International Journal of Earth Sciences Knowledge and Applications
journal homepage: http://www.ijeska.com/index.php/ijeska
e-ISSN: 2687-5993

Research Article https://doi.org/10.5281/zenodo.22165146

Study of Soil Pollutants in the Chahar Asyab Selected Regions, Kabul, Afghanistan

Hafizullah Rasouli[1]*, Ashok Vaseashta[2,3]*

[1]*Department of Geology, Geoscience Faculty, Kabul University, Jamal Mina 1006, Kabul, Afghanistan*
[2]*Strategic Research Division, International Clean Water Institute, Manassas, 20108, VA, USA*
[3]*Research Institute of the University of Bucharest, Bucharest, Romania*

INFORMATION

Article history
Received 03 August 2026
Accepted 25 August 2026
Published 31 August 2026

Contact
*Hafizullah Rasouli
hafizullah.rasouli133@gmail.com (MR)
*Ashok Vaseashta
prof.vaseashta@ieee.org (AV)

How cite
Rasouli, H., Vaseashta, A., 2026. Study of Soil Pollutants in the Chahar Asyab Selected Regions, Kabul, Afghanistan. *International Journal of Earth Sciences Knowledge and Applications* 8 (2), 232–242. https://doi.org/10.5281/zenodo.22165146 .

Abstract
Chahar Asyab District, one of the most densely populated areas of Kabul, Afghanistan, has faced decades of armed conflict, leaving substantial quantities of military debris, metallic fragments, and other hazardous residues in the environment. Weathering, oxidation, and corrosion of these remnants release potentially toxic elements (PTEs), including heavy metals, into the surrounding soils. The accumulation of these contaminants poses significant environmental and public health concerns, particularly for vulnerable populations such as children and the elderly, due to prolonged exposure through soil, water, and airborne dust. The district comprises extensive agricultural lands that rely on irrigation, creating pathways for contaminant mobilization and transport into the soil profile and groundwater. Irrigation water can enhance the leaching of toxic elements, increasing their bioavailability and the potential for uptake by crops. Consequently, contaminated soils may become a source of human exposure through the food chain and direct contact. During the dry season, from late spring to mid-autumn, wind readily entrains contaminated surface sediments from rivers, irrigation canals, and exposed soils, generating dust rich in potentially toxic elements. Atmospheric transport redistributes these particles over varying distances, depending on particle size, density, and meteorological conditions, thereby expanding the spatial extent of contamination. In contrast, precipitation during the wet seasons (winter and spring) removes airborne particles through wet deposition, returning contaminants to the soil surface. We show that subsequent infiltration, leaching, ion exchange, and mineral weathering govern the vertical migration and redistribution of these elements within the soil profile, thereby altering soil physicochemical properties, including pH, cation exchange capacity, and elemental mobility. Understanding the environmental behavior of potentially toxic elements in Chahar Asyab is essential for assessing ecological and human health risks, protecting groundwater and agricultural resources, and developing effective remediation and sustainable land management strategies in post-conflict environments.

Keywords
Soil pollution, Atmospheric pollution, Soil acidity, Soil alkalinity, Dust, Chahar Asyab, Kabul

1. Introduction

Soil is one of the most important components of the terrestrial environment and serves as a fundamental resource for agriculture, groundwater recharge, ecosystem functioning, and human health. However, soil quality can be significantly degraded by the accumulation of potentially toxic elements (PTEs) and other hazardous chemical compounds originating from both natural and anthropogenic sources. Once introduced into the soil, these contaminants migrate through soil pores and fractures, interact with minerals and organic matter, and may eventually reach groundwater systems through leaching and infiltration processes (Asaad and Lamoreaux, 2004). Consequently, soil contamination is a major environmental concern because it directly affects groundwater quality, food safety, and ecological sustainability.

Chahar Asyab District, located south of Kabul, Afghanistan, has experienced several decades of armed conflict that have left substantial quantities of military debris, metallic fragments, explosive residues, and other hazardous materials in the environment. Weathering, corrosion, and oxidation gradually release potentially toxic elements, including lead (Pb), cadmium (Cd), chromium (Cr), nickel (Ni), copper (Cu), zinc (Zn), and arsenic (As), into surrounding soils. The long-term accumulation of these contaminants may threaten agricultural productivity and increase the risk of groundwater pollution, particularly in irrigated areas where contaminant mobility is enhanced.

A combination of physical, chemical, and biological processes governs contaminant mobility and fate in soil. Soil texture, porosity, permeability, mineral composition, cation exchange capacity, and soil organic matter strongly influence the transport and retention of dissolved metals. Likewise, soil pH and redox conditions control the solubility, adsorption, and bioavailability of potentially toxic elements.

Variations in these physicochemical properties may significantly alter contaminant migration pathways and determine whether metals remain immobilized within the soil matrix or are transported into groundwater (Vaseashta, 2021a; Vaseashta, 2021b; Vaseashta, 2022; Ando, et al., 2012; Banks and Soldal, 2002).

