International Journal of Earth Sciences Knowledge and Applications
journal homepage: http://www.ijeska.com/index.php/ijeska

Research Article e-ISSN: 2687-5993

Study of Physicochemical Properties of Soil at Qargha Dam Areas in Paghman District, Kabul, Afghanistan

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INFORMATION

Article history
Received 24 June 2023
Revised 08 August 2023
Accepted 09 August 2023

Keywords
Soil
Physiochemical
Soil fraction
Geology
Loam

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ABSTRACT

We report our results of the soil research carried out and aimed at the soil around the Qargha areas in the Paghman district, province of Kabul, Afghanistan. For this investigation, we used dissimilar soil samples from the Qargha Dam areas. The samples consist of six different profiles and after extraction, the samples were carefully transported to our research laboratory for analysis. One of the objectives of this study is to identify and profile such areas in terms of their physical and chemical properties and draw any correlation with earlier geological periods of Qargha around Areas. The portions of the dam reservoir are situated at different widths of stratigraphy and hence discharge into dry Rivers during the snow-melting seasons. Normally during years of extra precipitation, the thickness of soil layers varies in size, however, during years of drought the thickness of layers is thin. Since the 1980s, we have not observed noticeable precipitation and snow melting, primarily due to climate change and its impact on Afghanistan. The aquifers, therefore, consist of different sizes of sediments, and in the dam reservoir, we find different sizes of clay, silt and sand, granules. During this investigation, we profiled different formations of stratigraphy consisting of different layers like sand, silty clay, gravel, sand, clayey loam, loam, and silty clay, gravel. Overall, the profiles consist of larger and smaller sizes of sediments, but such profile consists mostly of fine materials, such as clay, silts, and sands. With associated physico-chemical characteristics, such as pH, electro-conductivity, and elemental composition of the soil, this research is, therefore, crucial to study the different profiles, and hydrological patterns in the Paghman district, due to a lack of previously available literature.

1. Introduction

Qargha is a dam and reservoir about 15 kilometers west of Qargha near Kabul, the capital. Qargha Dam was built in 1951 and is located and serves the Paghman district and its surrounding areas (Abdullah and Chmyriov, 1997). The dam has a capacity of 12 million cubic meters of water and has been working as a source of water for the whole town and is the best source of hydroelectricity for the country. Unfortunately, the dam was partially destroyed during the war. The reservoir is made of impermeable soil and the dam has a control tower where there are three gates, and the dam is adjusted through these gates. Sediments are transported from the Paghman mountain range by floods and surface streams during snow-melting seasons and are accumulated in the basin, which consists of different types of layers and terraces (Avouac and Burov, 1996). The sediments of the Qargha Dam pertain to the lower Quaternary (Pleistocene) and occur in different sizes of layers (Banks and Soldal, 2002). The sediments arise directly from the surrounding mountains and are transported at different times during the snow-melting seasons (Bohannon, 2005). Generally, the geology of Qargha relates to the mountains' mother rocks which are weathered over time by physical weathering and are transported by streams (Bohannon and Turner, 2007).

The surrounding mountains of this basin consist of Gneiss, Schist, and Granite conglomerates (Böckh, 1971). From the gravel analysis method, we can find different sizes of gravels of Gneiss, Granite, Schist, Quartzite, and conglomerates (Rasouli, 2019; Broshears, et al., 2005). The mountains of this basin are located to the north and northeast of this basin, and they intersect from southwest to northeast (Japan International Cooperation Agency (JICA, 2007).

