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ARTICLE

Investigation of Physicochemical Properties of Qalay Abdul Ali Soil, Kabul, Afghanistan

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ABSTRACT

The article presents the physicochemical properties of soil from six different areas in Qalay Abdul Ali, Kabul, Afghanistan. The authors collected dissimilar samples from six diverse areas, each with a unique profile identifier, and transported them to the research laboratory. The key objectives of this study are to recognize and profile such areas in terms of their physical and chemical characteristics and correlate them with the earlier geological periods of the Qalay Abdul Ali Region. Due to regional conflicts in the region, such quantifications are necessary as very limited data for this region existed. From the analysis, the authors assess that the soil type is gravely soil, and silt with gravels with mostly neutral pH of the soil, although, in specific regions, it was near-acidic. The amounts of $CaCO_3$, EC (electroconductivity), and pH are dissimilar according to the locations, the values of EC, and pH within a normal range at whole locations, and the remnants of plants in various quantities. These observations recommend that the soil limitations can be used accordingly for the utilization of soil factors in the regions of the study sites and extra washbasins in the country. As the population continues to grow, such data will be critical to the future sustainability of this region.

Keywords: Geology; Topsoil profiles; Physicochemical limitations; Qalay Abdul Ali; Kabul Basin

1. Introduction

The Kabul Province is surrounded by a series of high mountains, with the maximum height reaching up to ~4,522 m in elevation toward the west of the study area. Koh-e Safi, a major historical district, lo-

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cated in South-Eastern Parwan Province, has an elevation of approx. 2,816 m above sea level. The region of Qalay Abdul Ali Soil, Kabul, is to the west of our area of investigation [1,2] with the sedimentary formation ranging from approximately 200-500 m above the neighboring valleys and gorge bottoms. The heights of the series of central plateaus start at about 1,800 m in the adjacent main basins to 2,200 m in Paghman and Higher Kabul Sub-basins [3]. From the north and at the source in the Smaller Himalayas [4], noticeable seal terraces were accumulated, perhaps throughout the late Pleistocene carved out [5]. The relief of stress creates an active balance between current tectonics and other ongoing processes [6]. The sharp stress relief in conjunction with the uplift rates in the upper Himalayas Regions reproduces pushing over the mean-crustal slope quite a potion the isostatic reaction to re-carving of the Tibetan Plateau determined by late Cenozoic macroclimate alteration, or late Miocene repetition of the key Dominant Thrust. The kinetics of highland textures result from the mixture of crustal distortion and loss, with the two processes being perhaps joined [7-9]. These processes along with anthropogenic activities resulting from years of regional conflict and growing population necessitate a physicochemical assessment of this region for safe and sustainable water resources.

Hence, one of the goals is to map out river terraces of the Kabul Province and assess the place of diverse mineral deposits in the region of interest for this investigation. For the present objective, all samples from these terraces were collected and carefully transported to the research laboratory for analysis to account for different minerals. Furthermore, almost every basin in Afghanistan is from the tertiary geological period (ioncene and oligocene), since it is surrounded by mountains that were formed around (20-45) million years ago and their residues are formed by tertiary creation. The higher portion of the Kabul Basins is also from this period [10]. The greater portion of these sediments is enclosed by terraces, and it becomes gradual at the lower quaternary (Pleistocene). The value of these deposits is correlated to the neighboring peaks. The Kabul Province is a part of the structurally dynamic Kabul mass in the transferred platter border section of the country [11]. Afghanistan lies along a highly active plate region that has formed the world's highest peaks, viz. the Himalayas, Karakoram, Pamir, and the Hindu Kush. In Kabul, due to the tectonic movement of mountains, different sections consist of composites of displaced materials, viz. bottomless Gneiss Graben was designed and occupied by hundreds of meters of river sediments, sediments by gravity, and lake deposits [12]. The greatest sediment thus Neogen is enclosed by the medium quaternary and currently, a large portion is soft, and these sediments are protected by the alluvial of the upper quaternary. A smaller portion of these districts is positioned at the bottomless area of Tangi Mahipar (800 m a.s.l) and the maximum section of these areas is placed at the upper Kabul Mountain Series (up from 4,522 m a.s.l). The gorges of rivers form V and U shapes. Usually, the capital [13], involves gravel formations, and its width is changed from region to region. Bagrami Hill, Maranjan Hill, Bibi Mahrow Hill, and Kalola Pushta Hill are sited in the catchment, which is associated with the tertiary geological time scale, and whole remnants of dissimilar Kabul Basin regolith [14,15]. The neighboring elevations are mainly composed of Paleoproterozoic gneiss and Late Permian through Late Triassic rocks. The inter-basin edges which are collected of metamorphic core-complex rocks, are Paleoproterozoic gneiss. Underground basements in the Safi Mountains, to the east of the Kabul Basin, are Paleoproterozoic gneiss and migmatite of the Sherdarwaza Sequences and low-grade schist and quartzite of the Walayati Series. The underground is superimposed by the Permian to Jurassic shelf or platform carbonate rocks of the Khengal Group. The Khengal and basement rocks are overthrust by schist mixture, which has been called the Cottagay Series, in the northern Kohe Safi range, and they are underthrusted by concoction in the Kabul River valley [16].

