BioChemMed

Technium BioChemMed Vol. 2, Issue 2 pp.86-98 (2021)
ISSN: 2734-7990
www.techniumscience.com

Determining the Physical and Chemical Characteristics of Groundwater in 4th District of Kabul City, Afghanistan: A cross-sectional study

Fahima Sharifi[1]
Mohibullah Salih[2*]
Department of Chemistry, Kabul University of Medical Sciences, Kabul, Afghanistan
Department of Microbiology, Kabul University of Medical Sciences, Kabul, Afghanistan

*Correspondent author: Mohibullah Salih, Department of Microbiology, Kabul University of Medical Sciences, University Road, Ali Abad, Jamaal Mina, Kabul, 1001 Afghanistan; Phone: +93744388367; Email address: mohibullahsalih786786@gmail.com

Abstract

Introduction: The 4th district is one of the most populated residential and commercial areas of the Kabul city. This increase in population has created many problems both in terms of environmental protection and drinking-water supply. In addition, the increase in construction of low quality buildings on planned and unplanned areas, excavation of deep or semi-deep wells, and the absence of proper sewage recycling systems have negative effects on the quality of drinking-water. The results of quantitative and qualitative researches on drinking or wholesome water show that the physical and chemical parameters such as electrical conductivity, turbidity, pH, Cl, and total hardness of deep-wells water in the district of Kabul does meet the WHO and ANSA standards and have almost better quality. However, most samples of the semi-deep water wells in 4th district of Kabul city do not match the WHO and ANSA standards. Thus, the presence of dissolved elements such as calcium, chlorine, and magnesium in drinking water resources show that the drinking-water of some of the mentioned areas do not have good quality which can cause environmental and health problems. This study is aimed on the assessment and determination of physical and chemical characteristics of drinking groundwater in different parts of the 4th district of Kabul city, Afghanistan.

Method: An observational cross-sectional study was conducted over a period of two-month from April the first to June the 6, 2021 in different parts of the 4th district of Kabul city, Afghanistan. A total of 64 samples were collected. The data was entered and analyzed using SPSS 26. Frequencies and percentages were calculated for variables. Minimum, maximum, mean and standard deviation were calculated for continuous variables.

Results: A total of 64 water samples (32 samples from deep & 32 samples form shallow wells) were collected from the 4th district of Kabul city, Afghanistan. The physical and chemical parameters, in shallow wells in 17 samples (53%) were normal and in 15 samples (47%) were found in abnormal ranges according to WHO and ANSA standards. In deep-water wells, the physical and chemical parameters in 27 Samples (84%) were normal and in 5 samples (16%) were found and calculated in abnormal ranges.

Keywords: determining, groundwater, drinking-water, physical and chemical, characteristics, chemical elements, Afghanistan standards.

Technium BioChemMed Vol. 2, Issue 2 pp.86-98 (2021)
ISSN: 2734-7990
www.techniumscience.com

Introduction

Water is part of the life of all living beings. Drinking water, in addition to providing water required for the body, also contains minerals and other essential elements, the deficiency, and increase of which can cause various problems and diseases [1]. i.e., the decrease and increase in the amount of fluoride can result in tooth decay and sclerosis [2, 3]. Drinking water is water that is devoid of any kind of physical or chemical contaminant and radioactive radiation and is not harmful to consumers [4]. Due to the presence of chemical solutions in water, water is classified as hard and soft water. The presence of such chemical elements solutions in water is very harmful to human health and is not safe to drink [5]. Likewise, excessive calcium and magnesium consumption can also increase the risk of high blood pressure, stroke, cardiovascular disease, and obesity [1]. Therefore, studying the concentration of physical-chemical parameters of groundwater is the most efficient method for its consumption. The increase in droughts and decrease in groundwater levels results in alteration of the physical-chemical qualities of water [6]. physical-chemical parameters change as water passes through different layers of the earth which consequently results in climate change. In the lower layers of the earth, different layers of rocks can change the quality of groundwater [7]. Groundwater quality protection is a major global concern that has always been researched by reputable scientific organizations such as the WHO [8]. In general, groundwater contamination is divided into natural and unnatural categories. The quality of groundwater is divided into 3 types, which consist of chemical, physical, and microbial parameters [9, 10]. After measuring the chemical ions of suspended particles and physical parameters such as color, turbidity, odor, taste, PH, EC, and microbial test of water, the obtained results are compared with the standards of the World Health Organization and thus, the suitability of water for drinking and other uses is found [11]. The city of Kabul as a result of overpopulation is at a low level in terms of drinking water supply. In most places, although deep wells have been drilled by government authorities in the last four decades, they still do not meet the needs of citizens. Although in recent years, deep wells have been dug by people in a non-standard way, which has caused serious problems for the residents of this large city [12].

In 2015, all UN member countries adopted the SDGs objectives for Sustainable Development. SDG acts as a global call to end poverty and aims to protect planet earth and ensures that all people would achieve peace and prosperity by the year 2030. SDGs other goals include improving public health, reducing poverty, hunger and improving other plans of related environmental systems and vice versa [12]. Thus, consider the development goals within SDGs by considering broad societal, economical, and environmental goals [13]. Access to universal sustainability in a community according to the World Health Organization (WHO) in 2015, nearly 1.8663 billion people in the world will be exposed to unclean drinking water resources. Millions of people who use unclean drinking water resources face serious challenges [14]. In general, the development of drinking water due to lower layers is generally related to increased population, high levels of migration, urbanization, poor infrastructure, and the effects of changing environmental conditions especially climate change which the governments and scientists, and the international community are attentive towards. Groundwater quantity and quality are often deteriorating and threatens the lives of millions of people [15, 16]. Similar processes for the Kabul Basin in Afghanistan emphasize that high concentrations of chemical parameters pollute groundwater. Authorities in Afghanistan plan to reach SDGs by 2030 [17].