It is well known that in Afghanistan, there have been almost 30 years of continuous drought, resulting in reduced precipitation and its adverse impact on surface and groundwater (Koons, 1989; Rasouli et al., 2023b). In this study, we have compared the water volume in Qargha Dam from 2013 to 2022. As we view the reservoir of Qargha Dam (Fig. 1), we find different volumes of water in this reservoir (Lave1 and Avouac, 2001). We further find that there was more volume of water in 2022 and a lower volume in 2021 (Malgary, 1987). We compared the soil layers at different depths (cross sections or stratigraphy) for profiling and we determined that in 2022, due to drought conditions during that period, the layers of soil were very thin. This is consistent with the observation that during ongoing drought the layers are generally this, as compared to 20 years earlier when the layers of soil were thick (Molnar, 1990; Rasouli, 2020b). Furthermore, corresponding to the thickness of layers, for a thicker layer the particles size is larger since it is due to the higher velocity of streams, as high velocity generally transports larger sizes, but when the layers of soil are thin, we determine that the smaller sizes of particles, would be transported in dry years due to the slow streams velocity, which only carries smaller sizes which make thin layers (Rasouli, et al., 2023a; Montgomery, 1994).

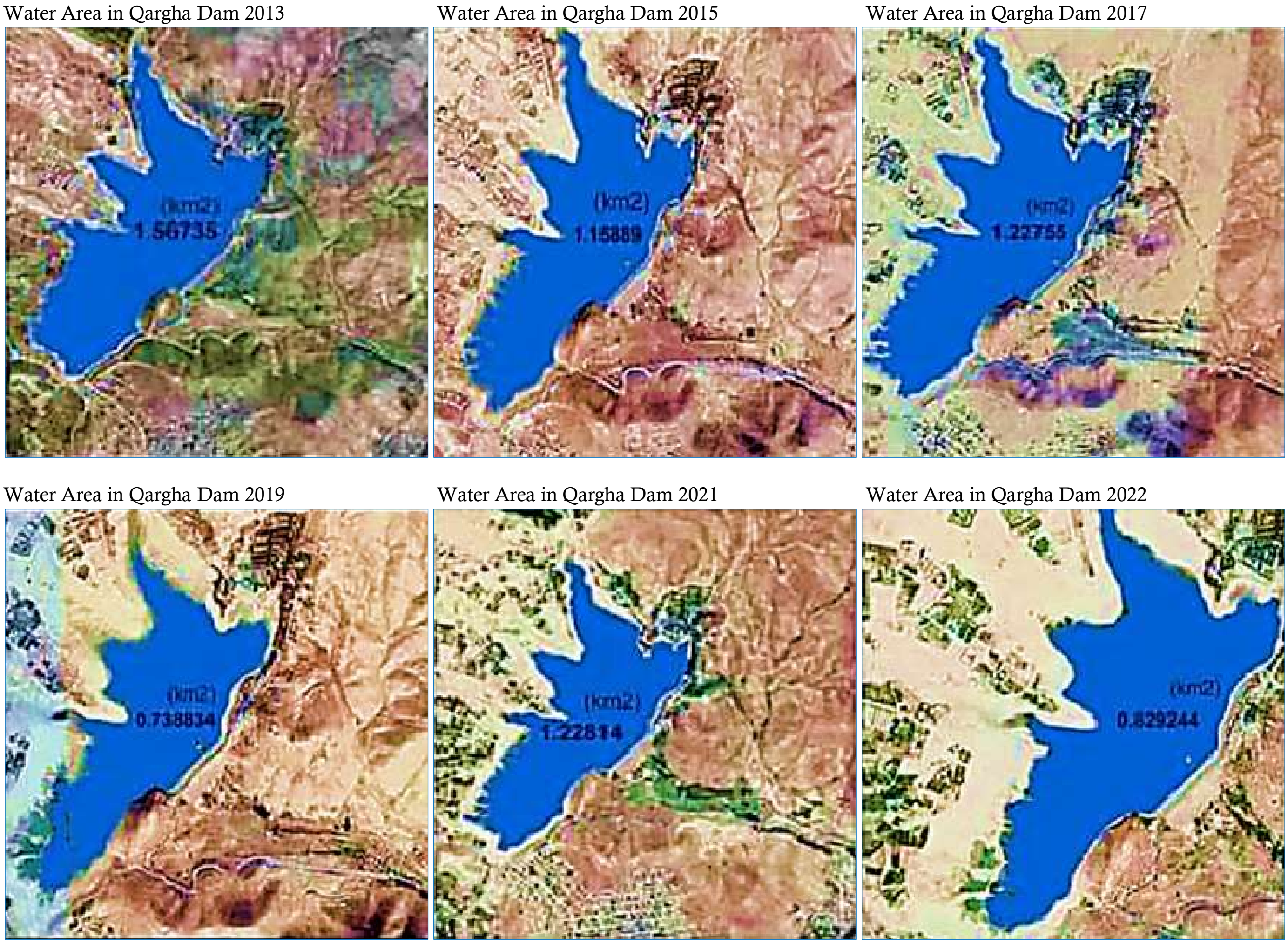

Fig. 1. The volume of water from 2013-2022 at the Qargha Dam and its direct effects on the transportation of sediments

The Qargha Sedimentary Basin is located on the west side of Kabul and covers an area of 15 km^2 (Munsell, 1999; Rasouli, 2015; Rasouli, 2021). In this basin, all regolith and sediments are transported from different points of the Paghman mountain range by sudden floods and it's accumulated at different thicknesses in different locations of this basin (Paetzold et al., 2005; Shamal and Rasouli, 2018). The Paghman and Qargha Dam areas basins date back to the Quaternary (Pleistocene) and Neogene geological periods with different sizes of sediments deposited over a period of time and also consist of different types of morphology. The varying sizes of these sediments can be observed at different levels (Nakata, 1972; Myslil et al., 1982). The type of sediment in this basin is directly related to the type of rock in the surrounding mountains, and between these sediments we can see granite, biotite and muscovite mineral particles

