ISSN: 2586-6036
JWMAP website: http://accesson.kr/jwmap
doi: http://dx.doi.org/10.13106/jwmap.2025.Vol8.no1.31

An Assessment of the Impacts of Car Wash Stations Effluents on Surrounding Soil Properties in Gilgit Baltistan, Pakistan

Benish ZAHRA[1], Arisha AMAN[2], Woo-Taeg KWON[3]

[1.First Author] Researcher, Dept. of Environmental Health & Safety, Eulji University, Korea
Email: beenishmirza005@gmail.com
[2. Second Author] Researcher, Dept. Environmental Science Karakoram International University, Gilgit, Pakistan,
Email:arishaaman3@gmail.com
[3. Corresponding Author] Research Professor, Dept. of Environmental Health & Safety, Eulji University, Korea
Email: awtkw@eulji.ac.kr

Received: February 05, 2025. Revised: February 18, 2025. Accepted: February 18, 2025.

Abstract

Purpose: This study evaluates the impact of car wash operations on surrounding soil properties in Gilgit City. The research focuses on key soil parameters, including pH, electrical conductivity (EC), soil organic matter (SOM), soil organic carbon (SOC), and soil texture. Understanding these impacts is crucial for assessing potential soil degradation due to car wash effluents. **Research Design, Data, and Methodology:** A reconnaissance survey identified three car wash sites: Danyore, Dumiyal, and Nagaral. Soil samples were collected from these locations and analyzed for pH, EC, SOM, SOC, and texture composition. One-way analysis of variance (ANOVA) was conducted to determine mean differences among sites, while Pearson's correlation coefficient was used to examine relationships between soil properties. **Results:** Significant variations were observed in soil properties across the study sites. The highest pH was recorded in Danyore (7.7), followed by Dumiyal (7.5) and Nagaral (7.2). EC was highest in Dumiyal (5.1 mS/m), followed by Nagaral (2.9 mS/m) and Danyore (2.3 mS/m). The highest SOM and SOC levels were found in Nagaral (2.6%, 1.5%), followed by Dumiyal (2.5%, 1.4%) and Danyore (1.9%, 1.1%). Soil texture analysis revealed that sand content was highest in Danyore (73.2%), while silt content was highest in Dumiyal (61.2%). Clay content remained constant across all sites. **Conclusion:** The findings indicate that car wash activities significantly alter soil properties, leading to chemical and physical degradation. Increased EC levels and altered SOM and SOC contents suggest contamination from car wash effluents, which can negatively impact soil health. These results highlight the need for implementing environmentally friendly car wash practices, including wastewater treatment, to mitigate soil degradation and preserve soil quality in urban areas.

Keywords : Soil Contamination, Car wash effluents, Detergents, Environmental pollution

JEL Classification Code : Q15, Q24, Q51, Q56, R14, R52

1. Introduction

1.1. Background

Soil is defined in a variety of ways depending on its significance and function. According to Doran, soil is a natural resource that serves important ecological, economic, and social purposes. The top section of the earth's crust is composed of air and water-filled pores as well as organic and mineral substances. In accordance with the Natural Resource Conservation Service (NRCS), soil is "a natural body that is the mixture of solids (minerals and organic matter), liquid, and gases that occurs on the earth's surface, occupies space, and is distinguished by horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter or the ability to support rooted plants in a natural environment" (Staff, 2014). The border between the many spheres that exist on Earth, such as the geosphere, atmosphere, hydrosphere, and biosphere, is created by soil, which is a crucial component of the terrestrial environment. The foundation of our agricultural production is soil, which is a crucial element. It's crucial to maintain healthy, fertile soil for a better result. The ability of the soil to maintain ecological production, advance plant and animal health, and preserve environmental quality is one significant component that characterizes the soil's fertility. The ecological productivity of soil lowers the number of non-renewable inputs and polluting outputs while assuring the highest production feasible over the long run (Scoot & Cooper, 2002). The planet's vitality depends on the health of the soil. Chemical processes in the geochemical cycle. The soil sciences community has never argued an issue as contentious as soil quality assessment (Andrews et al., 2008). By reducing the quantity and variety of microorganisms in the soil, unconventional land management techniques can reduce soil quality (Morugán-Coronado et al., 2014). To evaluate soil quality, soil organic carbon is essential (Shukla et al., 2006). Soil quality is "the degree of fitness of a soil for a certain use" or "a composite measure of both a soil's capacity to operate and how well it works related to a specific use." The number of automobiles has grown as living standards and general wellbeing have improved. The number of vehicles washing stations has increased as a result. (Gregorich et al., 1994). Among the activities that need a lot of fresh water each day are car wash facilities. These enormous amounts of water bring dangerous chemicals, such as petroleum products, to the wastewater released into the environment (Baddour, 2012). If not handled carefully, the wastewater that is drained from vehicle wash operations will result in an environmental issue. It also uses a lot of water, which is then wasted and contaminates groundwater and soil with harmful chemicals, heavy metals, and other chemically inactive compounds (detergents). The following contaminants may be present in the car wash runoff.