Technium BioChemMed Vol. 2, Issue 2 pp.86-98 (2021)
ISSN: 2734-7990
www.techniumscience.com

This research is designed to assess the quality of drinking water used by Kabul residents. The aim is not just to identify the problems related to water quality but also to identify wells study of which can help to evaluate the quality of drinking water not only in Kabul but also in the Central Asian region [18]. Perhaps due to poor condition of infrastructure with mixed resources, water supply and sanitation are poor. The present study focuses on the quality of drinking water [19, 20]. The 4th district of Kabul city is one of the most densely populated areas of the city with more than 323,000 population and 21 passages. The sources of drinking water supply in this area are semi-deep and deep water wells, most of which have been already excavated. With the above mentioned, water supply and effective parameters of water quality have also undergone changes in this area which will be studied in this study. The type of research depends on water resources, drinking water supply, and physical-chemical parameters of water. Sampling from semi-deep wells is performed by observation, analysis, and descriptive methods. Based on the statistics taken from District 4 of Kabul city, the total number of semi-deep and deep wells was determined using the following hypotheses. The average population of a family of 5 is a central number of 64,600 families. On average, three families live in one house, so the total number of families is 21533. It is estimated that all three houses share a semi-deep or deep well. Therefore, the total number of semi-deep wells is 7,177. According to WHO statistics, for every 5,000 people, a sample of 323,000 people in the target area is taken directly according to the sampling methods.

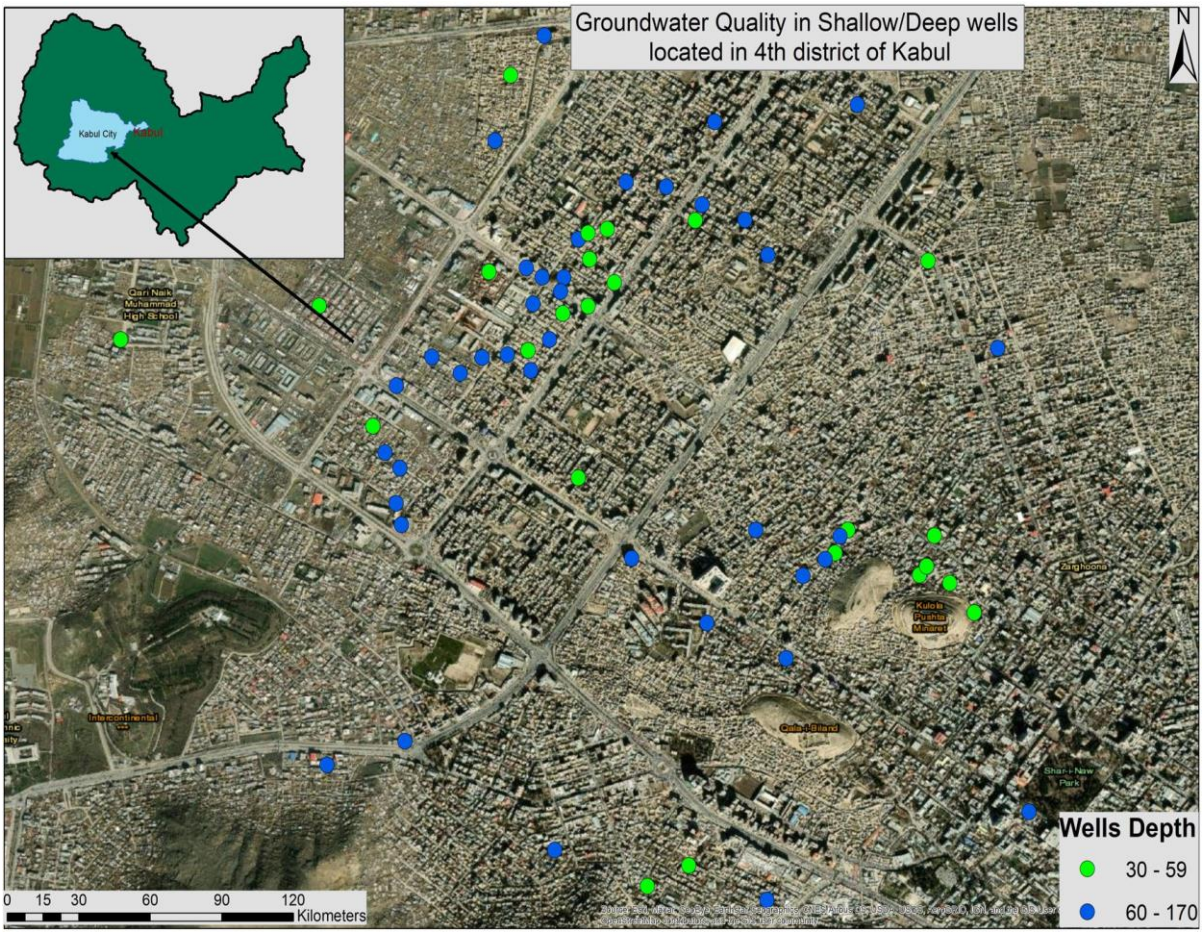

Figure 1*: geographical location shows the depth (deep and shallow) of wells located in the 4th district of Kabul Afghanistan.*

Technium BioChemMed Vol. 2, Issue 2 pp.86-98 (2021)
ISSN: 2734-7990
www.techniumscience.com

