calcium Measurement

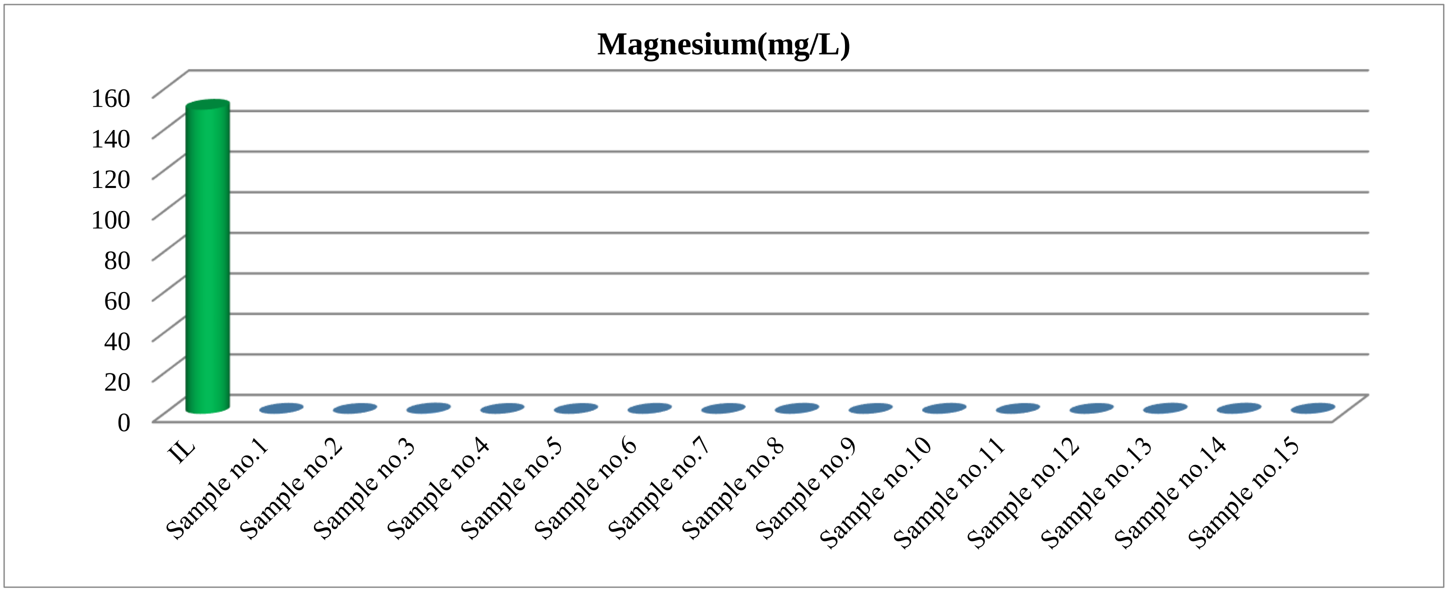

Figure 13: Comparative Chart of Magnesium Measurement

L. Arsenic

Arsenic is one of the most toxic materials can often be found in drinking water. The standard range for arsenic has been set in a very low amount of it in water. Luckily, all the water samples tested during this study proved to be absolutely safe from this toxic matter. All 15 samples contained 0.0 mg/l of arsenic. Table 5.4 contains the results for arsenic measurement.

The Drinking water samples collected from Kandahar city were analyzed for physio-chemical and bacteriological qualities (Tables 1 and 2). Different sources of drinking water showed different type of contamination including few processed water sources also. Table 1 Physio-Chemical Analysis of Drinking Water Samples Collected from Different Sources in Kandahar City. The physio-chemical analysis of drinking water samples collected within Kandahar city are shown in Table 1. The pH of the drinking water samples significantly varied from 6.3 to 8.0 and was found in alkaline range but slightly low in samples S3 and S7. This was due to mixing up of sewage water with drinking water pipeline which was under the desirable limit indicating water samples to be alkaline. In the present investigation, total dissolved solids (TDS) values ranged between 120 and 180 mg/l. The results obtained are in good agreement with Shivaraju (2011) and the range was within acceptable level. Total hardness (TH) values ranged from 43 to 88 mg/l and were within permissible limit. The concentration of TH values in the underground water samples around sewage treatment plant were slightly higher and had crossed the permissible limit The electric conductivity (EC) in levels of dissolved ionic substances in drinking water samples were within permissible limit and increased with the increase in calcium and magnesium level. The alkalinity of all water samples collected was slightly low. Present study shows allowable chloride contents in all samples. The concentration of iron (Fe) was below detection level (BDL); except S3 and S6 with 0.004 mg/l and 0.009 mg/l of iron respectively which was slightly higher. Alkalinity in natural waters is due to free hydroxyl ions and water with low alkalinity is more likely to be corrosive (Frank, 1987) and in the present study, level of alkalinity was found to be slightly low. The nitrate level in the present study was very low but ranged little higher in S3, S4 and S6 due to sewage discharge and turbidity in drinking water. The fluoride concentration was very low (0.2 mg/l) and negligible in all drinking water samples. Assessment of water samples from different localities in Kandahar city showed total bacterial count, a minimum of 2 CFU/ml in S7, S8 and a maximum of 32 CFU/ml in S1(Table 2). The total coliform bacteria ranged from 2 to 1600 MPN/100 ml in the collected water samples which exceeded when compared to the prescribed water quality standards in all samples except S7, S8 and S9. Fecal coliforms were present in all the samples except in S9. Raw water of the river showed fecal contamination of E. coli, K. pneumoniae, processed water with S. typhi and sewage mixed water with S. typhi, K. pneumoniae and C. freundii.