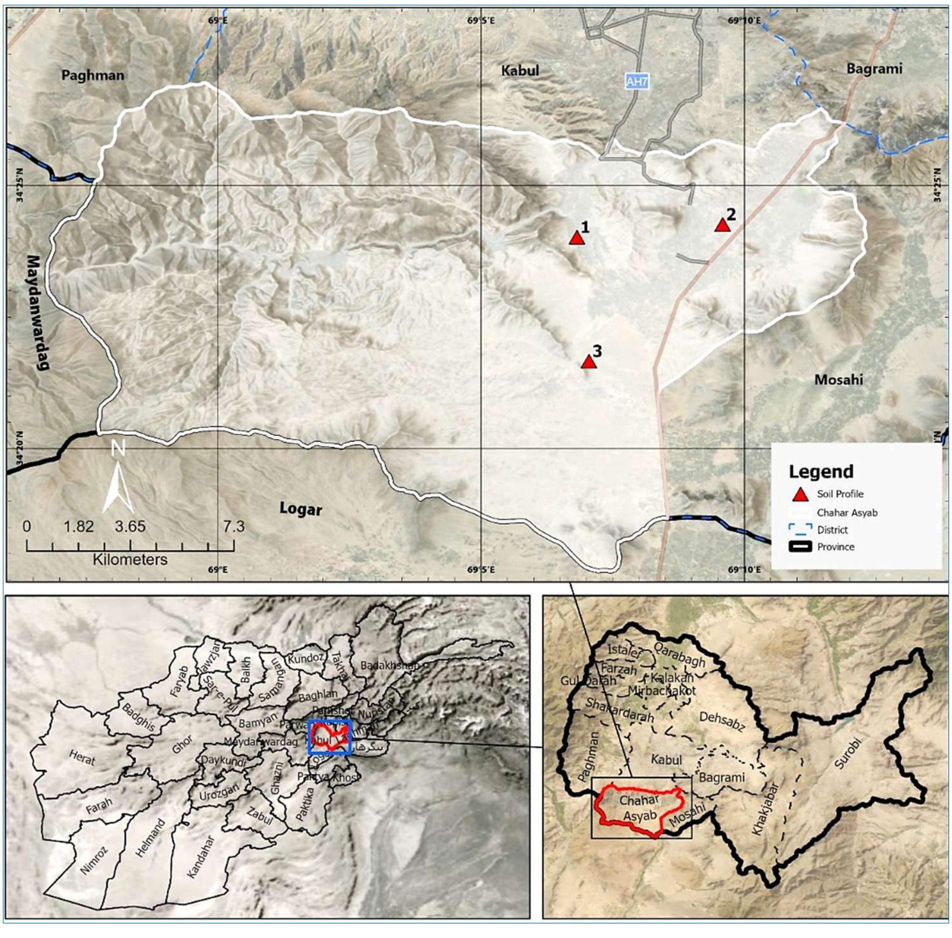

Fig. 1. Rainfall map of the Chahar Asyab River catchment

Atmospheric deposition represents another important pathway through which contaminants enter the soil environment. Industrial emissions, fossil-fuel combustion, open burning of plastics and household waste, vehicle exhaust, biomass burning, and metal-processing activities release sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter, and trace metals into the atmosphere. These pollutants react with atmospheric moisture to produce sulfuric acid (H_2SO_4) and nitric acid (HNO_3) (Karathanasis, 2010), resulting in acid precipitation. Acid rain typically has a pH below 5.6. It enhances mineral weathering, increases the dissolution and mobility of heavy metals, and modifies soil chemical properties, including cation exchange capacity and nutrient availability (Bohannon and Turner, 2005; Bohannon and Turner, 2007; Grotzinger et al., 2007).

Fig. 1 shows a rainfall map of the Chahar Asyab River catchment to highlight the rationale of this investigation.

During dry seasons, wind can also transport contaminated dust particles over long distances and redeposit them onto agricultural land and surface waters.

Interactions among minerals, soil colloids, microorganisms, and plant roots further influence the geochemical behavior of contaminants within soils. Biochemical reactions, ion exchange, adsorption-desorption processes, and mineral dissolution continuously modify soil chemistry and regulate the availability of nutrients and toxic elements. These processes influence both agricultural productivity and groundwater quality and may increase the ecological and human health risks associated with long-term contaminant accumulation (Biswas and Mukherjee, 1994; Maurice, 2001).

Groundwater is the principal source of drinking water and irrigation for many communities in Chahar Asyab. Therefore, contamination of soils by potentially toxic elements represents a significant environmental and public health concern. Once contaminants migrate into groundwater, they may persist for long periods because of slow groundwater flow and limited natural attenuation.

Chronic exposure to contaminated water has been associated with numerous adverse health effects, including neurological disorders, kidney damage, cardiovascular disease, and several forms of cancer. Despite the environmental importance of Chahar Asyab, relatively few studies have comprehensively evaluated the occurrence, mobility, and environmental behavior of potentially toxic elements in its soils and their implications for groundwater quality. This knowledge gap limits the development of effective environmental management and remediation strategies in this post-conflict region.

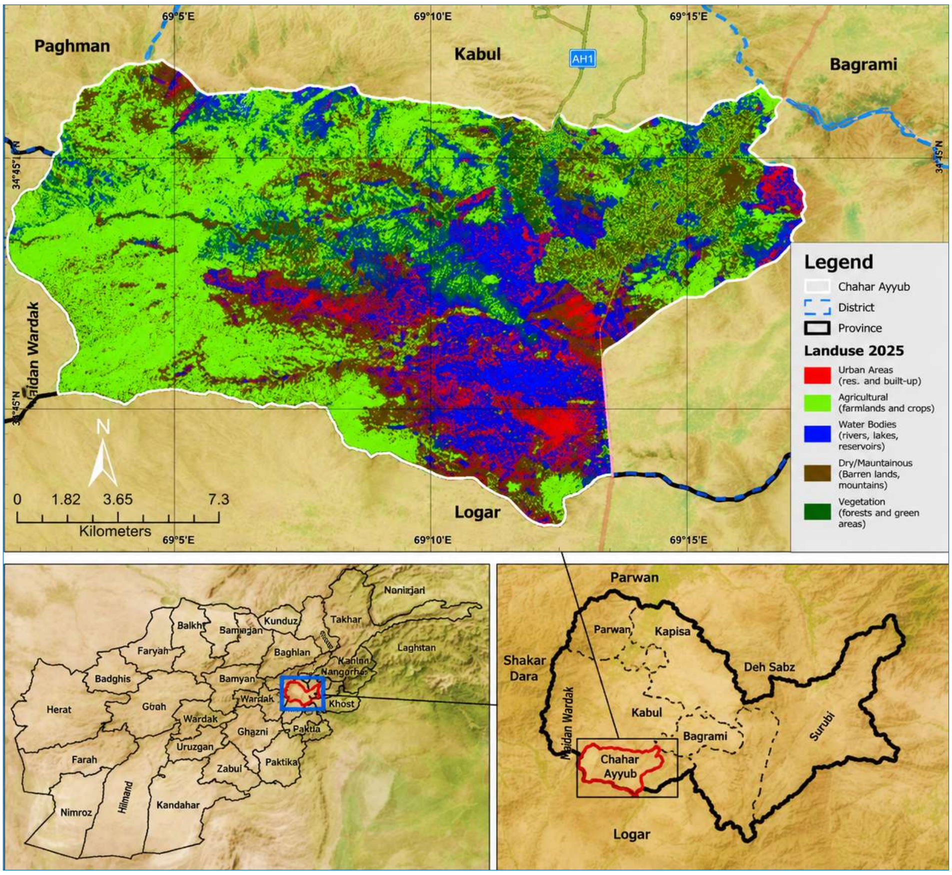

Fig. 2. The Land use of the Chahar Asyab Subbasin

Therefore, the objectives of this study are to (i) investigate the physicochemical characteristics of soils in Chahar Asyab District, including pH, electrical conductivity (EC), calcium carbonate content, soil texture, porosity, and soil profile characteristics; (ii) evaluate the occurrence and distribution of selected potentially toxic elements, including Pb, Cd, Cr, Ni, Cu, Zn, and As; (iii) assess the influence of soil properties on contaminant mobility and the potential for groundwater contamination; and (iv) provide scientific information to support environmental protection, groundwater management, and sustainable land-use planning in the Chahar Asyab region of Afghanistan.

2. Soils of Chahar Asyab Regions

The soil in the profiled region (as shown in Fig. 1 - three profile locations) is predominantly loam, as shown in Fig. 8. However, one profile has been affected by groundwater, which has transformed it into a ceramic-like mud. The soil profiles are located approximately 4 km southwest of central Kabul. In terms of soil texture, both profiles generally range from silt loam to loam. The calcium carbonate content can reach up to 15%, and the soil is alkaline. The amount of plant-available potassium in the soil profiles is sufficient, and no potassium deficiency is observed. However, plant-available phosphorus is deficient, with concentrations below

100 mg/kg. Lead concentrations in both soils reach up to 4 mg/kg, below the permissible limit of 27 mg/kg, and therefore do not pose a significant risk.