Methods and materials

We conducted an observational cross-sectional study from April the first to June the 6th, 2021 in different parts of the 4th district of Kabul city, for determination and quantitative analysis of physical and chemical parameters of drinking water. Regarding chemical norm, a total of 64 water samples (32 from deep-wells, 32 from shallow-wells) were practically collected in the study area in bottles drilled from the well by measuring and positioning its geographical location at the sampling site. The required tools for the study included polyethylene sterilized bottles with a volume of around 500-600 ml, EUTECH Con510 field test machine, turbidity meter, and meter pH, 6000 PH, EUTECH Cyber scan, alcohol, cotton, labels, markers, sampling forms, and coal boxes which were used from the 4th district laboratory. Before collecting samples, the bottles were cleaned with alcohol and cotton, run the water for 2 minutes and rinsed the bottle three times with the source water and filled the bottles with enough water to leave some air gap in the bottle so that the water is mixed easily inside the bottle. Then, all the specifications were entered in the sampling form. The physical tests were performed in the area (we did not perform the EC and PH tests in water because the probability of dissolving 1KC of water under test is off pH Meter electrode). Then we transferred the sample bottles to the laboratory for analyzing chemical parameters. i.e., determination of total hardness (TH), Mg, Cl, and Ca in the laboratory using EDTA ergonometric method titration [21]. The retrieved data from samples analysis was entered and analyzed using SPSS 26. Frequencies and percentages were calculated for variables. Minimum, maximum, mean and standard deviation were calculated for continuous variables.

Results

The research results from shallow and deep-wells water have shown the duality of quality in the physical and chemical parameters of water. The results of this study are summarized and illustrated in the following figures and tables:

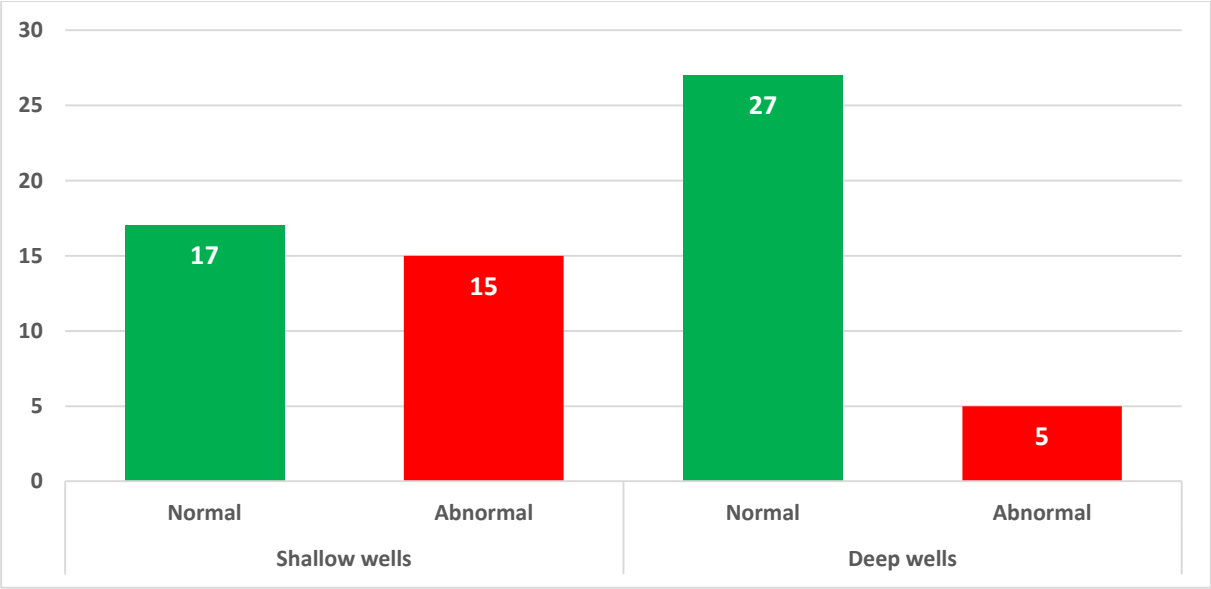

***Figure 2**: Depicts the numbers of normal and abnormal samples from shallow and deep-wells waters concerning physical and chemical characteristics.*

Technium BioChemMed Vol. 2, Issue 2 pp.86-98 (2021)
ISSN: 2734-7990
www.techniumscience.com