M. Statistical Analysis

Statistically, using Pearson’s correlation coefficient pH was found to be positively and significantly related to Fe (iron) and

EC (Electronic Conductivity), temperature was found to be significantly and positively related to MPN (most probable number), TDS (total dissolved solids) was found to be significantly and positively related to TH (total hardness), Cl (Chloride), Alk (alkalinity), NO3 (nitrate) and Fl (fluoride) whereas, TDS was negatively and significantly related to EC. TH was found to be significantly and positively related to Cl, Alk, NO3 and Fl and inversely or negatively related to EC. EC was found to be inversely and negatively and significantly related to Alk, NO3 and Fl. Cl was found to be positively and significantly related to Alk, No3, Fl and inversely and significantly related EC. Alkalinity was positively and significantly related to NO3 and Fl and NO3 was positively and significantly related to Fl. Rest of the combinations were not significantly related to each other (Table 3). Hierarchical agglomerative cluster analysis was performed on the normalized dataset. TH and MPN showed highest interrelationship among them (Fig. 2).

In this study, it is found that levels of total coliform and E. coli were much high in unprocessed river water, sewage contaminated drinking water and turbid drinking water. Further, the pattern of total coliform and E. coli in processed water were very low but not permissible.

V. CONCLUSION

The research work is an attempt to identify and assess different sources of contamination to drinking water. The physio-chemical analysis reveals the present status of drinking water quality is suitable for drinking purposes. Both physical and chemical quality falls within the standard limits of WHO standards. This indicates that the water of Kandahar city is suitable for drinking purposes.

REFERENCES

[1]. Budhlani, D. L., and Nagarnaik, P. (2011).Assessment of physico-chemical parameters of well water of kalmeshwar Town, Nagpur maharashtra (India). Current World Environment 6(1): 109-114.
[2]. Kausar, S., Asghar, K., Anwar, S. M., Shaukat, F., and Kausar, R. (2011).Factors affecting drinking water quality and human health at household level in Punjab, Pakistan. Statistics 100(600): 100.100.
[3]. Meybeck, M., and Helmer, R. (1996).An introduction to water quality. Water quality assessments, 2nd ed. Taylor & Francis, New York 122.
[4]. OCHA. (2015). Afghanistan: Population Estimate for 2015. Retrieved from http://www.refworld.org/pdfid/55eedf694.pdf
[5]. Daniels M, Scott T, Haggard B, Sharpley A & Daniel T, (2008). What is water quality? Agriculture and Natural resources, University of Arkansas, Division of Agriculture. FSA9528.
[6]. WHO, (2010). Water For Health, WHO Guidelines for Drinking-water Quality.
[7]. WHO, (2014). Water Sanitation Health, WHO Facts and figures on water quality and health, available online http://www.who.int/water_sanitation_health/facts_figures/en/
[8]. Budhlani D.L, Nagarnaik P.B. Assessment of Physico-chemical Parameters of Well Water of Kalmeshwar Town, Nagpur Maharashtra (India). Curr World Environ 2011:6(1);109-114.
[9]. Kausar S, Asghar K, Anwar S M, Shaukat F, and Kausar R, (2011). Factors Affecting Drinking Water Quality and Human Health at Household. Department of Sociology, University of Agriculture, Faisalabad-Pakistan. Pak. j. life soc. Sci. (2011), 9(1): 33-37
[10]. Meybeck. M and Helmer. R. (1996). An Introduction To Water Quality. In Deborah and Chapman (Eds.), Water Quality Assessments - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring - Second Edition (pp. 19-23). Great Britain at the University Press, Cambridge: UNESCO/WHO/UNEP.
[11]. Zajic. J.C.: Water Pollution Disposal and Re-use. Vol.1, MarelDekkar, Inc., New York (1971).
[12]. Shaji. C, Nimi. H, Bindu. L (2008). Water quality assessment of open wells in and around havara industrial area, Quilon, Kerala. Journal of Environmental Biology, 30(5):701-704.
[13]. Mohsin. M, Safdar. S, Faryal. A, Jamal. F (2013). Assessment of Drinking Water Quality and its Impact on Residents Health in Bahawalpur City, Pakistan. International Journal of Humanities and Social Science 3(15): 114-128.
[14]. WHO, (2011). Guidelines for drinking-water quality - 4th ed.). Geneva: World Health Organization.
[15]. Chapman. D and Kimstach. V. (1996). Selection of water quality variables. In Deborah and Chapman (Eds.), Water Quality Assessments - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring - Second Edition (pp. 82-83). Great Britain at the University Press, Cambridge: UNESCO/WHO/UNEP.
[16]. Sampson Mickey, (2008). Study of rope pump's impact on bacterial water quality of shallow hand dug wells in Kandal Province, Cambodia. RDI/IaW study.
[17]. World Health Organization (2004). Guidelines for Drinking-water Quality, World Health Organization, Geneva.
[18]. TambekarPratiksha, Morey Pravin, Batra. J R. and Weginwar G.R., (2012). Quality assessment of drinking water: A case study of Chandrapur District (M.S.). Journal of Chemical and Pharmaceutical Research, 2012, 4(5):2564-2570.