- Phosphorus and nitrogen, which may cause the growth of troublesome plants in water courses.
- Oils and greases, which include dangerous substances such as benzene, lead, zinc, chromium, arsenic, cadmium, nitrate, and other metals such as copper resulting from auto brakes.
- Chemicals and oils are used for maintenance of cleaning machines.
- Chemicals, such as hydrofluoric acid and ammonium bifluoride products and solvent-based solvents, which are considered harmful to living organisms.

Car-wash effluents are the wastewater produced by the cleaning of motor vehicles, trucks, tanks, bicycles, and motorbikes. Detergents, gasoline, kerosene, and diesel are all used in car washes to clean the vehicle. Large amounts of water are used throughout the car wash operation, either to wash the automobiles or as a medium for a bigger attraction. Large amounts of wastewater are produced throughout the process, carrying with it leftover detergents and hydrocarbons. Water, which has been discharged from domestic dwellings, institutions, and commercial establishments (domestic wastewater and car wash) together with discharge from manufacturing industries (known as industrial wastewater), contains a large number of potentially harmful compounds. The numerous living forms that live in this water may suffer severe harm if it were to be released directly into a stream. Additionally, the use of watercourses by humans for washing, bathing, or as a source of drinkable water would pose significant concerns for the spread of a wide range of illnesses associated with water. Over time, man has contaminated water in a variety of ways. Industrial pollutants, agriculture runoff, and even home sewage have all polluted surface water (Ogedengbe & Elutade, 2003).

However, the chemicals and detergents used to wash automobiles have the potential to deposit heavy metals into the soil. Detergents may be a source of heavy metals including copper (Cu), as well as mercury (Hg), cadmium (Cd), lead (Pb), and zinc (Zn). In very small amounts, organisms need some heavy metals such as copper (Cu), iron (Fe), manganese (Mn), and zinc (Zn). However, using too much of these substances might endanger living things (Morgan, 2013). Since they are very detrimental to plants and animals, other heavy metals including Cd, Hg, and arsenic (a metalloid but commonly referred to as a heavy metal) are considered to be the "primary dangers" since they have no good effects on organisms (Marque et al., 2009). Vehicle wastewater (VWW) is contaminated with a variety of substances, including salts, organic debris, heavy metals, surfactants, asphalt, and petroleum hydrocarbon wastes (petrol, diesel, and motor oil) (Boluarte et al., 2016). Due to impurities that have been washed down from the vehicle's body, VWW is often greasy, oily, and quite turbid (Rai et al., 2018). The rhizosphere, where bacteria develop and dwell in thin water films around soil particles close to roots, is a crucial and essential component of the ecosystem.

Bacteria generally range in number from 100 million to 1 billion in a teaspoon of soil anyplace on Earth (Ingham, 2009), and they carry out several critical tasks linked to water flow, filtration, and nutrient cycling. They achieve this by forming micro aggregates, or microscopic collections of particles, which are formed when soil bacteria bind soil particles together with the substances they produce, such as polysaccharides and glycoproteins. This improves soil structure, speeding up water filtration and increasing the soil's holding capacity. As a result, several human actions that are frequently assumed to be safe, like washing automobiles, may really be harming the soil bacteria. There are two typical soaps used to wash cars. Common dish soap and high-quality automotive soap are two types of soap frequently used to wash cars. Water and surfactants are the two primary ingredients in both cleansers, and it is the latter that truly cleans and removes the dirt from the surfaces of the automobile (Duplessie, 2012). The definition of "clean" soil is necessary for soil quality evaluation (Sims et al., 1997). According to this definition, high-quality soil "...poses no harm to any typical usage by people, plants, or animals; not negatively impacting natural cycles or functions; and not polluting other environmental components" (Moen et al., 1988).

1.2. Objectives

- To assess the effect of car wash station effluents on soil properties.
- To investigate the variation of soil properties at different car wash stations in the study area

1.3. Hypothesis

- Soil properties are significantly affected by car wash effluents.

2. Literature Review

Soil serves as a fundamental natural medium that supports plant growth, sustains vegetation, and provides a habitat for various microorganisms, including algae, fungi, and insects. However, its quality is increasingly compromised by anthropogenic activities, particularly the disposal of hazardous waste and chemically contaminated wastewater. In many regions, including Pakistan, soil contamination has become a critical environmental concern due to the uncontrolled discharge of pollutants into the environment.