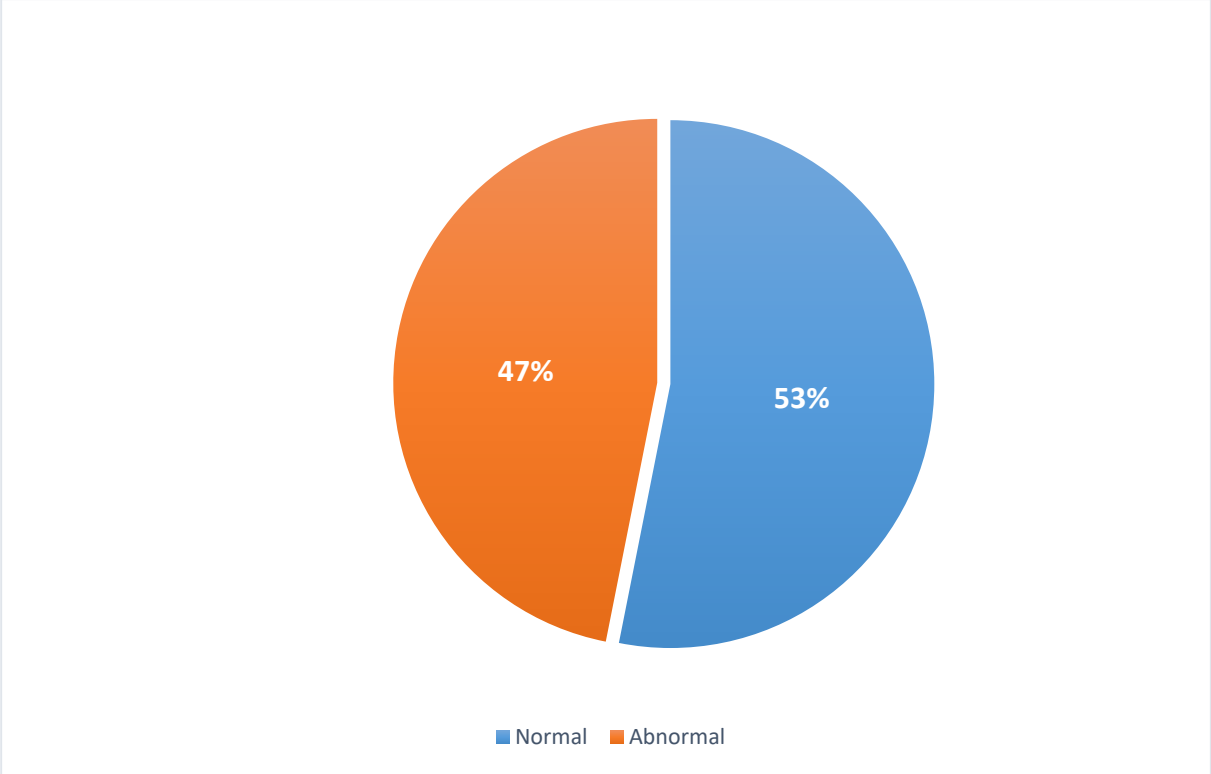

***Figure 3**: Illustrates groundwater quality in shallow-wells located in the 4th district of Kabul concerning the concentration of Ca, Mg, Cl and total hardness, as per Afghanistan standards.*

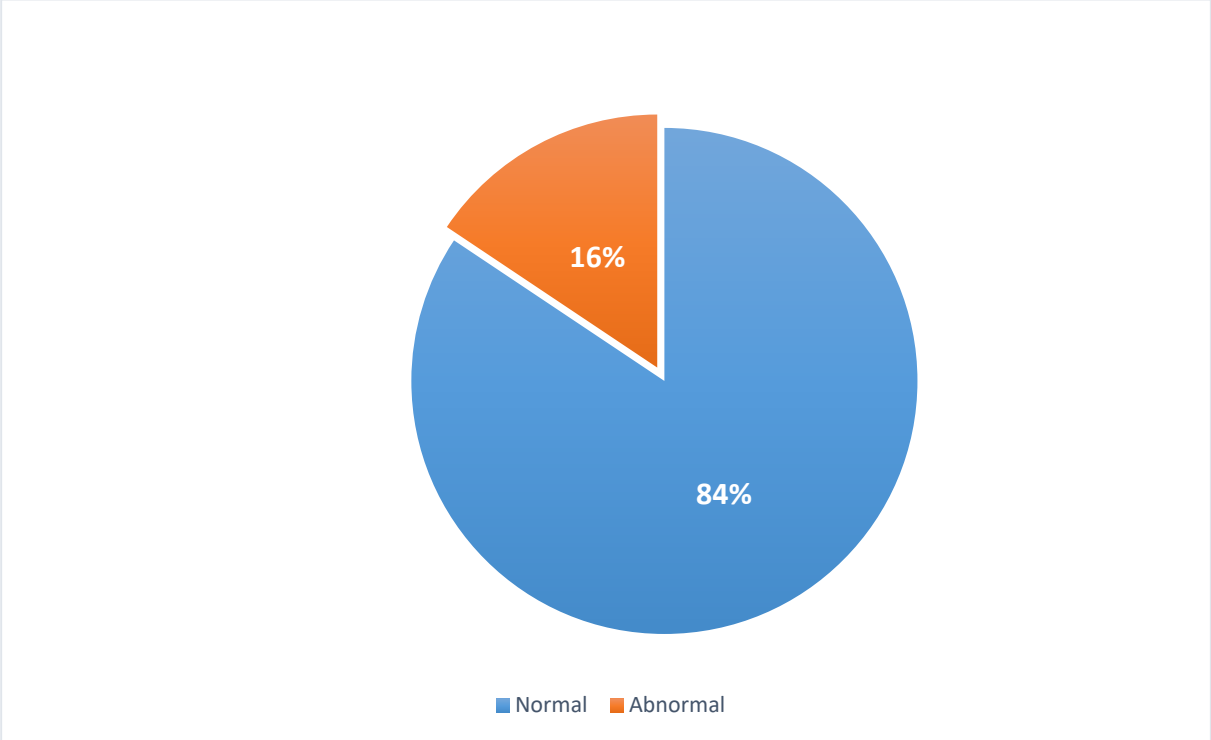

***Figure 4**: Illustrates groundwater quality in deep-wells located in the 4th district of Kabul concerning the level of Ca, Mg, Cl and total hardness, as per Afghanistan standards.*

Technium BioChemMed Vol. 2, Issue 2 pp.86-98 (2021)
ISSN: 2734-7990
www.techniumscience.com