The quantity of the main streams flowing into the Kabul Basin certainly contributes to the historical importance of the Kabul Region. The headwaters of the Kabul Waterway are west of the southwest angle of the study area and passes region from the south, with currents due north about 21 km to the urban of Kabul that formerly flew east [17], leaving the reformed valley in the Safi Highlands Peaks. The Paghman Watercourse flows eastward from the Paghman Uplands and reaches the Kabul River in the city of Kabul close to the point where the Kabul River originates to flow east. The Logar River, a huge stream to the Kabul River, reaches the study area from the south from side to side with a sharp cut between mountains and runs northward for about 28 km. The Logar River combines with the Kabul River at the eastern edge of the city of Kabul, around 17 km downstream of the entry of the Paghman streams [18-20].

1.2 Geology of the Kabul Basins

Sediments are approved from Paghman, Aliabad, Asmayie, Qurugh, and Logar mountains. These altitudes are in the close regions of the Kabul Basin and these deposits are transported by water at dissimilar periods of time and form diverse thicknesses, the upper and middle portions of the Kabul Basin terrace sand there store some types of minerals, and these minerals deposits related on the source rocks that located at the immediate mounts are as of Kabul Basin [22,23]. For example, in Epidote, Kyanite, and Granite we can find terraces of the Kabul River basin since these are all sections of Metamorphic rocks (Crystalline), which are found in the mountains near the Kabul Basin. Besides, some minerals such as Rutile and Zircon also originate here because it is also some of the Igneous rocks of the Paghman Mountains strike [24]. In addition, there are some extra natural resources such as Muscovite and Biotite, also part of metamorphic rocks which is in the close mountains of the Kabul Basin, also Biotite and Rutile reserves in the inside and lower porches of the Paghman River fitting to Igneous Rocks of Paghman Mountain variety and all dregs approved by water and altogether further in terraces [25]. All rivers of the Kabul Basin are joined at reformed seats and all of them, composed, stream from west to East, and residues of this basin belong to Tertiary (Eocene and Oligocene), and the period of such sediments, surrounded by the upper and middle portions of the Kabul Basin is about (20-45) millions of years and are named Tertiary growths [26]. The upper part of these deposits is surrounded by fresh sediments of lower quaternary (Pleistocene) remains and it includes these terraces, having different composite, raises, and positions, for example, the upper part of the Kabul river basin belongs to the quaternary and here we can see more Stable and unstable gravels sediments, but the middle part of Kabul River Basin belong to Tertiary and there is certain unconsolidated sands, Marls (gray, white, green and brown) colors, and upper part of these sediments are covered by rivers terraces [27]. All mountains adjoining Kabul Province are made by means of metamorphic rocks, except for Paghman Mountains, which are shaped by metamorphic rocks, so it consists of igneous rocks also, other all mountains made from metamorphic rocks, studies using the Radiometry method. It was assessed that the lifetime of these mountains is almost (928 ± 8) million years back (**Figure 1**). The elder mountain is in the Khear Khana and the earlier one is in the Shawaky and Qurugh Mountains series [28].

The Qalay Abdul Ali is part of the Paghman District and is positioned on the common banks of Kabul-Kandahar Road. All sediments transported from different points of surrounding mountains such as the Paghman, and Chaltan Mountains are transported by surface streams and gravity to this sedimentary basin. The contribution of the accumulation of sediments by other means in this basin results in different layers and profiles. The sedimentary layers of Qalay Abdul Ali belong to the lower Quaternary (Pleistocene) and have different thicknesses. The types of sediments directly pertain to the surrounding mountains' main rocks [29,30].

1.3 Geology of Qalay Abdul Ali

The adjacent mountains of Qalay Abdul Ali are made from plutonic and metamorphic rocks (gneiss, granite). The mountains that surround this basin are Paghman Mountain ranges and they continue from northeast to southwest. Analysis of gravels shows that parent rocks are Gneiss and Granite, and it has

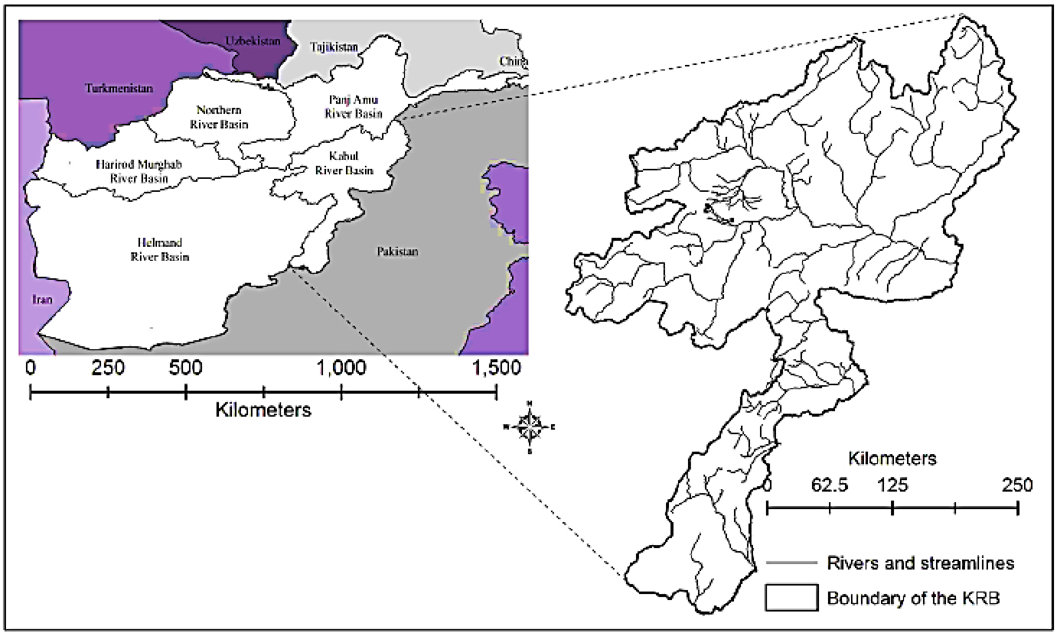

Figure 1. Site plot of Kabul basins, Afghanistan.

different sizes of bigger gravel formations. In these mountains, we found different structures such as anticline, syncline, dyke, and sill, and there are different types of valleys such as longitudinal, diagonal, transverse, synclinal, and anticlinal valleys in the area [31]. Also, there are different types of alluvial fans and alluvial aprons in the area (**Figure 2**).