According to Morgan et al. (2013), detergents used in various industrial and domestic applications may serve as sources of heavy metals such as copper (Cu), mercury (Hg), cadmium (Cd), lead (Pb), and zinc (Zn). While trace amounts of some heavy metals, including Cu, iron (Fe), manganese (Mn), and Zn, are essential for biological functions, excessive concentrations pose severe risks to soil-dwelling organisms and overall soil health. Studies by (Elbagermi et al., 2021) highlight that professional car wash stations, while providing a convenient means for vehicle cleaning, contribute to environmental pollution due to their high-water consumption and chemical usage. Regulatory frameworks require these facilities to direct their wastewater into oil/water separators or clarifiers for pre-treatment before discharge into municipal wastewater systems (Marque et al., 2009). However, inadequate enforcement of such regulations often leads to the release of untreated effluents containing toxic heavy metals, hydrocarbons, and surfactants into the soil and surrounding water bodies.

Heavy metals such as Cd, Hg, and arsenic (As) are particularly hazardous due to their high toxicity and persistence in soil ecosystems. Bazrafshan et al. (2012) identified car wash operations as a significant source of water contamination, emphasizing the need for rigorous sampling and analysis to determine pollutant concentrations. Sangodoyin, et al. (1993) further noted that certain soil properties, such as cation exchange capacity (CEC) and pH, influence the mobility and bioavailability of heavy metals. Research by Nguegang et al. (2019) demonstrated that car wash effluents contain both chemical and microbiological contaminants that pose risks to human health and the environment when released into surface water systems. Kiran et al. (2015) found that professional car wash wastewater contains toxic petroleum hydrocarbons and heavy metal-rich contaminants, which, if directly discharged into surface waters, could result in severe ecotoxicological consequences.

Urban wastewater discharge into soil and freshwater bodies is a global environmental and public health issue (Sibanda, 2019). According to Chibuiku (2017), heavy metals persist in soil for extended periods, leading to bioaccumulation and toxic effects on soil microflora, vegetation, and higher organisms. Duplessie et al. (2012) observed that vehicle washing activities significantly increase heavy metal concentrations in soil sediments. Various surfactants, particularly anionic and nonionic surfactants, are widely used in vehicle cleaning products (Jarkle, 2017). Anionic surfactants, such as sodium sulfate, ammonium sulfate, and magnesium sulfate, alter soil properties when present in high concentrations. Roach (2017) found that excess sodium from these surfactants adversely affects soil moisture retention, leading to desiccation and microbial degradation. Greaves (1992) further demonstrated that increased soil salinity reduces bacterial diversity, negatively impacting plant growth. However, some surfactants, such as ammonium sulfate, exhibit low toxicity to soil bacteria even at high concentrations (Muller & Walter, 2018).

Car wash effluents are known to contain hazardous pollutants such as polycyclic aromatic hydrocarbons (PAHs), which pose inhalation, ingestion, and dermal exposure risks (Ritchie et al., 2003). Stamenov et al. (2015) emphasized that oil spills and petroleum-based contaminants have long-term detrimental effects on human health and soil ecosystems. De La Rosa et al. (2008) defined soil as a fragile surface layer composed of weathered rock fragments influenced by biological, chemical, and environmental processes. Soil plays a crucial role in carbon sequestration, water retention, and nutrient cycling, supporting diverse microbial and plant communities. However, contamination from heavy metals and other pollutants disrupts these functions, leading to biodiversity loss and soil degradation.

The pH of soil is a key indicator of its chemical properties, influencing microbial activity, nutrient availability, and pollutant mobility (De La Rosa et al., 2008). Barnes et al. (2016) reported that wastewater from car wash facilities introduces hazardous chemicals and suspended particulates into soil and aquatic ecosystems, adversely affecting human health, drinking water sources, and biodiversity. Larson and Pierce (1991) defined soil quality as its capacity to sustain ecological functions, including plant growth, water regulation, and contaminant filtration. They identified three primary soil functions: serving as a medium for plant development, controlling hydrological processes, and acting as an environmental filter.

This study highlights the critical role of soil in supporting ecological stability, agriculture, and sustainable development. However, rapid urbanization and increased vehicle ownership in Gilgit-Baltistan have led to a proliferation of car wash stations, many of which lack proper wastewater treatment systems. The discharge of untreated effluents containing detergents, hydrocarbons, and heavy metals into the environment can significantly alter soil composition and pose environmental and health risks. Despite the prevalence of car wash stations, limited research has been conducted to assess their impact on soil quality. Understanding the extent of contamination is essential for developing effective mitigation strategies to prevent long-term environmental degradation.