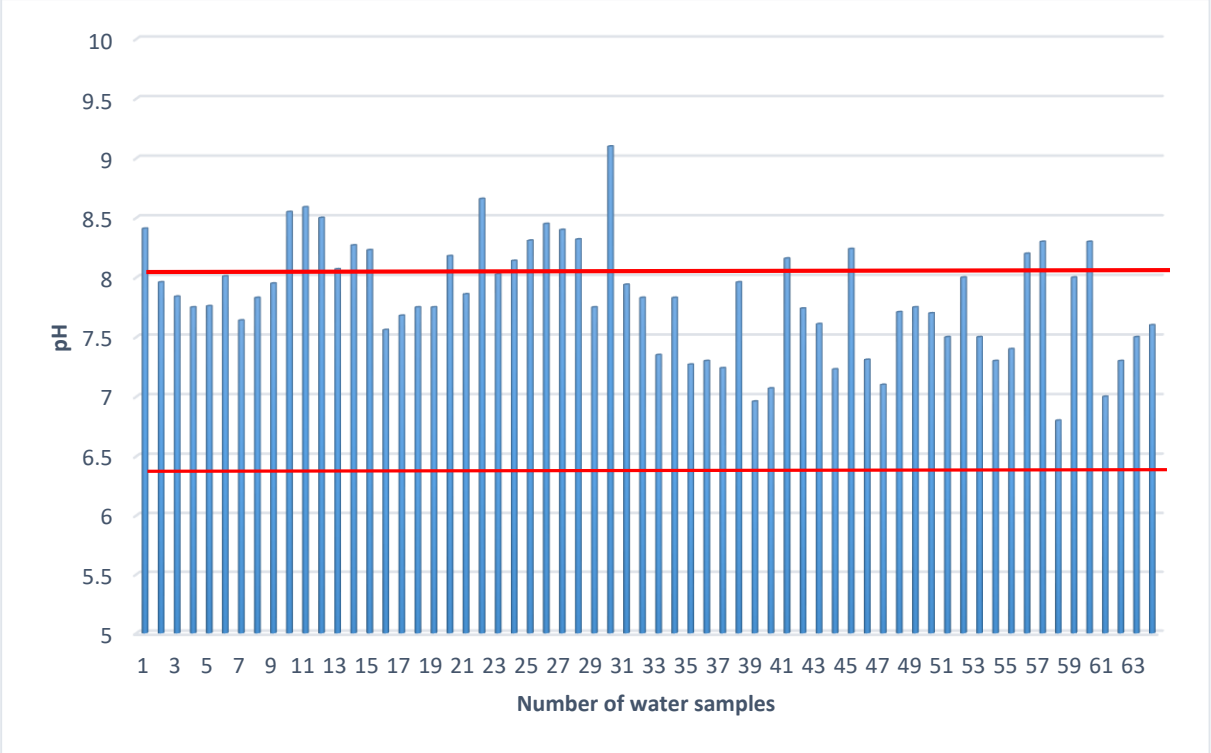

***Figure 5**: depicted the pH levels in 64 samples collected from 4th district of Kabul city*

.

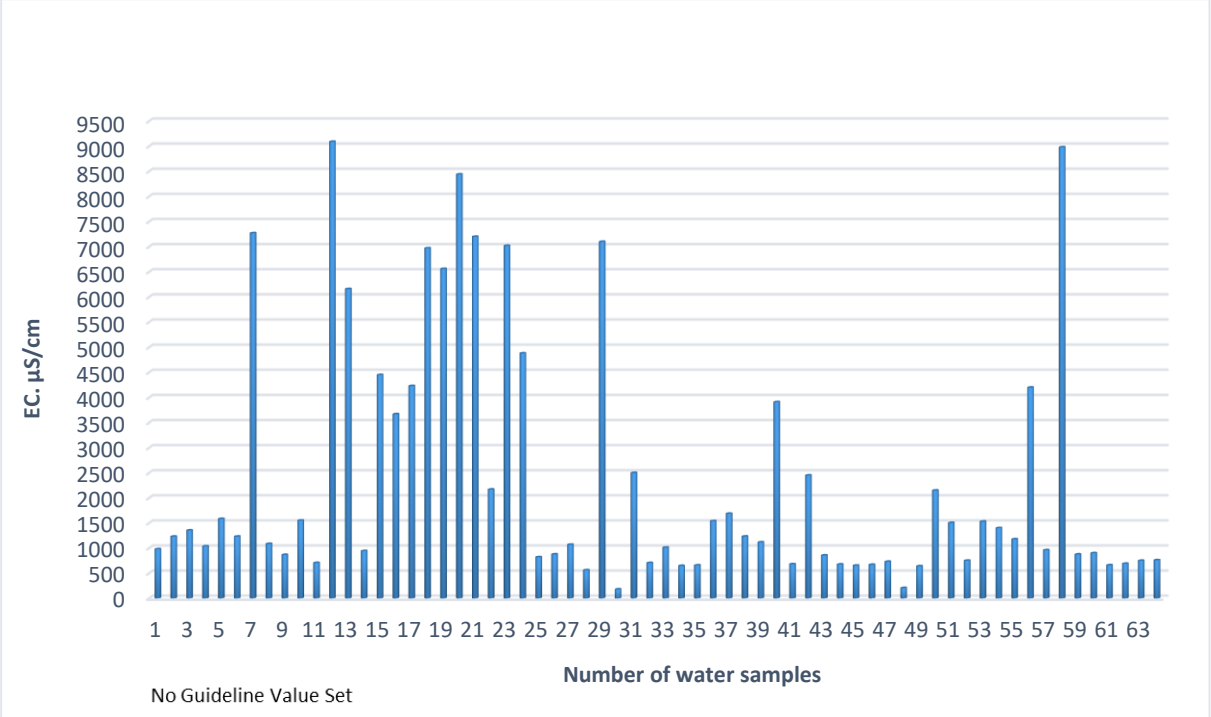

***Figure 6**: Depicted electrical conductivity µS/cm in 64 water samples collected from 4th district of Kabul, Afghanistan.*

Technium BioChemMed Vol. 2, Issue 2 pp.86-98 (2021)
ISSN: 2734-7990
www.techniumscience.com