1.4 The aim of research

The aim of this research is to analyze different data of soil physicochemical parameters, for six profiles of Qalay Abdul Ali to find pH, electroconductivity (EC), soil color, soil fraction, and its effects on water quality, soil quality and plants. One of the very significant goals is to quantity different parameters that impact water quality, soil quality and thereby agriculture, and its potential impact on groundwater. These parameters along with the identification of different toxic and nontoxic elements leaching into the ground impact human health with different health-related issues. Also, the amount of $CaCO_3$, found in some of these areas affects agricultural lands and thereby the quality of produce, typical to the area. Furthermore, we are also assessing different types of soil structures for groundwater infiltration rate, because the infiltration rate of such, generally platy, structures, is lower. However, in the prismatic, and columnar structures, the rate is higher. The pH indicates the amount of acidity and alkalinity of soil, in these areas and is mostly neutral, which can be used for both agricultural and drinking water. The EC shows the amount of salinity in soil which affects animals and plants. As we observe the amount of salt is normal and can be used for different purposes of agriculture and drinking water. The quality of soil is good and we can use it for different purposes of agriculture and drinking water. But in some places of Kabul province such as Qalay Zaman Khan, Taymany, and around Kabul airport the amount of EC and pH of soil are lower quality, and we cannot use them for agricultural and drinking purposes.

2. Area under investigation

This study is carried out from different soil profiles at the Qalay Abdul Ali (**Figure 2**), which is in the upper portion of the Kabul Province, on the Hindu Kush Mountain collection in the country. Kabul River starts from 80 km west side of Kabul, at an elevation of 4,522 m a.s.l in the Paghman elevation series (Sanglakh mountains regions) as part of the Hindu Kush elevation ranges in Afghanistan. The river throughout its first pass flows at a precise high

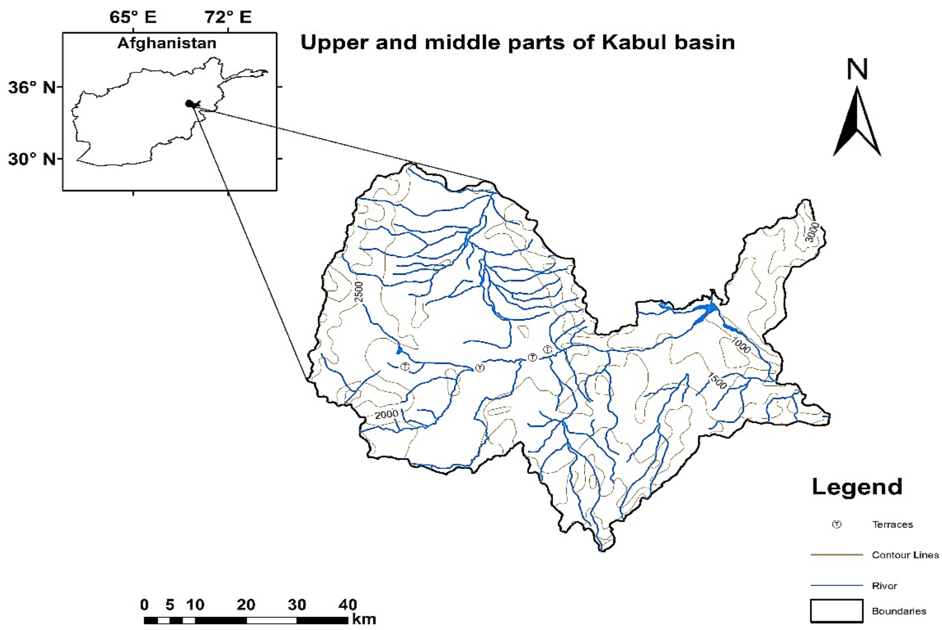

Figure 2. Scheme of the Qalay Abdul Ali basin, Kabul, Afghanistan.

speed with abundant carriage of residues from west to east and passes from the higher part of Maidan Share, Wardak Province. Afterwards, covering several kilometers, it changes direction to the southwest from Koha Qurugh and then it is called Kabul River. It then watercourses from the southwest of Lalander and arrives in Kabul City [31,32]. Paghman River starts from (3,500 m a.s.l.) Paghman Mountain Range, in the first stage the river running a very steep level and with very high velocity from north-south to Company Bridge after this river variations the course from Northwest to Northeast, and in the Gazarga area and junctions the Kabul River at Chahar Dahai. Logar River started from (4,600 m a.s.l) Daimirdad Mountain (Wardak mountain range) belongs to Wardak Province [33,34]. In the first stage, this river currents from west to east passes from Chack and Saidabad, Wardak Districts, and then enters Loger Province and Barakibarak Loger District which joins with the Charkh River. After that, it enters Kabul Province and joins with the Kabul River at the Sheena village into the Bagrami District [35,36].