This study aims to assess the impact of wastewater discharge from car wash stations on soil quality by analyzing key soil parameters. The findings will contribute to the growing body of research on soil contamination and provide valuable insights for policymakers and environmental agencies. By identifying pollution sources and their effects, this study can support the development of sustainable environmental management practices, ensuring the protection and preservation of soil resources in urbanized regions.

3. Material and Methods

3.1. Study Area

3.1.1. Location of Gilgit-Baltistan

Gilgit-Baltistan lies in the northern part of Pakistan, formerly known as the 'Northern Areas'. Gilgit-Baltistan (GB) is surrounded by three mountain ranges: the Karakoram, the Himalayas, and the Hindu Kash. This area is highly elevated from sea level almost 1,500 m. K2, Nanga Parbat, and Rakaposhi which are the world's highest mountain ranges reside in this province. It is located at the junction between the three mountain ranges near the foothills of the Karakoram Mountains. It shares international borders with Afghanistan to the northwest, China to the northeast, and India to the east (Akbar, et al., 2010). Gilgit-Baltistan covers an area of approximately 72,496 km² and has an estimated population of 1.2 million (Population Census Organization). The region is administratively divided into seven districts: Astore, Diamer, Ghanche, Ghizer, Gilgit, Hunza-Nagar, and Skardu. The administrative capital of Gilgit-Baltistan is Gilgit City.