Similarly, copper and nickel concentrations do not indicate toxicity. Cadmium (Cd) is the only heavy metal of concern, occurring at concentrations between 1 and 3 mg/kg, which are considerably higher than the permissible limit of 0.1–0.5 mg/kg. Therefore, cadmium may harm living organisms and the environment. However, because the soils are alkaline, cadmium solubility and mobility may be limited, reducing its immediate bioavailability in the soil solution. Overall, heavy-metal concentrations such as copper, lead, and cadmium are relatively high in both soil profiles compared with those in Profile 1 in Char Asyab. This may relate to historical heavy-vehicle traffic and, more likely, the presence of the former Soviet army near the road (Redman, et al. 2002; Selley, 2000). This estimation is extrapolative, based on historical events since 1970 that kept the region in a constant state of conflict.

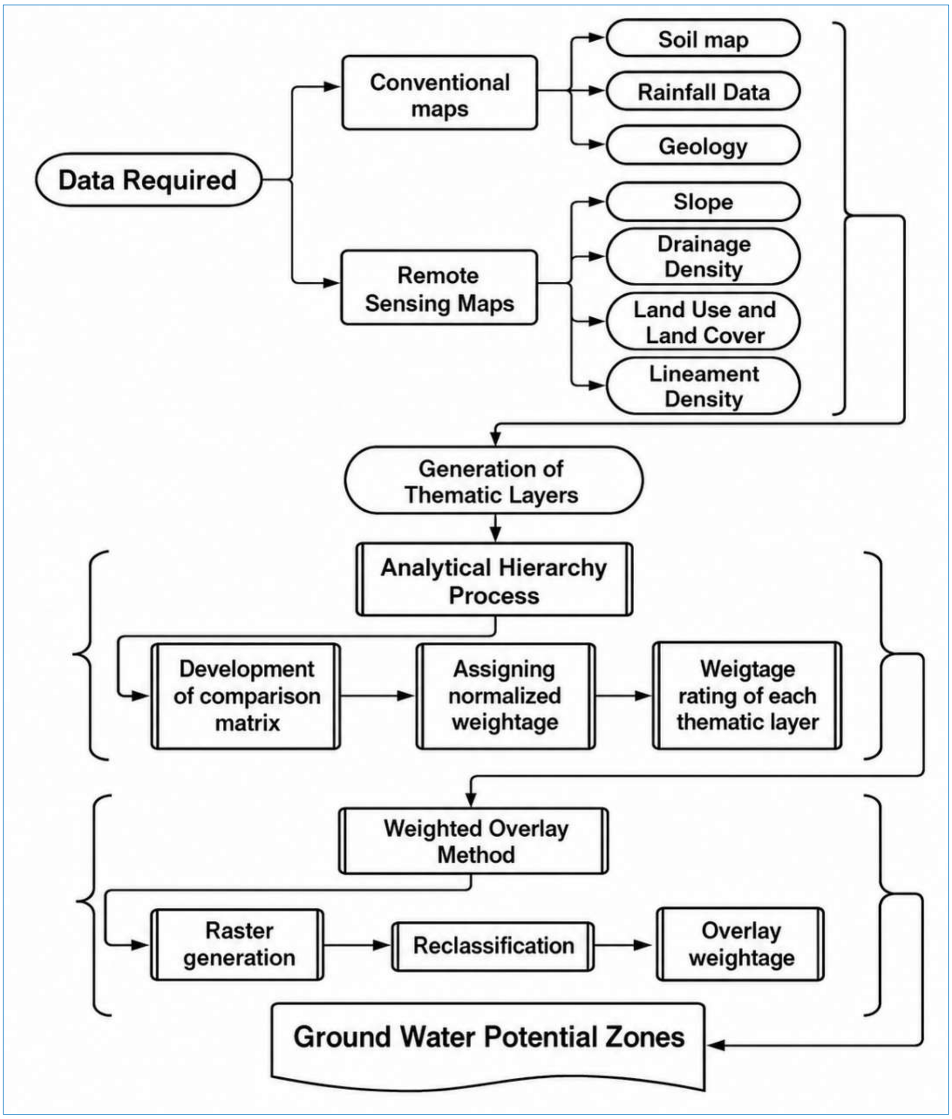

Fig. 3. Process flow diagram for the identification of Groundwater Potential Char Asyab

In general, heavy metals in Afghanistan's soils have not been extensively studied. Therefore, this study first investigates the Chahar Asyab area to identify the primary factors driving heavy-metal accumulation. Although heavy trucks and heavy-vehicle traffic are currently limited in Chahar Asyab, the area formerly contained a Russian military base with heavy vehicles and tanks. Because different heavy-metal concentrations can negatively affect animals, plants, and the broader environment, we investigated soil profiles in these areas. We excavated the profiles, collected representative samples, and analyzed the results using modern laboratory equipment. The findings provide important information for public awareness and environmental assessment (Ruleman et al., 2007; Saada, et al., 2003; Leeder, 2003)

2.1. Objective of This Investigation

This field and laboratory research aimed to identify the sources, distribution, and concentrations of selected heavy metals in the soil and to project their potential adverse effects on the local environment, including plants, animals, microorganisms, and human health. While the laboratory work consists of contaminant characterization, the correlation with potential adverse impacts on the environment and health is projected based on literature data.

3. Research Method

This study consists of three main parts.

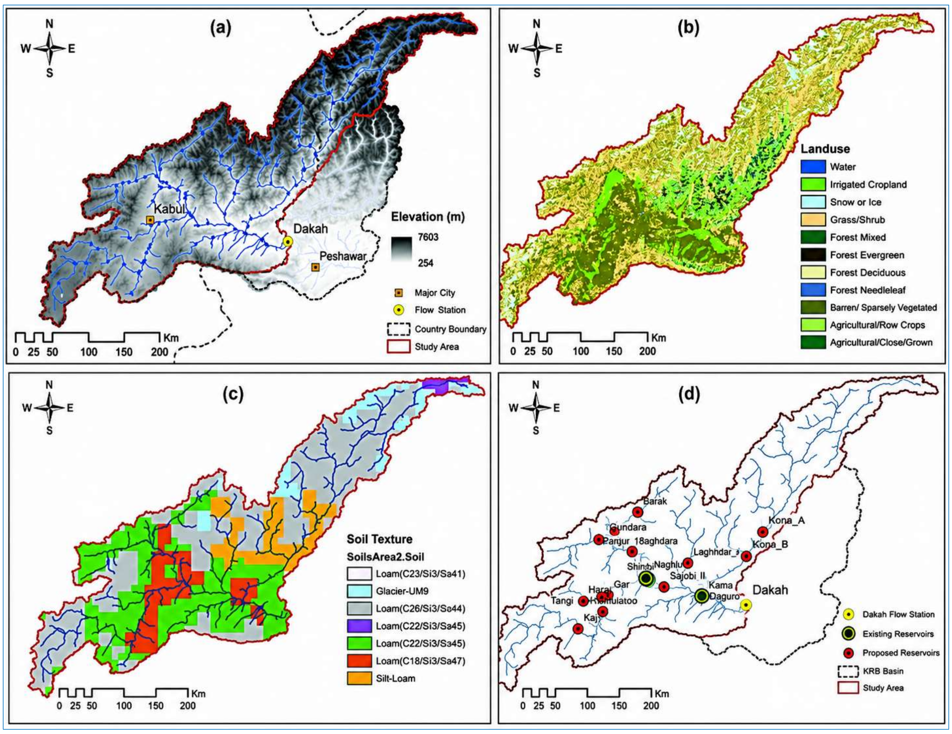

Fig. 4. Some parts of the Chahar Asyab River Basin (Study Area) spatial maps: a) digital elevation model (DEM) and flow stations, b) land-use Map, c) soil type map and d) the existing and proposed reservoirs in some parts of the Chahar Asyab River Basin [Color online]