3. Method and materials

In this investigation, we undertook a two-pronged approach. The first is the site or field research, in which we determine soil color by the Munsell color scheme using wet and dry conditions. The second approach is laboratory-based analysis in which we determine different chemical and physical parameters such as mechanical analysis of soil fraction, soil calcium carbonates, electro-conductivities, and soil pH, in the different locations in soil profiles at the Qalay Abdul Ali, Kabul. For the assessment to conduct this research we got 1 kg samples from every soil profile, and caring to the laboratory and performed the sieving analysis method for the determination of mixed smaller sizes we obtained 1 mg sample for determination of mechanical analysis, calcium carbonates, EC, and pH. Additionally, we study soil profiles, as well, in the field.

4. Results

4.1 Study of soil

In this research, we studied six different Pedogenic profiles which consist of profile 1, profile 2, profile 3, profile 4, profile 5*,* and profile 6. In these profiles, we found different types of plant roots, gravels, some caves of worms, and soil erosion, as well as in these profiles we can find different types of arrangements such as crumbling, platy, and prismatic.

4.2 Munsell color chart

For this investigation, we assessed the soil color, following the scheme by Munsell, who selected the color for soil in 1999 at dry and wet conditions. For determination, we compared soil at the two conditions one is dry soil condition, and the second is the wet condition on six profiles of Qalay Abdul Ali regions, Kabul, Afghanistan (**Figure 3**).

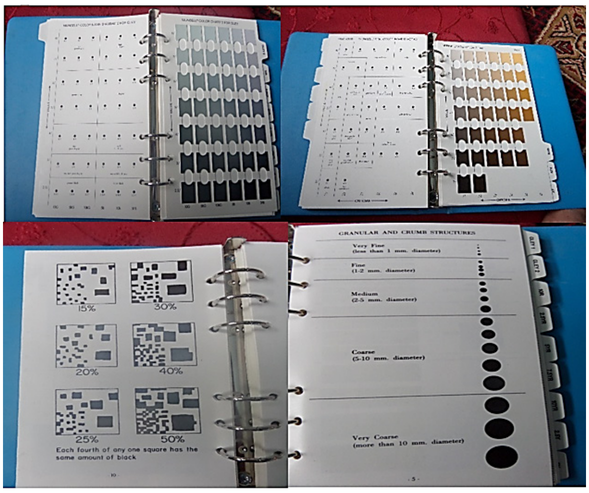

Figure 3. Munsell color chart for soil color determination.

4.3 Soil color

Rendering to the Munsell Color chart, the color of the soil in this profile 1 in the wet situation is reddish gray (2.5 YR 5/1) but in the dry state is yellowish brown (10 YR 5/6), profile 2 in the wet form is very pale brown (10 YR 8/2) but at a dry situation is reddish (10 YR 2.5/1), profile 3 at wet state is strong brown (7.5 YR 5/6) but at the dry state is reddish gray (2.5 YR 5/1), profile 4 at the wet form pale brown (10 YR 8/2), but at the dry form is strong brown (7.5 YR 5/6), profile 5 at the wet state is pinkish white (7.5 YR 8/2), reddish (10 YR 2.5/1), yellowish brown (10 YR 5/6), strong brown (7.5 YR 5/6) and at the dry state is pinkish white (7.5 YR 8/2) and at profile 6 at the wet state soil color is reddish (10 YR 2.5/1) and at the dry state is yellowish brown (10 YR 5/6) [14].

4.4 Laboratory approach

Comparative tools that we used in this investigation at laboratory and field in this study we used some laboratory devices such as a hydrometer, Calcimeter, pH meter, and Munsell color chart and we discovered the chemical and physical as well as microscope and discovered features of soil and sediments and rock type in Qalay Abdul Ali sedimentary basin.

4.5 Physical analysis

In this study, we conducted research laboratory work, such as mechanical analysis by hydrometer. In agreement with the hydrometer analysis, we establish the type of soil segment is silty loam and loam (**Figure 9**).

4.6 Calcimeter analysis

In this study from chemical laboratory work, we performed the determination of soil fractions by hydrometer analysis, $CaCO_3$ by Calcimeter, and pH and EC by pH-meter (**Figure 11**).

Profile 1

In this profile, we discover different soil structures such as platy, crumbling, and prismatic, and also found the roots of undergrowth at different depths and some gravels. After the decomposition of plants' roots, we conducted a study of different sizes of secondary pores for some live animals. During the secondary pores, there are some primary pores also, and they belong to the sizes of particles (**Figure 4**). As well as there are some caves of worms and macro animals caves also. According to the hydrometer analysis, the soil type from the A-horizon of this profile is silty loam, and the amount of calcium carbonate, EC and pH are 0.437%, 961 µs/cm, and 6.5.

Profile 2

In profile 2, there are not the same types of structures such as platy but for the other types of structures we cannot find such structures because in this profile, there is more gravel and the roots of plants is about 1 m depth, in this profile, we are able to discovery dissimilar sizes of gravel such as cobble, pebbles, granules, sands, silts. Also, can find different sizes of worm and animal caves (**Figure 5**). When we get 1 kg soil sample of B-horizon generally the soil type is silty loam, the $CaCo_3$ is 0.6%, EC is 920 µs/cm, and pH is 7.87.

Figure 4. Soil horizon 1 at Qalay Abdul Ali Kabul.