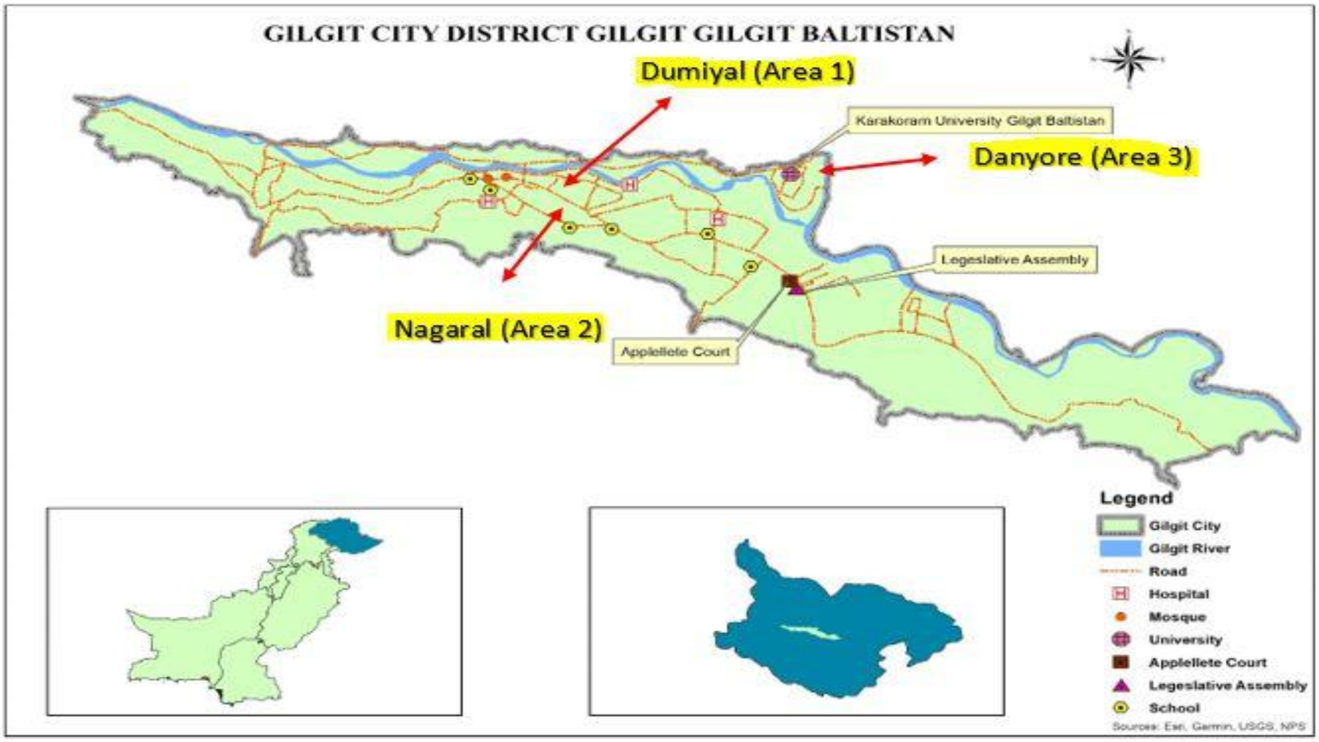

Figure 1: Study Area: Gilgit city, District Gilgit, Province Gilgit-Baltistan

3.1.2. Location of Gilgit City

The capital of Gilgit-Baltistan is Gilgit city. “The city is located in a broad valley near the union of the Gilgit River and Hunza River. The city extends from 35° 55' 0" North, 74° 17' 49" East” (wikipedia, n.d.). The total area covered by Gilgit city is 4208 km 2 and it is elevated at 1600 to 3000 meters above sea level. The boundaries of Gilgit City are linked with China in the northeast, Afghanistan in the north, Skardu in the east, Ghizar District to the west, and Astore and Diamer mostly distinguished by mountains covered with snow. The map of the study area in Figure.1

3.1.3. Climate

The region has dynamic climatic variations because of varied and diverse topography (Azam & Muhammad, 2009). Winter is the most dominant weather in the city, mostly comprised of eight to nine months a year. This region is covered with snowy mountains which impart its influence on climate parameters. Temperature shows a fluctuation from -10 in winter to 40 °C or above in summer. Most probably there is 120 to 240 mm of rainfall. Future temperature projections by Global Climate Models predicted that the temperature in Gilgit may rise up to 7°C by the end of the 21st century (Technical Report on Climate Change in Pakistan., 2013).

3.1.4. Population

The population of Gilgit city according to the senses conducted at the year of 1998 was 145,272 and now the population of Gilgit city is almost 216,760 (National Impact Assessment Programme, 1998).

3.1.5. Administrative Setup

Administratively Gilgit city consists of four Tehsils. Shina language is the main language and is spoken abundantly in this District. The Federal Government in Islamabad administers the northern area. In September 2009 the parliament of Pakistan passed a reform by declaring the Federally Administrative Northern Area as the province of Gilgit-Baltistan (GoGB) and the affairs were shifted from the center to the province.

3.1.6. Geographical Features

This district is a mountainous region containing the world's highest mountainous regions like Hind Kush, Karakorum, and Himalaya. It also contains an important site where two continental plates collided in the ancient era. Vegetation of Gilgit consists of grasses, shrubs/ herbs, and forests in mountainous areas. Most of the forest areas are Danyore, Karghah, Jutial, Naltar, Haramosh, Joglotgah, Bagrot, and Pahote.

3.2. Sampling Site

This data was collected from three main areas in Gilgit Danyore, chinar Bagh, and Nagaral. Four samples were collected from each station. These samples were collected from primary sources.

3.3. Material and Types of Equipment

Instruments used in the field are:

- Poly-ethane bags
- Shovel
- Gloves
- Labeling tape
- Markers(permanent)
- Notebook
- Dish

3.4. Sampling Procedure

Soil samples were collected from different car wash stations i.e. Nagaral, Dumiyal River View, and Danyoure. In each car wash station, Simple random sampling is used for soil sampling. The sample is taken from primary sources. Samples were collected from the upper layer of soil. The samples were labeled and packed in separate polyethylene bags. These samples were taken to a lab to be analyzed for physical and chemical parameters of the soil.

3.5. Physicochemical Parameters

1. Soil pH
2. Soil Electric conductivity
3. Soil organic matter (SOM)
4. Soil organic carbon (SOC)
5. Soil texture

3.6. Data Analysis

3.6.1. Laboratory Analysis

- Soil samples were air-dried and manually sieved through a 2mm sieve and some of the soil's physical and chemical properties were determined.

- EC will be measured by (OAKTON PC 700) Electrical conductivity meter the methodology which is given in US Handbook 60 (Richards 1954).

- Soil PH will be measured using the same instrument (OAKTON PC 700) PH probe with the glass-calomel electrode and 1:1 soil: water ratio (Mclean 1982).

- Soil texture will be measured by the soil hydrometer method (Gee and Bauder 1986).

- Soil organic matter and Soil organic carbon will be determined by dry combustion methods.

3.6.2. Statistical Analysis

Analysis of Variance (ANOVA) was used to determine the variation of soil physical and chemical parameters among different service stations. A least significant (LSD) comparison test was carried out to compare the statistical means difference of various stations. Correlation was done to determine the relationship between soil physico-chemical properties.

4. Results and Discussion

4.1. Soil Physico Chemical Parameters at Different Sites

The analysis of variance (ANOVA) was used to determine the impact of different car wash service stations on soil physical and chemical properties. The result of ANOVA showed that pH ($p<0.01$), Sand ($p<0.0001$), and Silt ($p<0.0001$) were significantly varied between service stations while, EC, SOM, and SOC were not significant (Table 1).