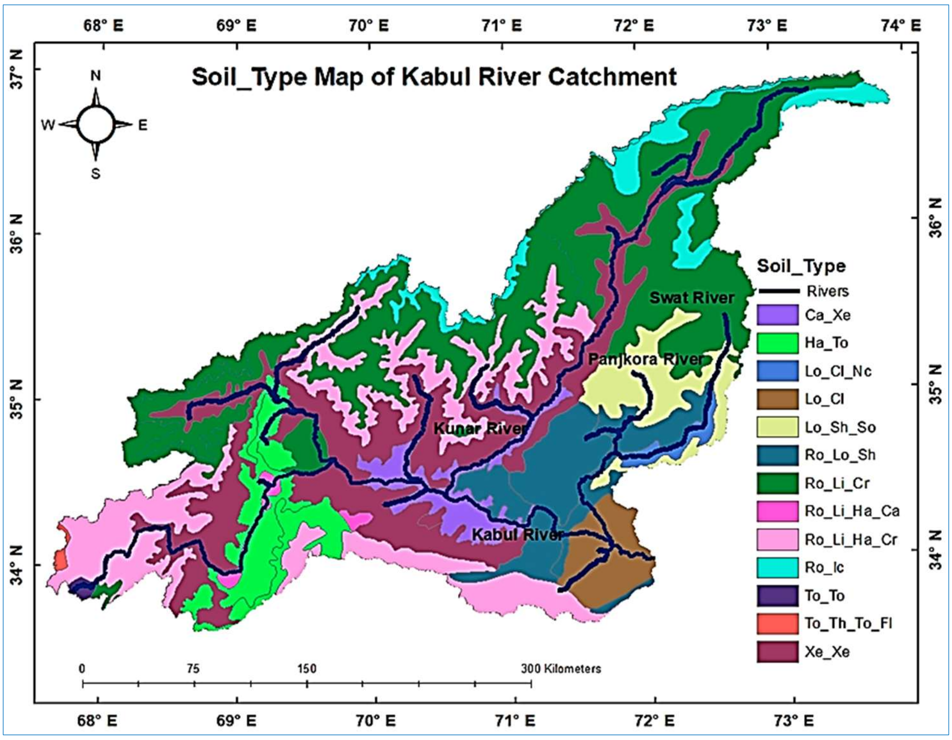

Fig. 5. Soil map of the Chahar Asyab River Basin

3.2. Laboratory Works

The laboratory work related to this research is performed in the laboratory of the Department of Geology, Faculty of Geology, which includes the following steps:

- When the sample is transferred to the laboratory, it is dried for 24 hours in an electric oven at 30 degrees Celsius,
- Determination of calcium carbonate by Calcimeter in the

presence of 14% acid,

- Determination of the density or mechanical breakdown of soil samples by hydrometer,
- Determination of the types of soil porosity by Richard's pot pressure.

All laboratory work was conducted in the Department of Geology laboratory. The topographic map was used to determine profile locations.

- The profiles were excavated with a shovel, and each of them was dug to a depth of 95 cm, which is the layer (C-Horizon), and from each soil layer, the layers (A-B-C-Horizons), one kg sample was taken for chemical analysis. has been.
- Soil color was determined by comparing Monzel color charts.
- Soil pH in pure water and n / 10 Kcl determined by an electrical electrode.
- The amount of calcium carbonate was determined by the Scheibler instrument in 14% hydrochloric acid (HCL) by gasometry.
- The size of soil particles was determined by hydrometry.
- Determination of the size of organic matter by the Walkley-Black method.
- Determination of potassium and phosphorus before plant availability, as well as Ni, Pb, Cu, and Cd, by Flame Atomic Absorption Spectrometer, Department of Soil Science (Fig. 3).

4. Results and Discussion

The results from field observations and laboratory analyses of Chahar Asyab soils in the upper sedimentary basin of Kabul are presented below (Rasouli et al., 2015; Rasouli, 2020; Rasouli et al., 2021).

Profile locations: As shown in Fig. 1, profile 1 is from the soil profile. The section below describes the location and raw materials investigated for the research profiles. The raw material of this soil is sandy loam, which is the lower sea terrace of the Logar River in the Chahar Asyab (Sree Devi et al, 2001; Thornthwaite, 1948; Torge, 2003). At the time of the research, the soil in this profile was thorny and not ready for cultivation. The soil formed morphologically as follows: approximately 200 meters southeast of the tomb in Kabul city (Fig. 7).