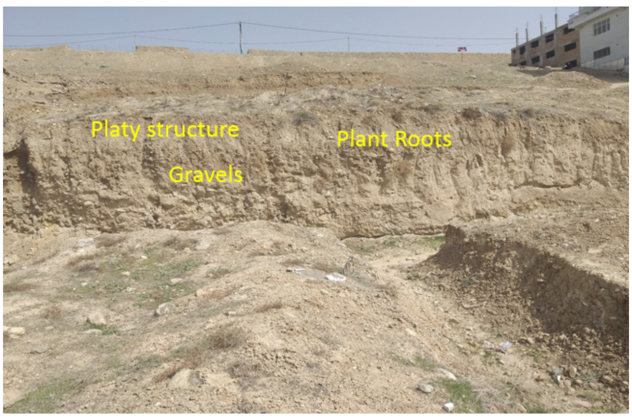

Figure 5. Soil horizon 2 at the Qalay Abdul Ali Kabul.

Profile 3

From the profile, we cannot find any gravel but there is more clay and silt, in this profile can find different types of topsoil arrangements such as platy, and prismatic. In this, we can find different forms of worms and animal caves. Also, there can understanding of altered soil erosions, the roots of plants are 1.5 m in depth (**Figure 6**). From the 1 kg sample of C-horizon of this profile, the soil type is loam, the amount of CaO_3 is 0.32%, EC is 875 µs/cm, and pH is 7.85.

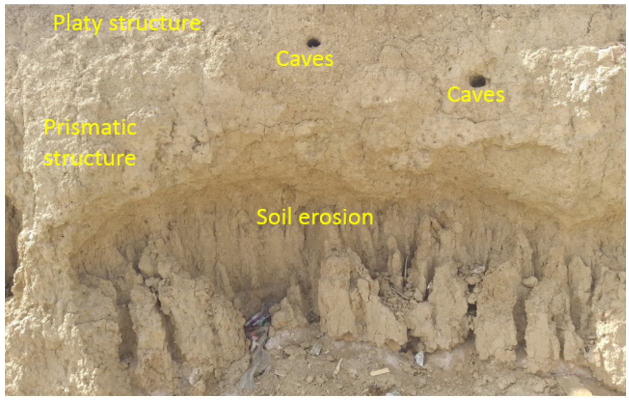

Figure 6. Soil horizon 3 at the Qalay Abdul Ali Kabul.

Profile 4

In profile 4, it is able to discover altered kinds of structures such as crumbling, and columnar. This profile is also made of silt and clay. Besides, nowadays this profile can find different sizes of caves, and roots, and there are changed soil erosion, and different categories of cracks (**Figure 7**). When we get the soil sample from A-horizon, the soil type is loam, the amount of $CaCO_3$ is 0.35%, the EC is 849 µs/cm, and the pH is 7.75.

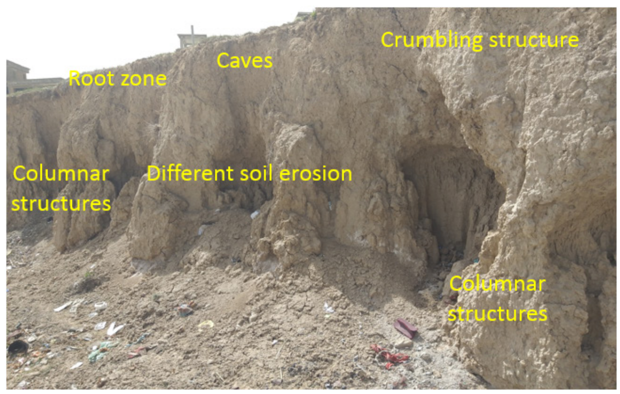

Figure 7. Soil horizon 4 at the Qalay Abdul Ali Kabul.

Profile 5

From this profile, can find different soil structures such as platy, crumbling or worm obstruct, and columnar structures. As well as in this profile we can find different caves of worms, and roots, the depth of roots is about 2 m (**Figure 8**). when we get 1 kg sample from B-horizon and analyzed it in the laboratory the soil type is loam, the amount of $CaCO_3$ is 0.46%, EC is 861 µs/cm, and pH is 7.75.

Profile 6

With this profile, we can find dissimilar worm caves, crumbling, and platy structures, as well as we can find different gravels, the depth of roots is about 1 m (**Figure 9**). When we get 1 kg sample from the C-horizon of this profile the soil type is silty loam, the amount of $CaCO_3$ is 0.474%, EC is 870 µs/cm, and pH is 7.75.

4.7 Textural triangle

In this research when we studied the sample via hydrometer the percentage of soil fine materials or fractions (sand, silt, and clay), we found by the triangle, in this triangle for found soil type from 12 classes of soil between the triangles (**Figure 10**). In this research study, generally, the soil type is silty loam and loam (**Figure 12**).

4.8 Hydrometer

In this research for soil fine materials, we used a hydrometer, as shown in **Figure 11**, for hydrometer analysis we get different samples from various horizons of profiles, and we find from the percentage of fine materials (sand, silt, clay) the soil types, as shown in **Figure 12**.

In this research for soil mechanical analysis, we used the hydrometer, and at what time we analyzed the soil sample by hydrometer the result, we found the soil types of silty loam and loam, as shown in **Figure 12**.