(Ruleman, 2007; Arian et al., 2015). The surrounding mountains of this basin are formed from metamorphic rocks like schist, gneiss, and Slate – also called crystalline and granite, belonging to Precambrian time (20-40 million years ago). The Paghman Mountains are in a series of the Hindu Kush Mountain ranges (Souriau et al.,1988; Torge et al., 2003; Rasouli et al., 2015). In these mountains, we can see different mining of rocks like slate, gneisses, granite, mica schist, and gravels for construction materials (Summerfield and Hulton, 1994; Wheeler et al., 2005).

The morphology of Qargha Dam consists of three kinds of relief, such as high (upper course) arising from the slopes of the mountain, middle relief (middle course) from the hills and plains areas (lower course) as agricultural lands, (Rasouli, 2022) and the Qargha Dam basin which is located between the rings of the mountain - called inter mountains backing basin (Rasouli, et al., 2015). The Kabul River flows in plain areas of this basin and on both banks of this river, there are agricultural lands, consisting of soft sediments (Rasouli, 2017; Rasouli and Safi, 2021).

The main objective of this study is to identify the physicochemical characteristics (Rasouli et al., 2020) of water from six different surrounding regions and how they correlate with environmental parameters. This pedogenic research is essential for the efficient management and planning of geology and soil. This investigation is crucial to study the different sizes of river sediments and soil and their characteristics since there is a lack of previous research and available literature pertaining to this basin. The main aim of this study is to build a database from this research on the geology (Rasouli, 2021), sediment, and soil in the Qargha Dam Basin in Afghanistan (Rasouli, 2020a; Hamdard et al., 2022).

2. Materials and Methods

To conduct this investigation, we studied sediments and pedogenic horizons in the Qargha Dam Basin to find different types of sediments and soil types by using sieving and hydrometer analysis for the area under investigation. One of the important parts of this study of soil and sediments is to categorize as per size to find the physical properties of soil particles, and we distinguish the different types of particles. The sieving method used different types of mesh to distinguish particle sizes after sieving. For soil studies, we used a heating stove for drying soil samples at ~150 C°, after we sieved the soil sample from 2 mm mesh and by using a hydrometer to find the soil fraction percentage of sand, silt, and clay – also called fine fractions, by using 12 classes of soils in a triangle.