Table 1: ANOVA-F value with respect to different service stations

pH	EC (mS/m)	SOC (%)	SOM (%)	CLAY (%)	SAND (%)	SILT (%)
11.5^{**}	3.1^{ns}	0.48^{ns}	487^{ns}	0.1^{ns}	6.3^{***}	2.5^{***}

Note: p<0.05* p<0.01** p<0.0001*** (shows significant) ns"non-significant

Table 2: Mean and standard deviation of soil properties in different stations

SITES	pH	EC (mS/m)	SOC (%)	SOM (%)	CLAY (%)	SAND (%)	SILT (%)
NAGARAL	7.2 ±.09	2.9±6.8	1.4±0.3	2.5±0.6	4.0±0.1	57.6±0.0	38.3±0.0
DUMIYAL	7.5±.19	5.1±2.7	1.5±0.9	2.6±1.5	4.0±0.1	34.7±0.0	61.2±0.0
DANYORE	7.7±.12	2.3±8.5	1.1±0.5	1.9±0.9	4.0±0.0	73.2±0.0	22.8±0.0

The pH of the soil determines the degree of acidity or alkalinity of the soil environment (Hazelton and Murphy, 2016). Soil pH values below 7 indicate (acidic) soil, and above 7 indicate basic (alkaline) soil which is determined largely by soil composition, cation exchange processes, and hydrolysis reactions associated with the various organic and inorganic soil components as well as by the CO2 concentration in the gaseous and liquid phase (Thomas and Hargrove, 1984). The result of the present study showed that soil pH significantly varies between sites. The mean value of pH was found to be slightly higher in Danyore (7.7) than in Dumiyal (7.5) and was lowest in Nagaral (7.2) (Table 2, Figure 2). According to Elbagerma et al, (2021), Total Petroleum Hydrocarbons and Heavy Metal Concentrations in Soils around Car Washing Stations show that the average pH of the soil samples inside the stations ranged between (6.6 and 8.5). Soil pH is a major factor influencing the availability of elements in the soil (Marschner et al., 1995).