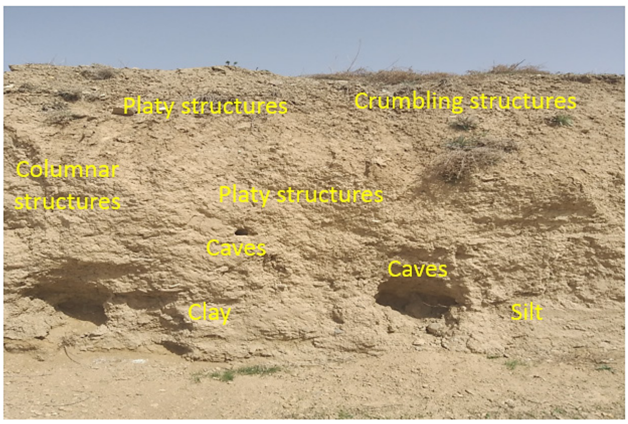

Figure 8. Soil horizon 5 at the Qalay Abdul Ali Kabul.

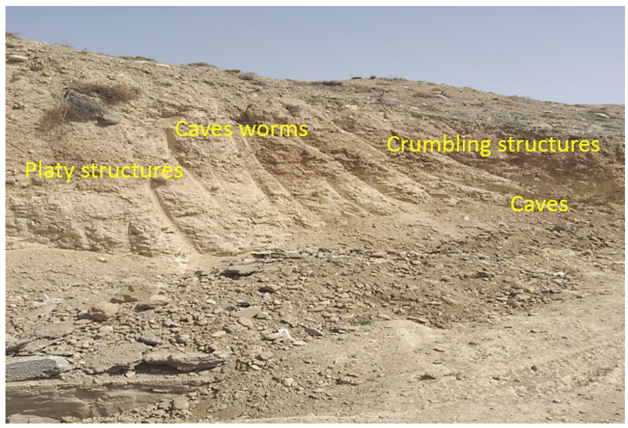

Figure 9. Soil horizon 6 at Qalay Abdul Ali Kabul.

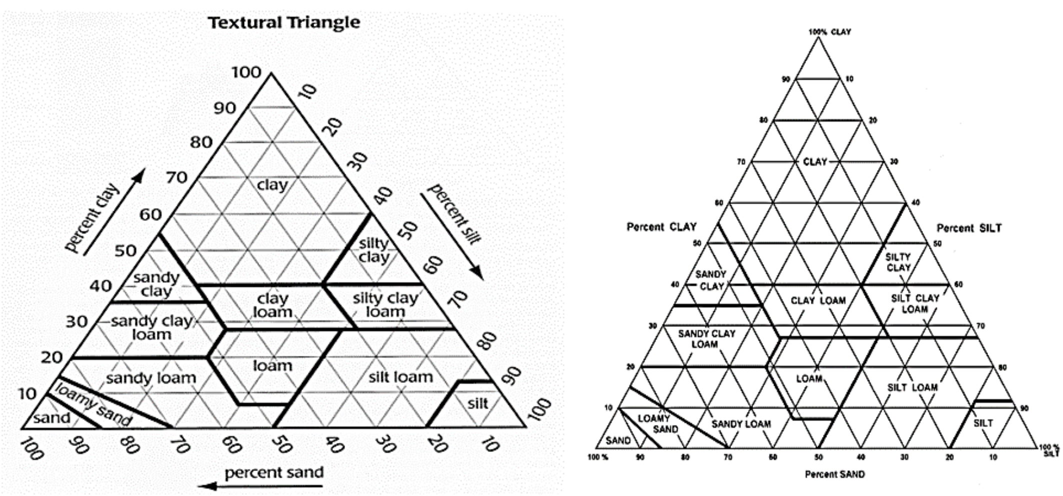

Figure 10. Triangle and 12 classes for determination of soil name from soil friction percentage.

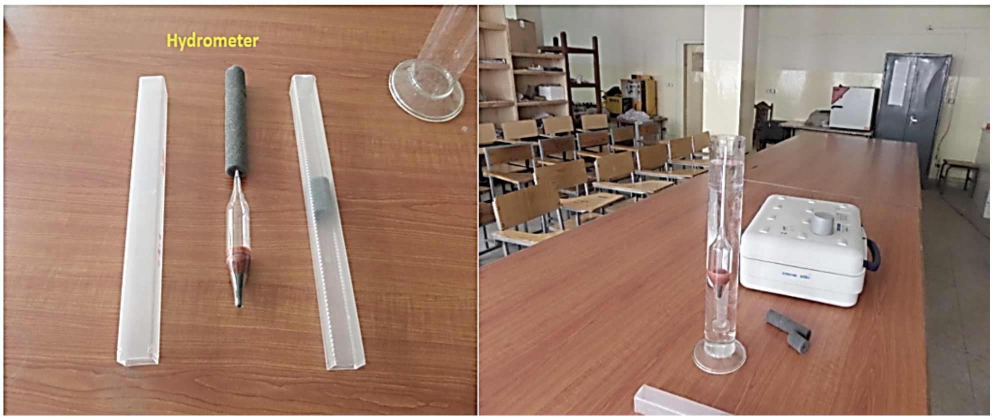

Figure 11. Device (tool) of the hydrometer for determination of soil mechanical analysis.