The surrounding hill of the Qargha Dam consists of different layers of gravel, sands, silts, and loam and it occurs due to the velocity of the stream. With the high streams, we have bigger sizes but in the slower streams, we obtain smaller sizes sands, silts, and clay. As shown in Fig. 2. The south part of the area is made from different heights and has different types of morphology. The reservoir of the Qargha Dam is located between hills and mountain areas, and this reservoir consists of different branches, typically known as fingerlakes having a dendritic form. This reservoir has a better recharge capability for different Kabul Basins and helps the recovery of groundwater in the surrounding areas. In this reservoir, the storage is higher during the spring season but lower in the fall season (Fig. 3).

Fig. 2. South side of Qargha Dam with different types of hills and types of soils

Fig. 3. Reservoir of Qargha Dam and surrounding areas

Fig. 4. southwest side of Qargha Dam, which is made by different hills and sediments

The surrounding areas of the Qargha Dam are very nice places for sightseeing and family picnics. The site attracts many people to spend their holidays because the weather in this area is normally very good with clear sky, good weather, and climatic conditions (Fig. 4).

3. Physicochemical Study of Soils

3.1. Mechanical and Hydrometer Analysis

For mechanical analysis, we used a Hydrometer for five samples collected from different locations around the Qargha Dam. For this part of the study, we obtained 1kg sample from every point and then we transferred it to the laboratory. This step was followed by sieving from the shaker and then converting them to smaller sizes to obtain an amount of ~500gr and to be analyzed by the hydrometer.

In point 1, the samples are collected from the earth's surface to a depth of 15 cm from the site and the type of soil is loam (Fig. 5). In point 2 the type of soil is different as it is Sandy loam (Fig. 6). The soil type in point 3 is silty loam (Fig. 7). At point 4 the type of soil is sandy loam ((Fig. 8), at point 5 the type of soil is sandy loam (Fig. 9) and at point 6 the type of soil is sandy loam (Fig. 10).