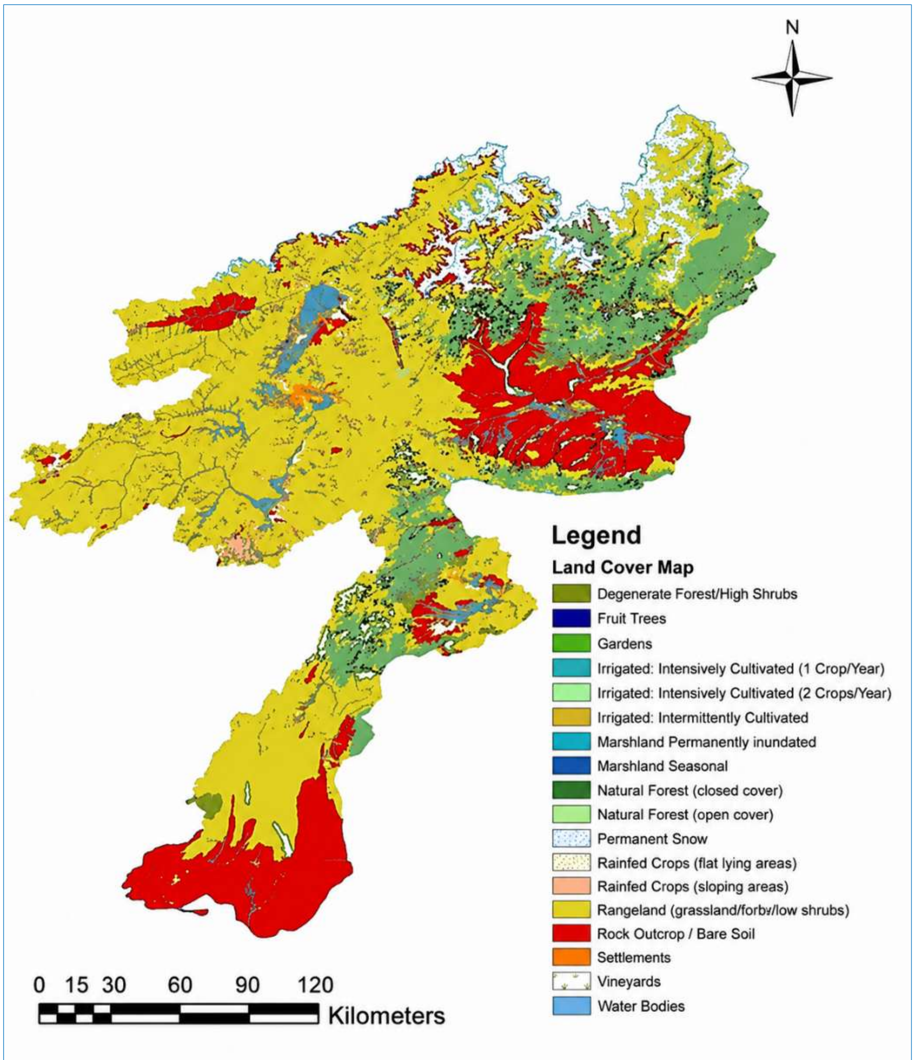

Fig. 6. Land cover map of some parts of the Chahar Asyab River Basin

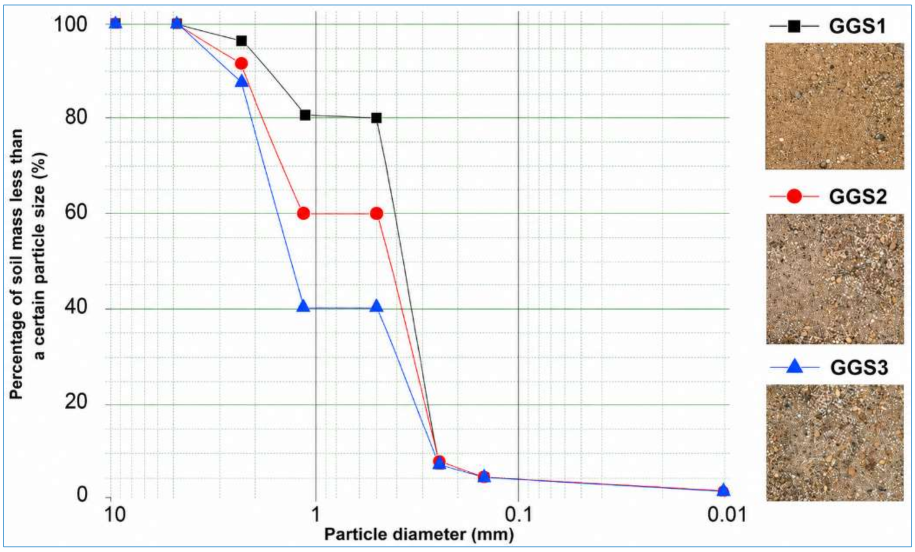

Fig. 7. Soil profile study

4.1. Profiles studied

4.1.1. Profile 1

Soil type: Loamy silty soil, brownish appearance.

Layer A: h (0 -28 cm) Light silty sand, earth color brown (7.5 YR) in dry and dark brown (7.6 YR) in moist, slightly humus condition. Well-grown and developed plant roots. Earthworm holes are sufficiently filled and have a weak stem-like structure. Weak platy structures.

Bgo layer - (28 – 61 cm) overall light brown loam color (7.5 YR, 7/2) in dry brown color (5.2 YR, 5/2) in wet condition. Porous polyhedral structure, with single roots, brown spots, white oxides, and iron oxide carbonate.

Layer – Cgo (61- 95 + Cm) brown loam silt (7.5YR, 5/4) in dry and dark brown (7.5YR, 4/4) in wet state with earthy white spots, partly black in proportion to organic matter, porous polyhedral subaltern structure.

4.1.2. Profile 2

The raw materials of this soil profile are the sediments of the lower terrace of the Narkh River, which is located in the Lalandar Strait and enters the upper basin of the Kabul sediments. The soil in this area is also barren during the propagation period, but it can be prepared for spring cultivation.

The morphological formation of the soil is as follows. Location of Profile 2: 150 meters east of Chahar Asyab Palace on the Chinese hive farm. Soil type: brownish soil, cerasium.

Layer – Ah (0 – 23 cm) light brown sandy loam silt (10 YR. 6/3) in dry condition, brown to dark (10YR, 4/3) in wet condition, very little humus, partially spherical structure, with 1–5 Cm round silt from the top to the bottom, the overall size decreases and the opposite increases, the structure of the crotovina (earthworm waste material) is also seen.

Layer – B (23- 44 cm): light yellow-brown loam (10YR, 6/4) in dry conditions, brown to dark brown (10 YR, 4/3) in wet conditions, with a porous sub-polyhedral structure; single plant roots and 5-inch stone clusters are seen.

Stratum – C (64 – 95 + cm) Yellow-brown loam silt (10YR, 6/6) in dry state, yellowish-brown (10 YR, 5/4) in wet state, coherent to sub-polyhedral structure.

Grain composition of Profile 1: According to the grain composition, this soil is generally loam, with sand content in the Ah and Cgo layers (38-31%) but in the Bgo layer reaching 17%. The amount of silt in all soil layers of this soil was almost the same.

The overall extent of this increases from stratum Ah (21.3%) to 32.3% in stratum Bgo but decreases to 18.6% in stratum Cgo (Fig. 8).

4.1.3. Chemical properties of soil profile 1

A. Soil pH of Profile 1: In all three soil layers, the soil pH is higher than 8 and therefore has alkaline properties. Therefore, its calcium carbonate content increases slightly from top to bottom, i.e., from 15% in layer Ah to 16-2% in layer Cgo.
B. Potassium and phosphorus are available to plants: The amount of potassium in the Ah layer is approximately 12 mg/kg of soil. In comparison, in the Bgo and Cgo layers, it decreases to 7mg/kg of soil.
C. Cation exchange capacity (CEC), alkaline cation exchange capacity (BEC), phosphorus and potassium available to plants: This soil is equal to 32mg/kg of soil in the Bgo, Ah layers, while in the Cgo layer it is 21.2 mg/kg The soil was determined, and in the Bgo, Ah layers was reduced to approximately 1.2 mg/kg of soil. Plant-available potassium and phosphorus decreased from 4.7 mg/100 gr in the Cgo stratum to 2.7 mg/gr soil, and phosphorus decreased from 11.8 mg/kg in the Ah stratum to 7 mg/kg soil in the lower stratum. are. The degree of alkaline saturation (BSP) in this soil towards the bottom is generally 73%-76%, indicating an abundance of carbonates. Table 1 reveals this fact.

D. The amount of organic matter in both soils is not more than one percent.

Heavy elements: Heavy elements that are determined and investigated based on milligrams per kilogram of soil. These are Cd, Pb, Cu, Cr, Zn, and As in the soil of profile 1 without nickel: 19.1 mg/kg in the Bgo layer; 14 mg/kg in the Ah layer; and 14 mg/kg in the Cgo layer.