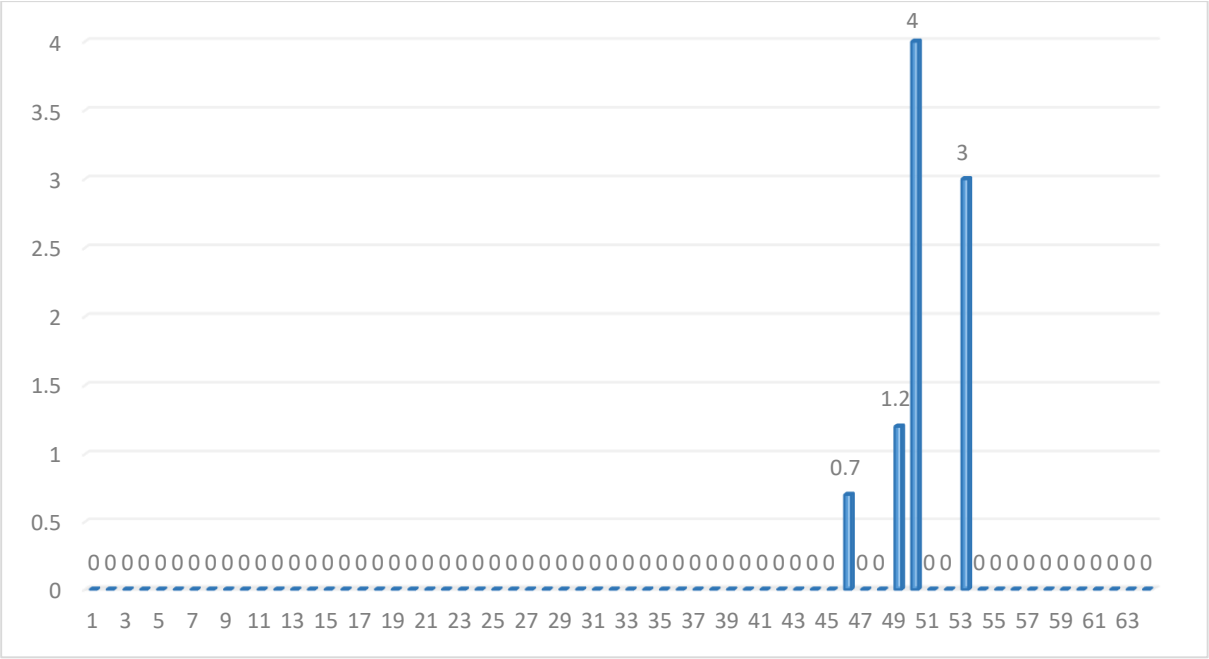

***Figure 7**: illustrated the turbidity NTU in a total of 64 samples collected from 4th district of Kabul.*

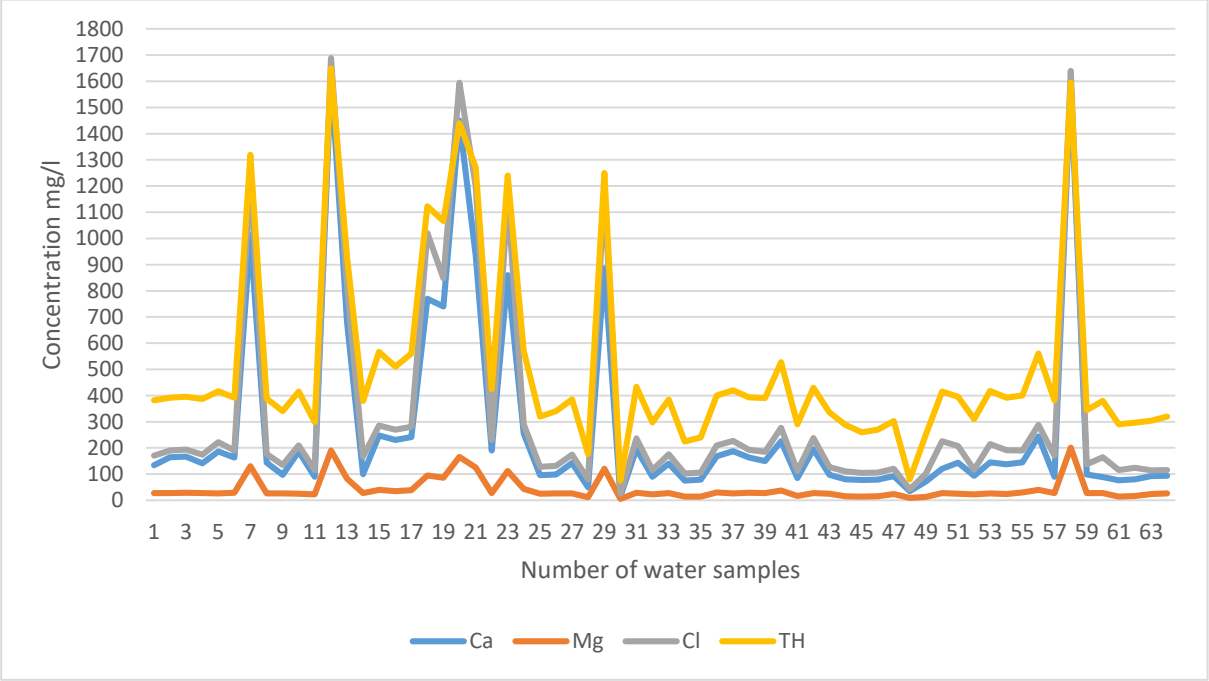

***Figure 8**: illustrated the concentration of Ca, Mg, Cl & Total hardness in 64 samples of water collected from 4th district of Kabul city.*

***Table 1**: Determining percentage and number of normal and abnormal samples of physical and chemical parameters in semi-deep wells.*

Parameters	Normal		Abnormal		Total	
	Frequency	Percent (%)	Frequency	Percent(%)	Frequency	Percent
PH	30	93.8	2	6.3	32	100
TURBIDITY	32	100	0	0	32	100
Ca	1	3.1	31	96.9	32	100
Mg	18	56.3	14	43.8	32	100
Cl	18	56.3	14	43.8	32	100
TH	18	56.3	14	43.8	32	100