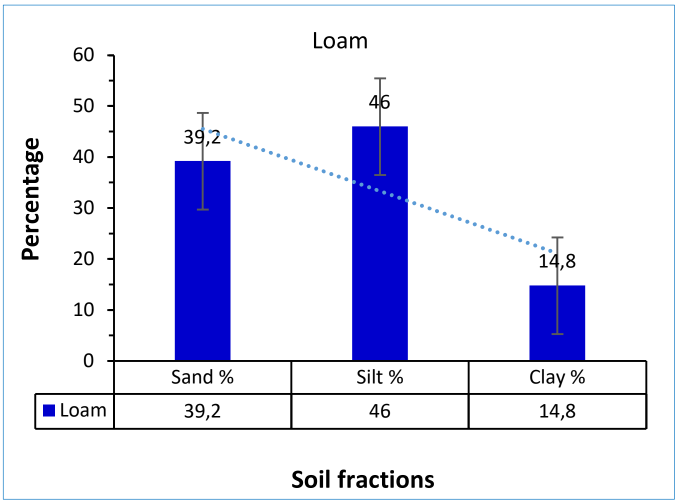

Fig. 5. Mechanical analysis in point 1

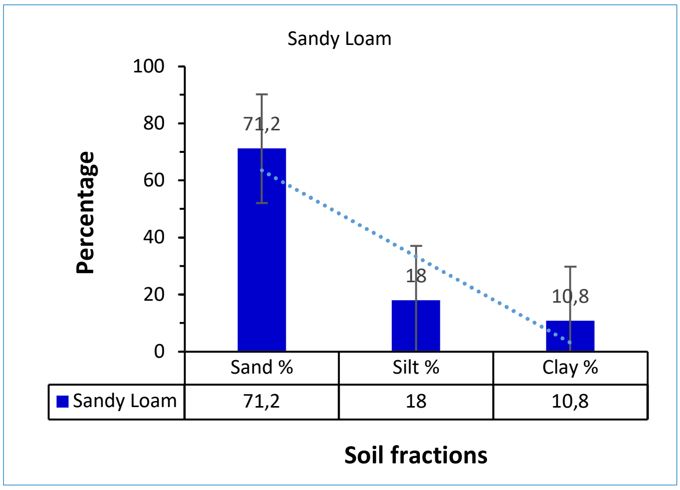

Fig. 6. Mechanical analysis in point 2

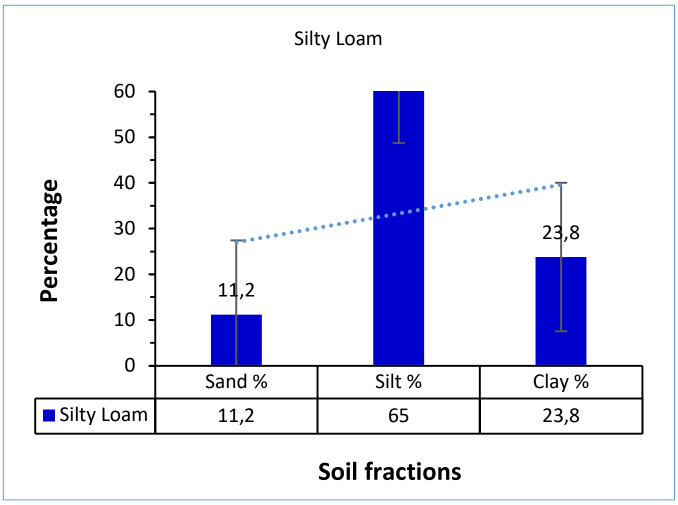

Fig. 7. Mechanical analysis in point 3

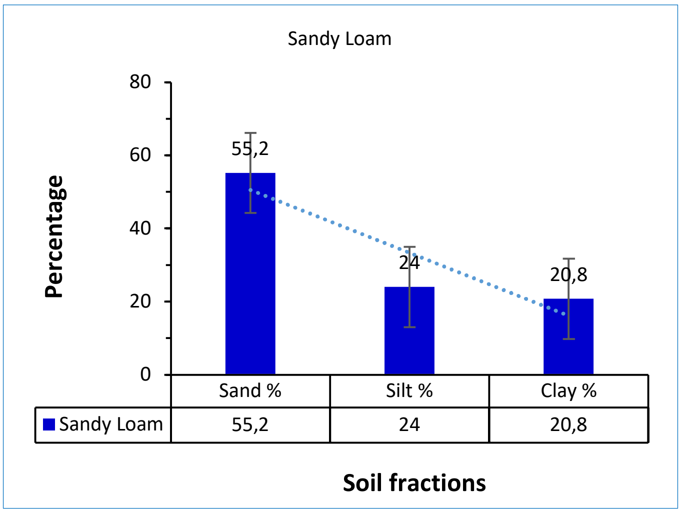

Fig. 8. Mechanical analysis in point 4

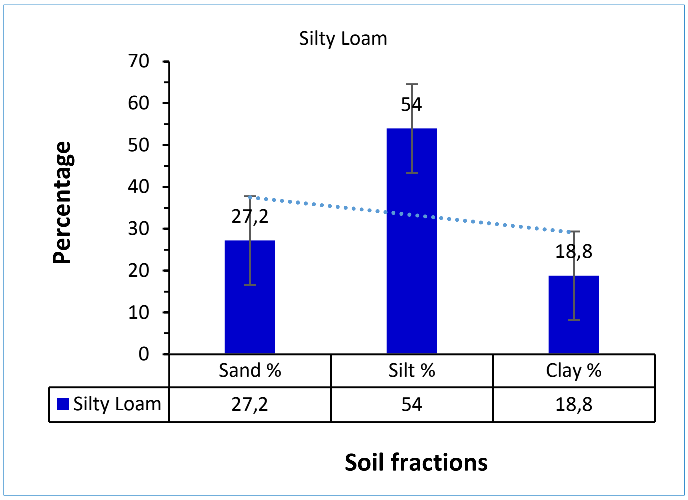

Fig. 9. Mechanical analysis in point 5

3.2. Electro-conductivity of Soil

Conductivity is the measurement principle of current in any solution, and it shows the quantity of salt dissolved in a given soil. The electro-conductivity is related to the soil temperature at the time of the measurement. In fact, this objective can be conducted at the test site. For this investigation, we performed the test three times for each sample. The average data is compared with the norms of Afghanistan, the European Commission, the World Health Organization (WHO), and Asian Countries' electro-conductivity – which is ~1500 μs/cm.