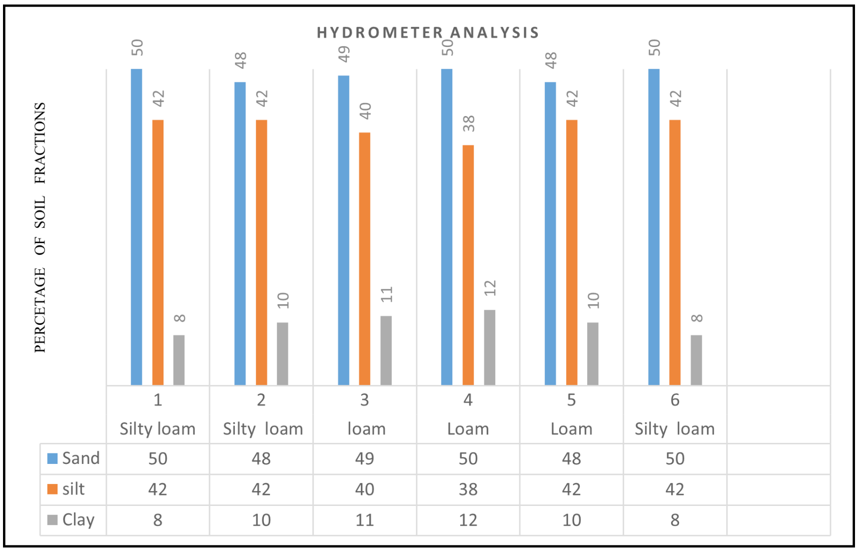

Figure 12. Determination of soil mechanical analysis by hydrometer.

4.9 Calcimeter

We conducted these experiments to find $CaCO_3$ in the soil profile. To do so, we used a Calcimeter, for doing this method we get a 1 kg sample from different horizons of profiles and it's analyzed by the sieving method, we mixed the fine sizes of sieves. After we get 1mg sample from this and mix we clean water and find the amount of $CaCO_3$ in soils of these profiles (**Figure 13**).

In this research at the Qalay Abdul Ali region soil profiles by using Calcimeter different amounts of $CaCO_3$, and this amount belongs to the location and type of soil. In these horizons of profiles, there are different amounts of $CaCO_3$: 0.437%, 0.6%, 0.32%, 0.35%, 0.46%, and 0.474% (**Figure 14**).

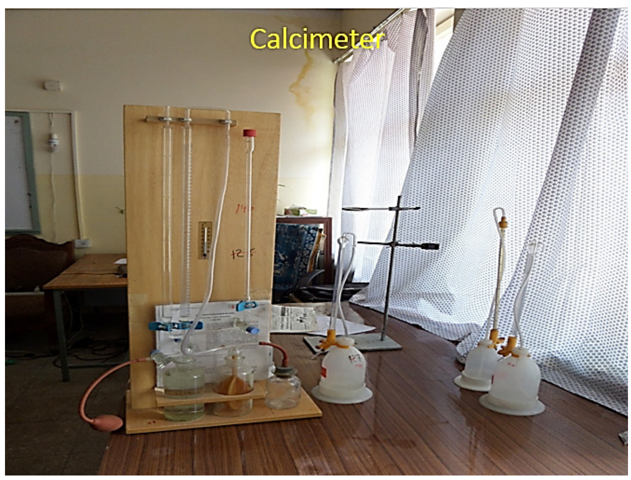

Figure 13. Calcimeter device for determination of calcium carbonates in soils.

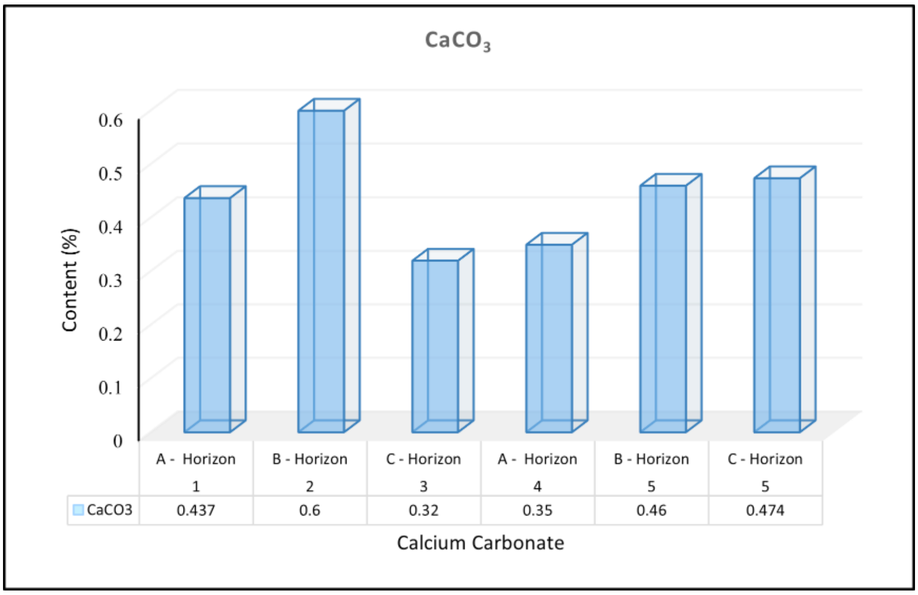

Figure 14. Determination of calcium carbonates in soils by a Calcimeter device.

4.10 pH-meter

In this research for the selection of the amount of EC and pH we used a pH meter (**Figure 15**), for these, we transported from different horizons of profiles. For determination we analyzed samples by sieving method, and after the smaller sizes were mixed after 1mg sample was analyzed by pH-meter and we find the amount of EC and pH (**Figures 16 and 17**).

In this research by pH-meter we find the different amounts of EC at the six different horizons of profiles, in this research generally the amount of EC is 961 µs/cm, 920 µs/cm, 875 µs/cm, 849 µs/cm, 861 µs/cm, and 870 µs/cm (**Figure 16**).

For the determination pH of Qalay Abdul Ali, we used the pH meter to assess the corresponding value of pH at the different horizons of six profiles. In this research, the pH around neutral consists of 6.5, 7.87, 7.85, 7.75, 7.75, and 7.75 (**Figure 17**).