The amount of lead (Pb) was determined from 4mg/kg soil in the Ah strata and 30 mg/kg soil in the Bgo and Cgo strata. Cadmium (Cd) was 2.2 mg/kg in the Ah layer and 1.3 mg/kg in the Bgo and Cgo layers.

In contrast, the average amount of copper (Cu), zinc (Zn), and Chromium (Cr) in all three soil layers (Ah Horizon - Bgo - Cgo -) was about 5.5 mg/kg, but Arsenic (As) was presented in horizon 1 very small amounts in horizon 1 (Table 1).

Grain composition of Profile 2: The soil of this profile is silt loam in grain size (texture), but in layer B, the total amount is the same (33.10%) as in the upper and lower layers and is called loam total. Silt size is 70.30% in stratum B and between 60 – 66 % in strata A and C.

The amount of sand in this soil is approximately 7% in layer B and 11- 12% in layers A and C respectively (Fig. 9).

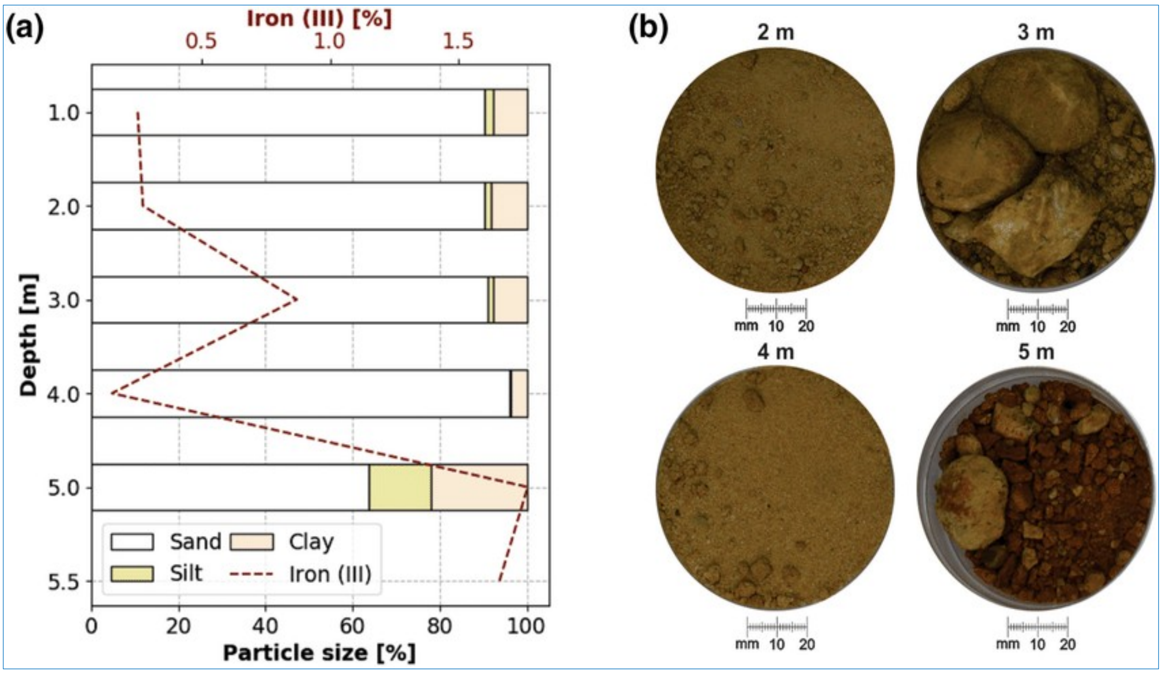

Fig. 8. Soil profiles study

4.1.4. Chemical properties of soil profile 2

A. pH: This soil is above 8 in all three soil layers and is alkaline; accordingly, the amount of calcium carbonate is 15.5-16.2%.
B. Potassium and phosphorus available to plants: The amount of potassium from the Ah layer gradually decreased from 7.8 to 4.6 mg/kg of soil. However, phosphorus decreased by half, while potassium increased, from the upper to the lower layer.

4.2. Cation Exchange Capacity (CEC) and Basic Cation Exchange Capacity (BEC)

The cation exchange capacity of the Ah stratum was 48.0 mg/kg of soil, but in the C stratum it was reduced to 43mg/kg of soil. Similarly, the exchange capacity of alkaline cations in layer B was approximately 36mg/kg of soil. However, in layers Ah and C, this value was nearly equal, at about 32mg/kg of soil. The percentage of alkaline elements (Basic saturated percentage, BSP) in the Ah stratum of the soil increased by 67%; in the B stratum, it increased to 75.5%; and in the C stratum, it decreased to 73.7%, generally indicating the alkaline property of the soil.

Heavy elements: Heavy elements in this soil were also similar to those in profile 1: Ni, Pb, Cd, Cu, Cr, Zn and As. The average amount of nickel in all three soil layers of this profile was 25 mg/kg of soil; the amount of lead in layers A and B of this soil decreased by 2.5 mg/kg of soil. The amount of Cd in the upper layer of this soil is 2.5mg/kg and in layers B and C of this soil is 3 mg/kg of mature soil. Copper content increased to 7.5 mg/kg Ah in layer B and 10 mg/kg in layer C, but decreased to 8.4 mg/kg in layer C.

4.3. Discussion of Results

Although soil profiles No. 1 and 2 are located about 5 km apart and their raw materials are the lower marine terraces, they are still considered silt loam based on the texture results. pH 4: Both soils are alkaline because the amount of calcium carbonate is between 10-16%, that is, the higher the amount of calcium carbonate in the soil, the more alkaline the pH 8. The amount of potassium available to plants in both profiles was appropriate because sufficient orthoclase and muscovite minerals were released over time through chemical degradation, and their deficiency was not felt. The deficiency of plant-available phosphorus in the investigated soil appears to be less than 100 mg/kg of soil in the both soil profiles (9). The amount of the heavy element nickel is within the permissible limit of 38 mg/kg of soil and does not cause any adverse effect on microorganisms and plants. Lead levels in both soil profiles were nearly equal and below the permissible limit.