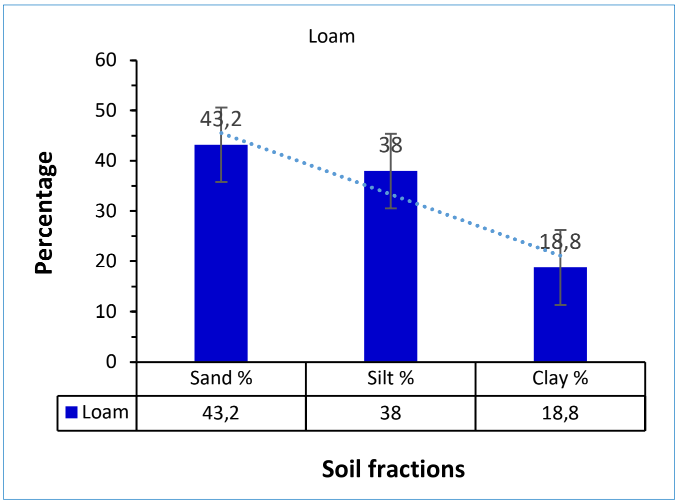

Fig. 10. Mechanical analysis in point 6

3.3. pH

For pH value demonstrations, we used acidic and basic samples of the soils under investigation, using a standard pH meter. Under normal conditions, pH was found to be between 6.5 – 8.5, which is consistent with the WHO and Asian Countries' data, which is also 6.5 – 8.5 (Rasouli, 2021a) (Fig. 11).

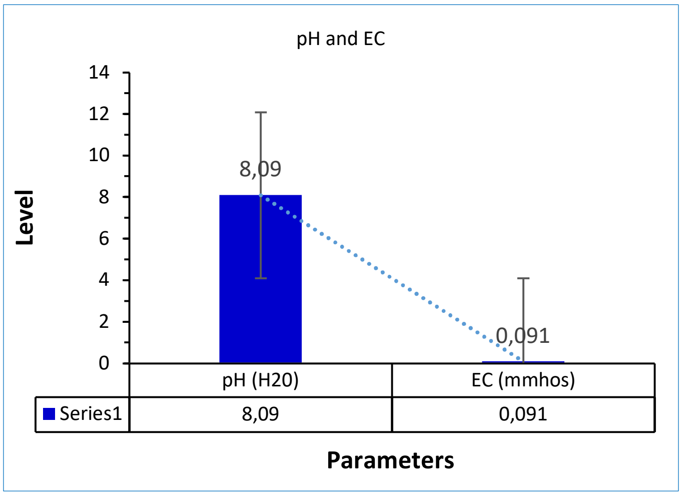

Fig. 11. The level of pH and EC in Qargha Dam soil

3.4. Calcium Carbonates

For this measurement, the amount of $CaCO_3$ in the soil samples is measured in the laboratory of the Geology department, Kabul University using a Calcimeter. The six profiles taken from the Qargha Dam areas contain different percentages of $CaCO_3$ in the six profiles of Qargha Dam areas, which are 7.5, 7.5, 21.75, 13.75, 12.75, and 15.25, respectively as shown in (Fig. 12).

3.5. Passphrase (P)

The level of P in the six horizons of Qargha Dam is different according to the location. In this soil, the amount of P (in ppm) is 96.07, 43.3, 0.85, 4.37, 44.15, and 35.83 respectively, and for better understanding is shown in Fig. 13.