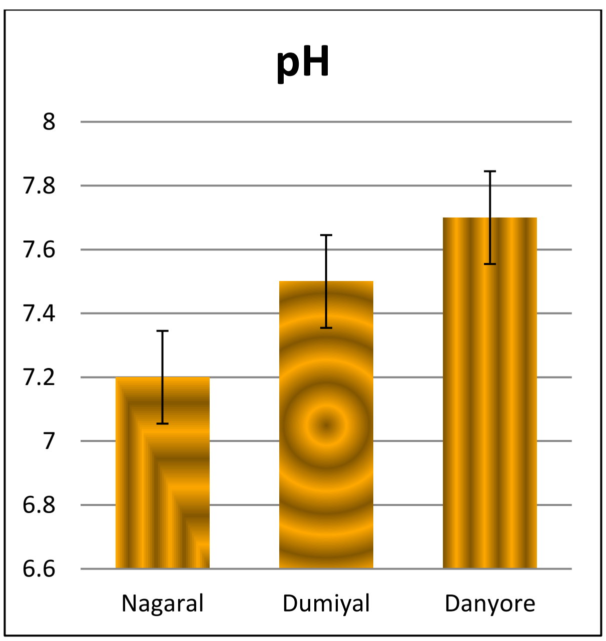

Figure 2: mean value of soil pH

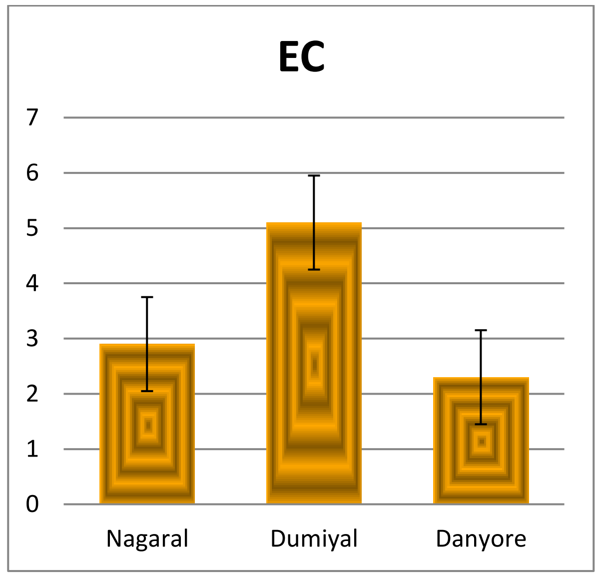

Figure 3: mean value of soil EC

Electrical conductivity (EC) serves as an indicator of soil microbial activity, nutrient cycling, and salinity, reflecting changes in soil structure, particularly in alkaline soils (Arnold et al., 2005). In this study, no significant differences in EC were observed between the study sites. However, the highest EC value was recorded in Dumiyal (5.1 mS/m), followed by Nagaral (2.9 mS/m) and Danyore (2.3 mS/m) (Table 2, Figure 3). Previous research suggests that soil EC is influenced by various environmental factors, including climate, geology, local biota, and anthropogenic activities that alter soil characteristics (Narshimha et al., 2013). A pH range of 7.3 to 8.5 typically indicates the presence of $CaCO_3$, while high EC values in saturated extracts reflect strong concentrations of neutral soluble salts. A pH exceeding 8.5 suggests significant levels of exchangeable CO_3. Pearson correlation analysis. (Table 4) revealed a negative relationship between EC and pH, soil organic matter (SOM), soil organic carbon (SOC), and sand content, while a positive correlation was observed with silt and clay content.

Soil organic matter plays a crucial role in determining soil quality (Komatsuzaki and Ohta et al, 2007). In this study, the highest mean values of SOC and SOM were recorded in

Nagaral (1.5% and 2.6%, respectively), followed by Dumiyal (1.4% and 2.5%) and Danyore (1.1% and 1.9%) (Table 2, Figures 4 and 5). Overall, the SOC and SOM levels were relatively low across all sampling sites, likely due to continuous soil compaction caused by vehicular movement and the disposal of toxic pollutants, both of which create unfavorable conditions for microbial activity. The post hoc least significant difference (LSD) test indicated that SOM and SOC did not show statistically significant differences among the study sites (Table 3). Pearson correlation analysis further demonstrated a strong positive correlation between SOC and SOM ($p<0.001$), while SOC exhibited a negative correlation with pH, EC, sand, and silt (Table 4).