***Table 2**: Determining Percentage and Number of Normal and Abnormal samples of Physical and Chemical Parameters in deep-wells.*

Parameters	Normal		Abnormal		Total	
	Frequency	Percent (%)	Frequency	Percent(%)	Frequency	Percent
PH	29	90.6	3	9.4	32	100
TURBIDITY	32	100	0	0	32	100
Ca	4	12.5	28	87.5	32	100
Mg	30	93.8	2	6.3	32	100
Cl	30	93.8	2	6.3	32	100
TH	30	93.8	2	6.3	32	100

***Table 3:** Physiochemical Parameters of Shallow Groundwater Samples*

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Ph	32	6.80	8.70	7.7338	.48204
EC	32	206.00	9090.00	3531.5313	2992.60165
TEM	32	17.00	23.20	18.1281	1.64851
TURB.NET	32	.00	3.00	.1156	.54067
Ca	32	35.00	1622.00	430.7188	474.39532
Mg	32	9.00	201.00	58.5312	54.90284
Cl	32	42.00	1689.00	512.7813	527.76569
TH	32	80.00	3020.00	718.4375	607.15109
Valid N (listwise)	32				

***Table 4**: Physiochemical Parameters of deep Groundwater Samples*

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
PH	32	7.07	9.10	7.9547	.45928
EC	32	179.00	3910.00	1191.5625	818.48936
TEM	32	17.00	23.00	18.0406	1.47907
TURB.NTU	32	.00	4.00	.1625	.73166
Ca	32	15.00	230.00	120.7313	49.21082
Mg	32	6.00	37.00	24.4531	6.66561
Cl	32	25.00	277.00	158.3125	55.32525
TH	32	75.00	528.00	347.9375	89.74118
Valid N (listwise)	32				

NB: EC (Electrical Conductivity), TH (Total Hardness)

As illustrated in above figures and tables, in 32 samples of semi-deep water wells, the physical parameter of pH was normal in 30 samples (93.8%) and abnormal in 2 samples (6.3%). Turbidity was 100% in 32 normal samples and 0% in abnormal samples. The chemical parameters in 32 samples of semi-deep water wells; Ca in 1 normal sample is 3.1% and in 31 abnormal samples is 96.9%. In 18 normal samples, Mg, TH, and Cl is 56.3% and in 14 abnormal samples 43.8%. In 32 samples of deep water wells, the pH in 29 normal samples is 90.6% and 9.4% in 3 abnormal samples. The Turbidity in 32 normal samples is 100% and 0% in abnormal samples. In 32 samples of deep water wells, the chemical parameter of Ca in 4 normal samples is 12.5% and 87.5% in 28 abnormal samples. In 30 normal samples, Cl, Mg, and TH is 93.8% and in 2 abnormal samples it is 6.3%. In the above mentioned parameters, the normal samples are in accordance with the WHO and ANSA standards but the abnormal samples are not in accordance with the WHO or ANSA standards.

PHYSICALPARAMETERS				
Properties/ Parameters	**Standard values for Afghanistan***	**WHO guidelines 2011**	**National Standard of most Asian countries**	**Remarks**
PH	6.5 – 8.5	NGVS	6.5 – 8.5	-
Turbidity	5 NTU	NGVS	5 NTU	-
Total hardness as CaCO3	500 mg/l	NGVS	500 mg/l	Permissible limit in the absence of alternate water source can rise up to 600 mg/l.
CHEMICAL PARAMETERS				
Chloride	250	NGVS	250	Permissible limit in the absence of alternate water source can rise up to 1000mg/l.
Magnesium	30	NGVS	30	Permissible limit in the absence of alternate water source can rise up to 100 mg/l.
Calcium	75	NGVS	75	Permissible limit in the absence of alternate water source can rise up to 200 mg/l.

Technium BioChemMed Vol. 2, Issue 2 pp.86-98 (2021)
ISSN: 2734-7990
www.techniumscience.com

From the results of the analysis of chemical parameters in terms of average and percentage values from table 1, 2, 3 and 4, we can say that the amount of Ca, Mg, Cl, and TH in semi-deep well water samples in district 4 of Kabul city was higher than WHO and ANSA standards. Due to the importance of the issue, most of the water in these areas is not of good quality, which can cause health and the environmental problems to the residents of these areas. However, the Ca, Cl, Mg, TH, PH, EC, turbidity parameters except for Ca of deep wells water in district 4 are in accordance with the WHO and ANSA standards, and based on the mentioned parameters, they are of good quality and can be used by its residents.

Discussion

The results of the analysis of chemical and physical parameters mentioned in the previous tables collected from semi-deep wells water in 32 samples, 18 of them are in accordance with the WHO and ANSA standards and 14 samples do not meet the standard. Moreover, in 32 samples of deep wells water of the parameters mentioned in the tables, 30 samples are in accordance with the WHO, ANSA standards and 2 samples do not meet the standard. As a result, based on the evaluation of this study which was conducted in deep and semi-deep wells water in District 4 of Kabul city in 64 samples, we found that deep wells water was of better quality than semi-deep wells water. The non-compliance of the samples with the standard is because of the presence of different chemical elements in different layers of the earth, which occurs during the passage of water through these layers. Chemical elements are dissolved in groundwater where their concentration increases even more. Therefore, based on the above data set, it was concluded that the study of water quality parameters is of great importance in the study of water resources. A relatively large positive correlation between some chemical and physical parameters indicates the common origin or the gradual enrichment of both parameters. In addition, the relatively large technical correlation between some chemical and physical parameters shows evidence of groundwater contamination resulted from human activities.