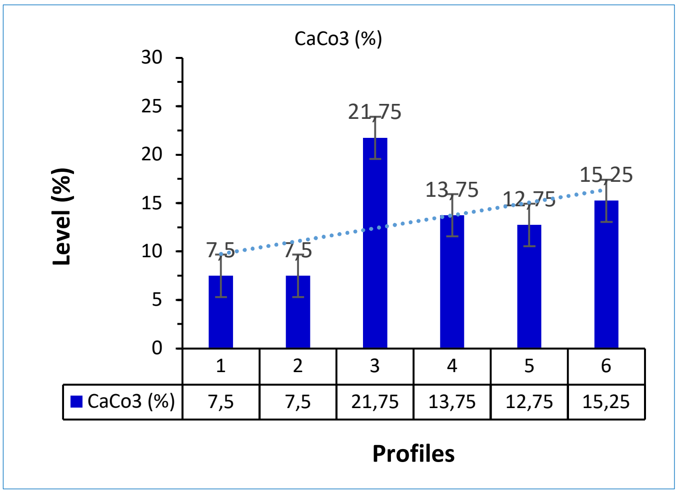

Fig. 12. Amount of calcium carbonate in Qargha Dam soil

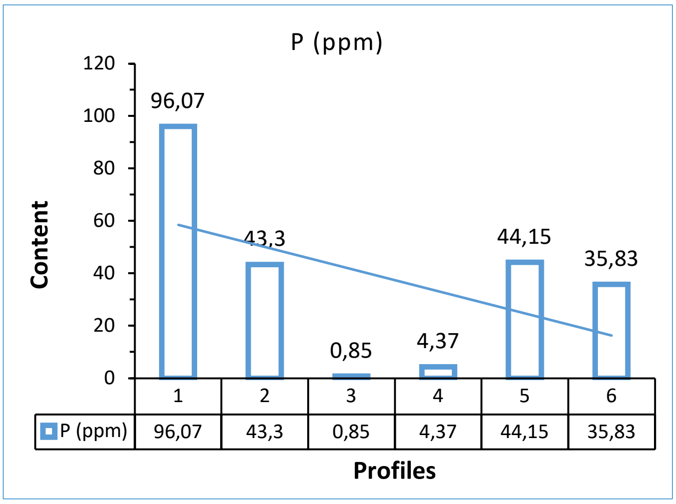

Fig. 13. Amount of passphrases in Qargha Dam soil

3.6. Sulfur (S)

The amount of sulfur is different according to the location. As per this study, the amount of sulfur is shown in PPM which is different at different depths and with water content. The study also shows that the amount of sulfur is 2.41, 1.31, 1.97, 1.31, 2.3, and 1.64 ppm, respectively. For a better understanding, we can use (Fig. 14).

3.7. Sodium (Na)

Na is also one of the important elements in the soil. The contents of Na in soil are due to some organic materials, mother rock formations, and the age of the soils. In this study, the amount of Na is observed to be 96, 102, 114, 122, 144, and 160 in ppm, respectively, as shown in Fig. 15.