[19]. Rout Chadetrik and Sharma Arabinda, (2011). Assessment of drinking water quality: A case study of Ambala cantonment area, Haryana, India. INTERNATIONAL JOURNAL OF ENVIRONMENTAL SCIENCES 2(2), 2011: 933-945.

[20]. Ramakrishnaiah R. C., Sadashivaiah C. and Ranganna .G, (2008). Assessment of Water Quality Index for the Groundwater in Tumkur Taluk, Karnataka State, India. Research Scholar, Department of Civil Engineering, S.I.T, Tumkur-572103

[21]. 2WHO/Unicef, (2010). Rapid assessment of drinking-water quality in the federal democratic republic of Ethiopia. Country report of the pilot project implementation.

[22]. 1WHO/Unicef, (2010). Rapid assessment of drinking-water quality in the federal democratic republic of Nigeria. Country report of the pilot project implementation.

[23]. Adekunle I. M., Adetunji M. T., Gbadebo1 A. M., and Banjoko1 O. B., (2007). Assessment of Groundwater Quality in a Typical Rural Settlement in Southwest Nigeria. Int. J. Environ. Res. Public Health 2007, 4(4), 307-318.

[24]. Hoko Zvikomborero, (2005). An assessment of the water quality of drinking water in rural districts inn Zimbabwe. The case of Gokwe South, Nkayi, Lupane, and Mwenezi districts. Physics and Chemistry of the Earth 30 (2005) 859–866.

[25]. VölkerSebastian , Christiane Schreiber, and Thomas Kistemann, (2009). Drinking water quality in household supply infrastructure—A survey of the current situation in Germany. International Journal of Hygiene and Environmental Health 213 (2010) 204–209

[26]. Warner R. Nathaniel, Jonathan Levy, Karen Harpp& Frank Farruggia, (2006). Drinking water quality in Nepal's Kathmandu Valley: a survey and assessment of selected controlling site characteristics. Hydrogeology Journal (2008) 16: 321–334. DOI 10.1007/s10040-007-0238-1.

[27]. Shaji C., Nimi H. and Bindu L., (2008).Water quality assessment of open wells in and around Chavara industrial area, Quilon, Kerala. Journal of Environmental Biology 30(5):701-704 (2009).

[28]. WHO. (1984). Guidelines for Drinking Water Quality. Health Criteria and Other Supporting Information, Vol. 2, Geneva: World Health Organization (WHO).

[29]. WHO. (1996). Guidelines for Drinking Water Quality. Recommendation, Vol. 1, Geneva: World Health Organization (WHO).

[30]. USGS: United States Geological Survey, (2014). The Water in you, The USGS water science school, available online on http://water.usgs.gov/edu/propertyyou.html.

[31]. MRRD, Provincial Profiles. Regional rural economic regeneration assessment and strategies study. National Area Base Development Program. Ministry of Rural Rehabilitation and Development. Islamic Republic of Afghanistan, 2006.