Conclusion

Water is a pivotal element of human life. Drinking water must contain standard physical and chemical parameters recommended by WHO and UNICEF. Any increase or decrease of physical and chemical parameters can raise environmental and health issues. The 4th district of Kabul city considering its population density, is at a low level in terms of drinking water supply which have been created health problems for its residents. Drilling of deep wells should be done in a scientific and standard way and hygienic maintenance around the well should also be considered. Proper disposal and recycling of sewage is highly recommended.

Limitations

The relevant laboratories provided the context for only 64 samples, most of which are limited due to the lack of chemical materials. To overcome this limitation, water sampling should be done accurately in the area by assessing the situation.

Strength

Coordinating the sampling plan with people who have the required knowledge about the area so that the sampler is assured of residential areas and private neighborhoods. In district 4 areas of Kabul city, access to the mentioned areas of the district is possible only with:

Technium BioChemMed Vol. 2, Issue 2 pp.86-98 (2021)
ISSN: 2734-7990
www.techniumscience.com

cooperation of the district directory, local deputy, water supply of Kabul city, and the performing laboratory work in the ministry of rural rehabilitation and development.

Authors contribution

F.S drafted the manuscript, collecting and analyzing the data. M.S developed methodology, prepared a structured abstract, designed and intensively reviewed the manuscript for linguistic and grammatical errors, reference managing and respondent to reviewer's comments.

Conflict of interests

The authors declared that there is no conflict of interests as every authors take part voluntarily in this study.

Technium BioChemMed Vol. 2, Issue 2 pp.86-98 (2021)
ISSN: 2734-7990
www.techniumscience.com

References

1. Sengupta, P., *Potential health impacts of hard water.* International journal of preventive medicine, 2013. **4**(8): p. 866.
2. Yari, A., et al., *The physical, chemical and microbial quality of treated water in Qom's desalination plants.* 2007.
3. Miranzadeh, M.B. and D.K. Rabbani, *Chemical quality evaluation for the inlet and outlet water taken from of the desalination plants utilized in Kashan during 2008.* Kaums Journal (FEYZ), 2010. **14**(2): p. 120-125.
4. Organization, W.H., *Drinking-Water-Fact Sheet No. 391; 2015*. 2015.
5. Engebretsen, K.A., et al., *Prevalence of atopic dermatitis in infants by domestic water hardness and season of birth: cohort study.* Journal of Allergy and Clinical Immunology, 2017. **139**(5): p. 1568-1574. e1.
6. Bruckmann, J. and C. Clauser, *Ensemble-based stochastic permeability and flow simulation of a sparsely sampled hard-rock aquifer supported by high performance computing.* Hydrogeol. J, 2020.
7. Maples, S.R., G.E. Fogg, and R.M. Maxwell, *Modeling managed aquifer recharge processes in a highly heterogeneous, semi-confined aquifer system.* Hydrogeology Journal, 2019. **27**(8): p. 2869-2888.
8. Bastani, M. and T. Harter, *Effects of upscaling temporal resolution of groundwater flow and transport boundary conditions on the performance of nitrate-transport models at the regional management scale.* Hydrogeology Journal, 2020: p. 1-24.
9. Apollaro, C., et al., *Release and fate of Cr (VI) in the ophiolitic aquifers of Italy: the role of Fe (III) as a potential oxidant of Cr (III) supported by reaction path modelling.* Science of the Total Environment, 2019. **660**: p. 1459-1471.
10. Critelli, T., et al., *Dissolution rates of actinolite and chlorite from a whole-rock experimental study of metabasalt dissolution from 2≤ pH≤ 12 at 25 C.* Chemical geology, 2014. **390**: p. 100-108.
11. Batabyal, A.K. and S. Chakraborty, *Hydrogeochemistry and water quality index in the assessment of groundwater quality for drinking uses.* Water Environment Research, 2015. **87**(7): p. 607-617.
12. Jawadi, H.A., J. Sagin, and D.D. Snow, *A detailed assessment of groundwater quality in the Kabul Basin, Afghanistan, and suitability for future development.* Water, 2020. **12**(10): p. 2890.
13. Ait-Kadi, M., *Water for development and development for water: realizing the sustainable development goals (SDGs) vision.* Aquatic Procedia, 2016. **6**: p. 106-110.
14. WHO, U., *Progress on Drinking Water and Saniation: Joint Monitoring Program 2014 Update.* Geneva/New york: World Health Organisation and United Nations International Children's Fund, 2014.
15. Mubarak, M.Y., *Drinking water safety and sanitation in relation to diarrheal diseases in under-developed areas of District 5, Kabul, Afghanistan*, 2012. **61**: p. 483-484.
16. Bain, R., et al., *Fecal contamination of drinking-water in low-and middle-income countries: a systematic review and meta-analysis.* PLoS Med, 2014. **11**(5): p. e1001644.
17. Houben, G., et al., *Hydrogeology of the Kabul Basin (Afghanistan), part II: groundwater geochemistry.* Hydrogeology journal, 2009. **17**(4): p. 935-948.
18. Zaryab, A., et al., *Assessment of Water Quality and Quantity trends in Kabul Aquifers with an outline for future water supplies.* Central Asian Journal of Water Research (CAJWR) Центральноазиатский журнал исследований водных ресурсов, 2017. **3**(2): p. 1925.
19. Schmoll, O., et al., *Protecting groundwater for health: managing the quality of drinking-water sources*. 2006: World Health Organization.

Technium BioChemMed Vol. 2, Issue 2 pp.86-98 (2021)
ISSN: 2734-7990
www.techniumscience.com

20. Racho, P. and K. Namseethan. *Hardness removal from water by modified starch*. in *Materials Science Forum*. 2017. Trans Tech Publ.
21. Association, A.P.H., *APHA (1998) Standard methods for the examination of water and wastewater.* American Public Health Association, American Water Works association, Water Environment Federation, Washington.