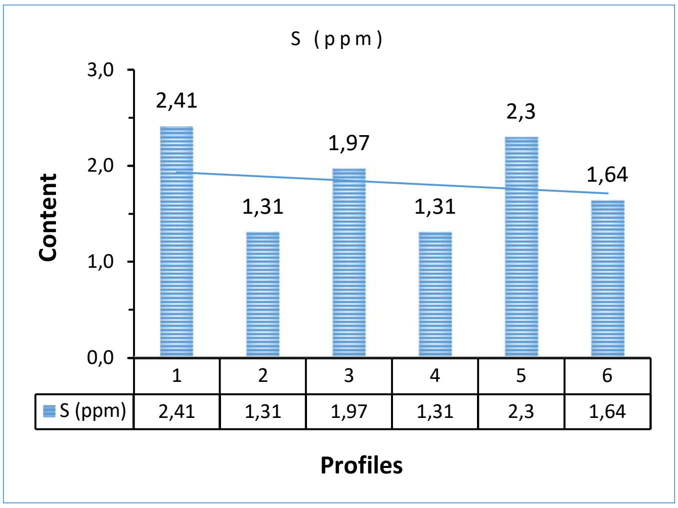

Fig. 14. Amount of sulfur in Qargha Dam soil

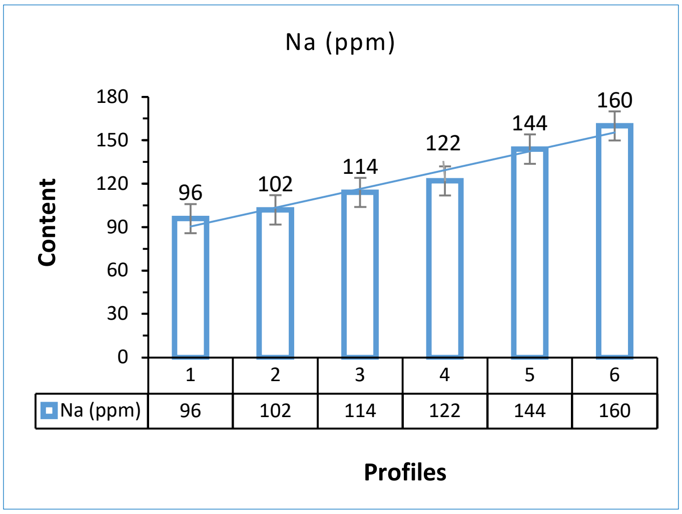

Fig. 15. Amount of sodium in Qargha Dam soil

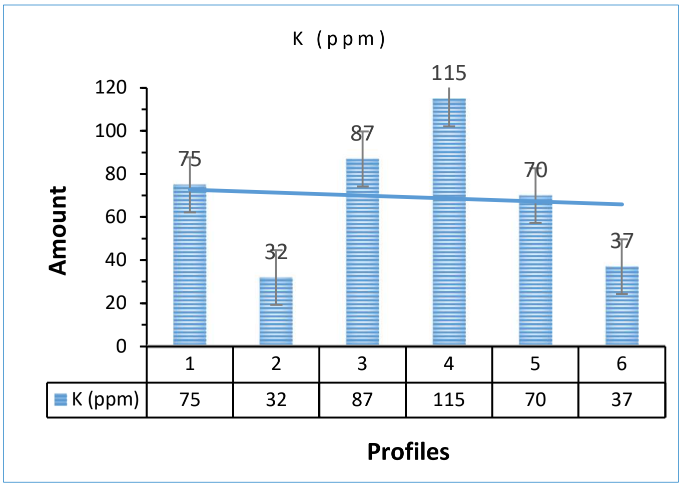

Fig. 16. Amount of potassium in Qargha Dam soil

3.8. Potassium (K)

The amount of K also belongs to organic materials, soil formation factor, and depth of soils. For this study, the amount of K according to the depth and soil formations is 75, 32, 87, 115, 70, and 37 ppm, as shown in Fig. 16.

5. Conclusion

This targeted research conducted here is for six specific sites in the Qargha Dam. The recent sediments of the Qargha Basin are different in thickness, primarily due to the recent climatic conditions. Generally, in sloped areas, we have fewer sediments than in the plain areas where the thickness is higher. The sloped areas consist of gravel, but plain areas consist of smaller sizes such as sand, silt, and clay. These all sediments are made by exogenic force and transported by streams during the snow-melting seasons. From hydrometer analysis, we found different fractions of soils such as loam, clayey loam, silty loam, and sandy loam.

This pedogenic research is used here to distinguish between different sediment sizes, of river sediments that are transported during the snow melting season by stream discharges from different parts of surrounding mountains in the Paghman District. In this study, we have found different kinds of fractions in different horizons. We also found some fractions such as sand, silt, clay, and loam. All these fractions belong to the surrounding mountains' mother rocks, which are transferred by seasonal snow-melting. The results from this investigation show that we can use this soil, according to its physicochemical properties, for groundwater storage and agricultural activities. This investigation is about the pedogenic characteristics of the Qargha Dam reservoir and as the next step, we plan to do a detailed analysis of petrography, engineering geology, mining, and groundwater and surface waters. The results attained here propose that the sedimentological analysis can be used professionally for the petrographical, aquifer, geological mapping, stratigraphy, geochronology, and engineering geological studies for other mountain basins in Afghanistan.

Acknowledgments

We would like to thank the members of our faculty who helped us resolve some of the logistical issues encountered during this investigation.

Conflict of Interest

The authors declare no conflicts of interest regarding the publication of this paper – financial or otherwise.

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