Table 1. The levels of heavy element concentrations (mg/kg) in the soil samples

Sample site	Cd (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	Cr (mg/kg)	Zn (mg/kg)	As (mg/kg)	Ni (mg/kg)
SP_1	2.2	4.2	5.5	19.1	19.3	0.0065	19.1
SP_2	2.3	4.3	5.6	19.2	19.2	0.0065	19.2
SP_3	2.3	4.4	5.5	19.3	19.3	0.0065	19.1

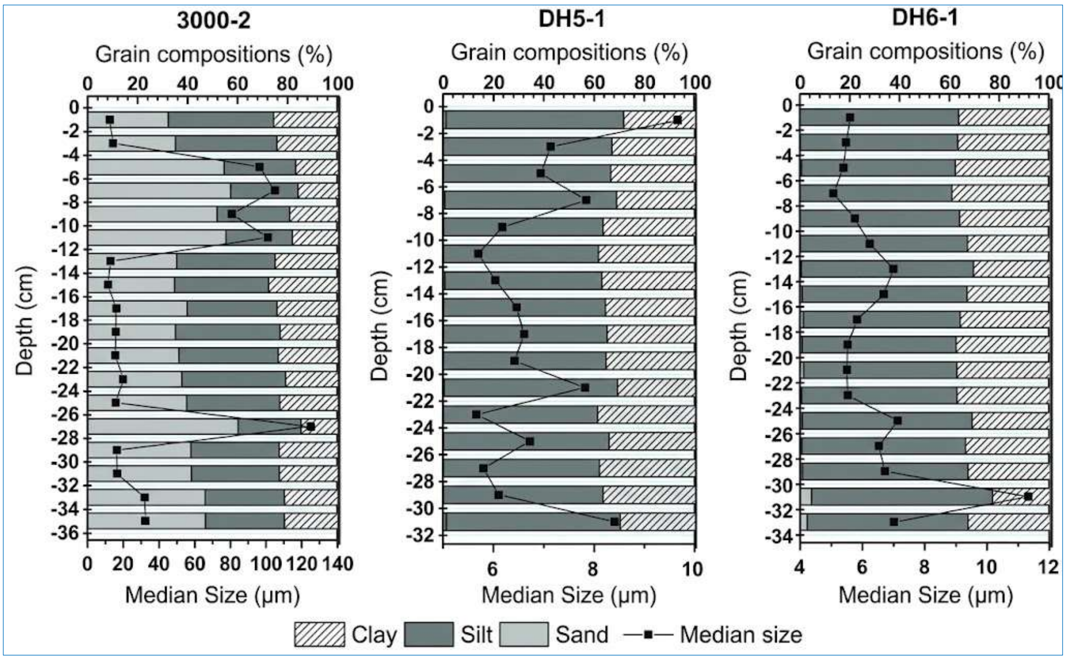

Fig. 9. Grain size composition of soil

It does not pose any risk to animals and plants, but the cadmium content is higher than the permissible amount of 0.1-0.5 mg kg. In both profiles, 1 to 3.5 mg/kg of cadmium is toxic and harmful. However, because the soils investigated are alkaline and the element does not dissolve in alkaline soils, it does not cause adverse consequences for the soil or subsoil. However, when the amounts of cadmium in the soils of the university and Chahar Asyabis are compared, it is seen that the amount of the above-mentioned element in the soil of Chahar Asyabis is high, and the reason for this is the passage of vehicles and heavy tanks of the former Soviet forces at that time. Cars and heavy tanks mix the smoke from their engines into the air and penetrate the ground with rainwater, causing various diseases such as cancer and chromosomal damage. Therefore, due to the breakdown of chromosomes, defective children are born, which causes suffering to parents and themselves throughout their lives.

Finally, the soil in both profiles was alkaline (pH > 7), and the elements mentioned in the soil began to dissolve as the pH decreased to 6- 4 and then increased to pH = 4. They are discharged into the groundwater mixed with rainwater.

5. Conclusion

This study focused on characterizing selected chemical and physical soil properties, identifying soil-layer types, and vertically profiling subsurface strata in different parts of Kabul City. The investigation included field surveys and laboratory analyses to assess spatial variations in soil characteristics and potential contamination. Field activities included recording the geographic coordinates of sampling points and points of interest, consulting topographic maps, excavating and documenting soil profiles, describing individual soil horizons, determining soil-layer colors, and collecting representative samples for laboratory analysis. Particular attention was given to variations in soil properties among different areas of Kabul, including Chahar Asyab, Paghman, Shioki, and the Four Mills area. The results and observations indicate spatial differences in the concentrations of potentially harmful elements in soil and groundwater. Some areas showed elevated concentrations of elements such as cadmium (Cd) and arsenic (As), potentially reflecting weathering and transformation of parent rocks, anthropogenic activities, and other sources of environmental contamination. However, the reported association between elevated concentrations of these elements and increased cancer incidence should not be interpreted as a causal relationship without epidemiological data and appropriate statistical analysis. Establishing such relationships requires systematic investigation, including representative environmental sampling, exposure assessment, health surveillance, and appropriate control of confounding factors.

Similarly, deteriorating wintertime air quality in Kabul warrants attention. The widespread combustion of plastic, rubber, and other waste materials for domestic heating can release particulate matter and hazardous gaseous pollutants, including carbon monoxide, volatile organic compounds, polycyclic aromatic hydrocarbons, and other toxic combustion products (Stabnikova et al., 2021; Stabnikova et al., 2022). These emissions may contribute to respiratory and cardiovascular health risks and should be investigated through integrated air-quality monitoring and exposure assessment.

Groundwater quality should likewise be evaluated comparatively across different sectors of Kabul. Preliminary observations suggest spatial variability in the concentrations of potentially harmful constituents, with elevated levels reported in some areas, including Paghman and Chahar Asyab. To establish reliable spatial patterns, collect samples systematically from multiple locations, depths, geological settings, and potential contamination sources. Standardized sampling, preservation, laboratory analysis, quality assurance/quality control procedures, and appropriate statistical methods are essential for distinguishing natural geochemical variability from anthropogenic contamination. Integrating soil, groundwater, geology, land-use, and demographic information would further improve interpretation of contaminant sources and potential exposure pathways.

Controlling the factors contributing to soil, water, and atmospheric pollution in Kabul is critically important but challenging. Prolonged conflict, rapid urban expansion, inadequate environmental infrastructure, limited monitoring capacity, and insufficient enforcement of environmental regulations have likely contributed to the persistence and spatial distribution of contaminants. Limited financial and technical resources within municipal authorities, research institutions, and academic laboratories further constrain systematic environmental assessment and remediation. Population growth, poverty, inadequate waste-management practices, and poor living conditions in some urban and peri-urban communities compound these challenges.

Although this investigation primarily focused on the elemental and physicochemical characterization of soils, it considered potential implications for human and environmental health through a review of relevant scientific literature. The findings provide an initial basis for understanding the distribution of selected chemical constituents in Kabul's soil and sediments and highlight the need for more comprehensive environmental investigations. The Department of Geology at the Faculty of Geology has laboratory capabilities to evaluate selected physical and chemical soil properties; however, collaboration with national and international universities, government ministries, environmental agencies, and specialized analytical laboratories could substantially strengthen the scope and reliability of future investigations. Access to advanced analytical techniques, including inductively coupled plasma mass spectrometry (ICP-MS), inductively coupled plasma optical emission spectrometry (ICP-OES), X-ray fluorescence (XRF), X-ray diffraction (XRD), and complementary hydrochemical and mineralogical methods, would enable more accurate identification and quantification of potentially hazardous elements and their geochemical associations. Future research should adopt an integrated, multidisciplinary framework combining geological, geochemical, hydrological, environmental, public-health, and spatial-analysis approaches. Long-term monitoring of soil and groundwater quality, coupled with systematic assessment of atmospheric pollution and exposure pathways, would help establish temporal trends and identify priority areas for intervention. Where contamination is confirmed, follow source identification with risk assessment, remediation planning, and evaluation of mitigation effectiveness. Particular attention should be given to potentially toxic elements such as arsenic, cadmium, lead, chromium, mercury, and other contaminants of environmental significance.