Figure 15. pH-meter instrument for determination EC and pH in soils.

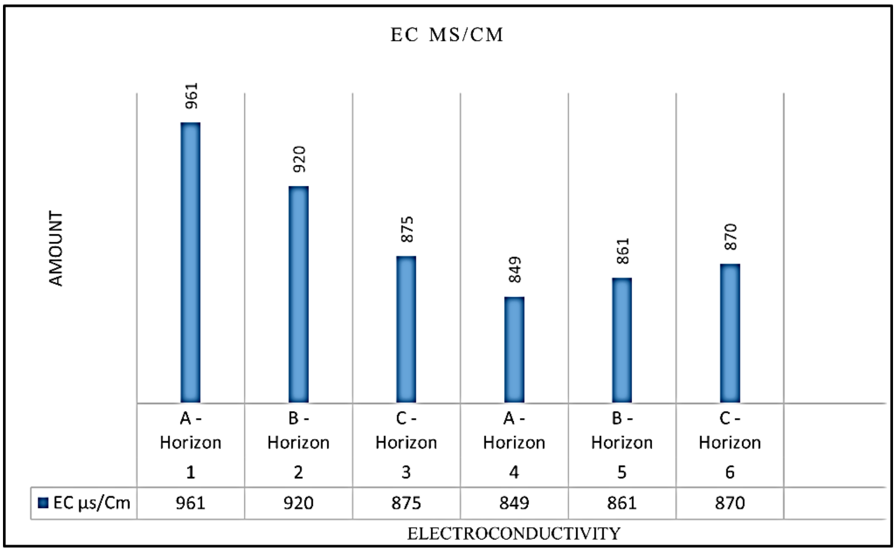

Figure 16. Determination of EC by pH-meter in soils.

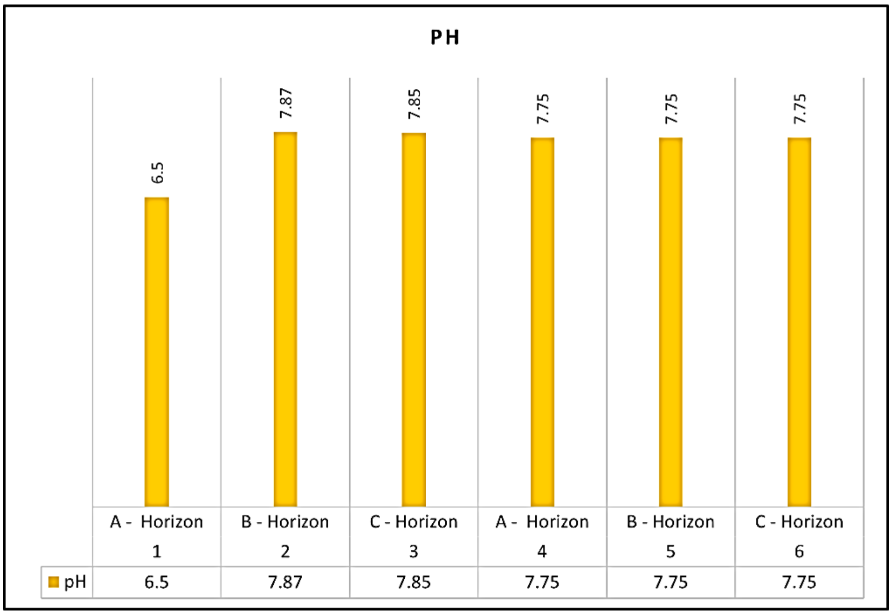

Figure 17. Determination pH by pH-meter in soils.

5. Conclusions

This physio-chemical investigation is used on six profiles to describe profiles of soil and chosen diverse masses of sand types of soils transported via surface stream discharges at the previous geological periods in Qalay Abdul Ali regions, Kabul, Afghanistan. From physical and chemical analysis, we found mechanical analysis, $CaCO_3$, electroconductivity, and pH of soils. For the determination, we conducted a mechanical analysis. We used a hydrometer on all the soil types—such as loam and silty loam. For $CaCO_3$ we used a Calcimeter and the amount of $CaCO_3$ was 0.437%, 0.6%, 0.32%, 0.35%, 0.46%, and 0.474%, for determination of EC and pH we used a pH-meter, in this research the amount of EC was 961 µs/cm, 920 µs/cm, 875 µs/cm, 849 µs/cm, 861 µs/cm, 870 µs/cm, and the amount of pH were 6.5, 7.87, 7.85, 7.75, 7.75, 7.75, and the soil colors are in the wet condition is reddish gray (2.5 YR 5/1) and at the dry condition pale brown (10 YR 8/2), strong brown (7.5 YR 5/6), pinkish white (7.5 YR

8/2), reddish (10 YR 2.5/1), yellowish brown (10 YR 5/6). In this research, the pH, EC, and $CaCO_3$ are according to national and international standards, and it's not desisted for plants growing in soils. Also, there is no risk for surface and groundwater. The outcomes proposed in this pedogenic investigation be able to be used professionally in the further catchments of the basin and further highland basins in Afghanistan.

Author Contributions

Hafizullah Rasouli (H.R.), Ashok Vaseashta (A.V.), Conceptualization: H.R., A.V.; Methodology: H.R.; Software: H.R., A.V.; Validation, H.R., A.V.; Formal analysis, H.R., A.V.; Investigation, H.R.; Resources, H.R, A.V.; Data curation, H.R., A.V.; Writing-original and draft preparation, H.R., A.V.; Visualization, H.R., A.V.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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