Continued environmental degradation could increase risks to Kabul's population if effective monitoring and mitigation measures are not implemented. Therefore, researchers, environmental professionals, public-health specialists, policymakers, and relevant government institutions should collaborate to establish a scientifically robust environmental monitoring and management framework. Because soil and water are fundamental resources for human health, agriculture, ecosystems, and socioeconomic development, their protection requires sustained scientific investigation, effective regulation, responsible waste management, pollution prevention, and evidence-based remediation. This study is a useful preliminary step toward a more comprehensive understanding of soil and groundwater contamination in Kabul. It provides a foundation for future research, environmental risk assessment, and sustainable resource management.

.

Data Availability Statement

Data is contained within the article.

Funding

This research received no external funding.

References

Ando, S., Garzanti, E., Padoan, M., Limonta, M. 2012. Corrosion of heavy minerals during Weathering and diagenesis: A catalog for optical analysis. Sedimentary Geology 280, 165-178. https://doi.org/10.1016/j.sedgeo.2012.03.023.

Asaad, F.A., Lamoreaux, P.E., 2004. Field methods for geologists and hydrogeologists. Springer-Verlag Berlin, Heidelberg.

Banks, D., Soldal, O., 2002. Towards a policy for sustainable use of groundwater by non-governmental organizations in Afghanistan. Hydrogeology Journal 10, 377-392. https://doi.org/10.1007/s10040-002-0203-y.

Bohannon, R.G., Turner, K.J., 2005. Geologic map of quadrangle 3468. Chak-e-Wardak (509) and Kabul (510) quadrangles: Afghan Open-File Report (509/510), 1001.

Bohannon, R.G., Turner, K.J., 2007. Geologic map of quadrangle 3468, Chak Wardak-Syahgerd (509) and

Kabul (510) quadrangles, Afghanistan (No. 2005-1107-A). Geological Survey (US).

Biswas, T.D., Mukherjee, S.K., 1994. Textbook of soil science, second edition. Tata McGraw Hill Education Private Limited: New Delhi.

Grotzinger, J.P.S., 2007. Understanding Earth, Fifth Edition. W. H. Freeman and Company, 41 Madison Avenue, New York, NY 10010.

Karathanasis, A.D., 2010. Composition and Transport Behavior of Soil Nanocolloids in Natural Porous Media, in: Frimmel, F. H., and Niebner, R., Ads., Nanoparticles in the Water Cycle, Chapter 4, Springer-Verlag, Berlin, Heidelberg.

Leeder, M., 2003. Sedimentology and Sedimentary Basins. Iowa State University Press, A Blackwell Science Company, 2121 S. State Avenue, Ames, Iowa, USA. PP: 56, 404, 445.

Maurice, E.T., 2001. Sedimentary Petrology, © 1981, 1991, 2000, Blackwell Ltd, a Blackwell Publishing Company.

Rasouli, H., 2020. Well design and stratigraphy of Sheerkhana Deep Well in Chak District, Wardak, Afghanistan. International Journal of Geology, Earth & Environmental Sciences 10 (2), 54-68.

Rasouli, H., Kayastha, R.B., Bhattarai, B.C., Shrestha, A., Arian, H., Armstrong, R., 2015. Estimation of discharge from Upper Kabul River Basin, Afghanistan using the snowmelt runoff model. Journal of Hydrology and Meteorology. 9 (1), 85-94. https://doi.org/10.3126/jhm.v9i1.15584.

Redman, A.D., Macalady, D.L. And Ahmann, D., 2002. Natural Organic Matter Affects Arsenic Speciation and Sorption onto Hematite. Environmental Science & Technology 36, 2889-2896. http://Dx.Doi.Org/10.1021/Es0112801.

Selley, R.C., 2000. Applied Sedimentology, Second Edition. A Harcourt Science and Technology Company, 525 B Street, Suite 1900, San Diego, California 92101-4495, USA. https://www.Apnet.com.

Ruleman, C.A., Crone, A.J., Machette, M.N., Haller, K.M., Rukstales, K.S., 2007. Map and database of probable and possible Quaternary faults in Afghanistan. US Geological Survey Open-File Report. 1103 (1).

Saada, A.D., Breeze, D., Crouzet, C., Cornu, S. and Baranger, P., 2003. Adsorption of Arsenic (V) On Kaolinite and on Hallolinite-Humic Acid Complexes: Role of Humic Acid Nitrogen Groups. Chemosphere 51, 757-763. https://doi.org/10.1016/S0045-6535(03)00219-4.

Stabnikova, O., Stabnikov, V., Marinin, A., Klavins, M., Klavins, L., Vaseashta, A., 2021. Microbial Life on the Surface of Microplastics in Natural Waters. Applied Sciences 11, 11692. https://doi.org/10.3390/app112411692.

Stabnikova, O., Stabnikov, V., Marinin, A., Vaseashta, A., 2022. The role of microplastic biofilms in the accumulation of trace metals in aquatic environments. World Journal of Microbiology and Biotechnology 38, 117. https://doi.org/10.1007/s11274-022-03293-6.

Sree Devi, P., Srinivasulu, S., Kesava Raju, K., 2001. Hydro-geomorphological and groundwater prospects of the Pageru River basin using remote sensing data. Environmental Geology 40 (9), 1088-1094.

Thornthwaite, C.W., 1948. An approach toward a rational classification of climate. Geographical Review 38 (1), 55-94. http://dx.doi.org/10.2307/210739.

Torge, T., Georg, H., Thomas, H., 2003. Hydrogeology of the Kabul Basin Part I: Geology, Aquifer Characteristics, Climate, and Hydrography [Internet]. https://www.bgr.bund.de/EN/Themen/Wasser/Projekte/abgeschlossen/TZ/Afghanistan/hydrogeology_kabul_basin_1.pdf?__blob=publicationFile&v=3. Accessed: Dec. 20, 2023.

Vaseashta, A., 2021. Introduction to Water Safety, Security and Sustainability. In: Vaseashta, A., Maftei, C. (eds) Water Safety, Security and Sustainability. Advanced Sciences and Technologies for Security Applications. Springer, Cham. https://doi.org/10.1007/978-3-030-76008-3_1.

Vaseashta, A., Gevorgyan, G., Kavaz, D., Ivanov, O., Jawaid, M., Vasović, D., 2021. Exposome, Biomonitoring, Assessment and Data Analytics to Quantify Universal Water Quality. In: Vaseashta, A., Maftei, C. (eds) Water Safety, Security and Sustainability. Advanced Sciences and Technologies for Security Applications. Springer, Cham. https://doi.org/10.1007/978-3-030-76008-3_4.

Vaseashta, A., Duca, G., Travin, S., (Eds.). 2022. Handbook of Research on Water Sciences and Society. IGI Global Scientific Publishing. https://doi.org/10.4018/978-1-7998-7356-3.