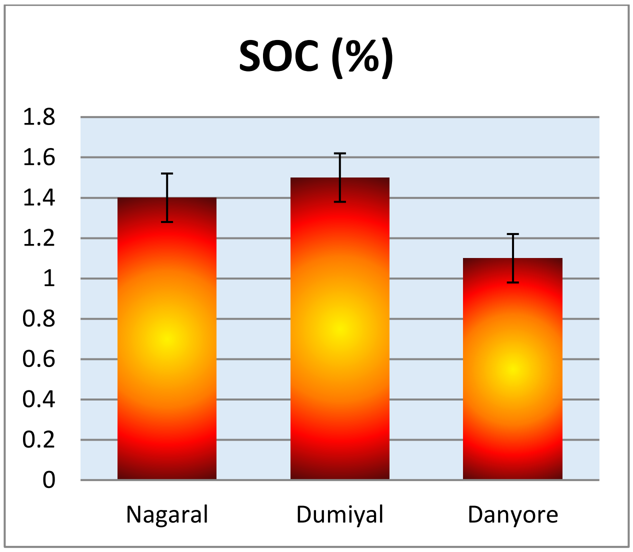

Figure 4: mean value of soil SOC

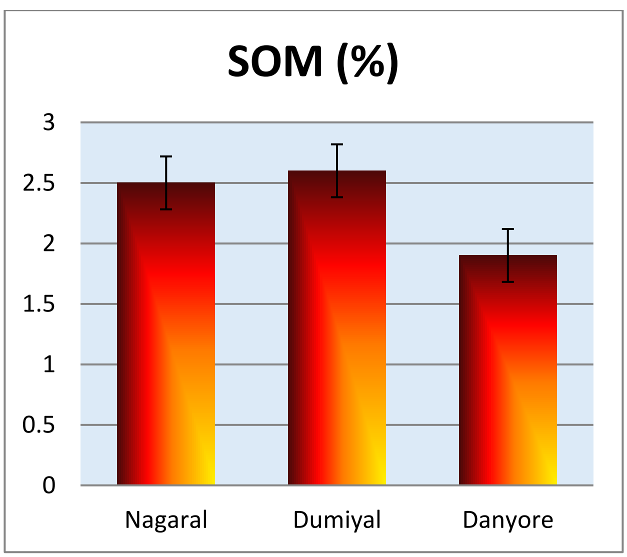

Figure 5: mean value of soil SOM

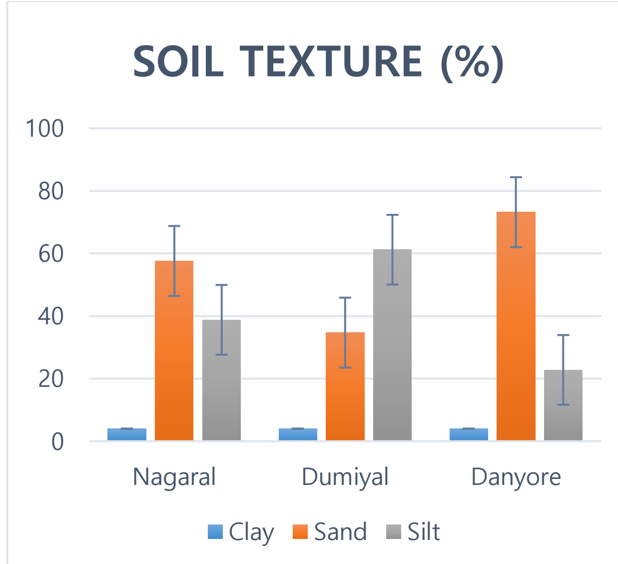

Figure 6: mean value of soil texture

Soil texture is one of the most important properties to know how to measure, as it affects many other chemical, physical, and biological soil processes and properties such as the available water-holding capacity, water movement through the soil, soil strength, how simply pollutants can leach into groundwater, and the natural soil fertility (Alam et al., 2020). The post hoc (LSD) test reveals that there were no significant changes in clay between Nagaral and Dumiyal, Nagaral and Danyore, and Dumiyal and Danyore. The mean value of clay was the same for all three sites. While the sand content was found high at Danyore (73.2%) followed by Nagaral (57.7%) and was lowest at Dumiyal (34.7%) respectively (Table 2, Figure 6). LSD test showed that there were no significant changes in the sand between Nagaral and Dumiyal, Nagaral and Danyore, and Dumiyal and Danyore (Table 3). The mean value of slit was highest in Dumiyal (61.2%) than Nagaral (38.3%) and Danyore (22.8%) (Table 2, Figure 6). The post hoc test showed silt content was highly significant between Dumiyal and Danyore, Nagaral and Danyore (Table 3). Due to the excessive use of chemicals and detergents at car wash sites chemical weathering has played an important role in increasing the quantity of clay, sand, and silt. However, it is observed that the concentration of clay is lowest in all three areas as compared to sand and silt due to the density of the clay being quite low and due to the excessive use of water at car wash sites, clay flows with the water quickly as compared to sand and silt (Foley, environmental characteistic of clays and clay mineral deposits, 2005).

Table 3: Post hoc test (LSD) among different service stations

Sites	Sites	pH	ECmS/m	SOC (%)	SOM (%)	CLAY (%)	SAND (%)	SILT (%)
Nagaral	Dumiyal	0.1^{*}	232^{ns}	0.05^{ns}	0.09^{ns}	0.00^{ns}	22^{ns}	22^{***}
Nagaral	Danyore	0.5^{**}	47^{ns}	0.36^{ns}	0.63^{ns}	0.00^{ns}	15^{ns}	15^{***}
Dumiyal	Danyore	0.2^{ns}	279^{*}	0.41^{ns}	0.72^{ns}	0.00^{ns}	38^{ns}	38^{***}

Table 4: Correlation between soil parameters under different sites

	pH	EC	SOC (%)	SOM (%)	CLAY (%)	SAND (%)	SILT (%)
pH	1						
EC	-0.3	1					
SOC (%)	-0.01	-0.2	1				
SOM (%)	-0.01	-0.2	1.0^{***}	1			
CLAY (%)	-0.29	0.2	0.06	0.06	1		
SAND (%)	0.29	-0.6^{*}	-0.2	-0.2	0.00	1	
SILT (%)	-0.29	0.6^{*}	0.2	0.2	0.00	-1.0^{**}	1

5. Conclusion and Recommendation

5.1. Conclusion

The present study indicated that the difference in use of chemicals and detergents for carwash purpose has significant influence on soil physicochemical properties. There was a significant difference for soil pH, EC, soil organic matter, soil organic carbon and soil texture among the three different locations in Gilgit city. SOC is negatively affected in these areas due to the usage of different chemicals in carwash station. Low SOC and SOM parameters in soil indicated lower soil quality based on our investigated soil properties (SOM, SOC, pH and EC) soil present in these areas is not fit for any productive activity especially for agricultural purposes. However, continuing monitoring of soil properties is needed to sustain soil health and to curb land pollution and sustain natural properties of soil. The results showed that the soil present in these carwash stations have lost its basic physical and chemical property, around these carwash stations physicochemical properties of soil are degraded and depleted. Degradation of physical and chemical properties of soil due to the use of different chemical and detergents had negative effects on deliberate soil properties. In order to sustain the natural property of soil and to control further degradation of the vital elements around these car wash station strict management practices are needed to improve the quality of soil and to curb heinous activity around important locations which will exacerbate the ongoing practices of pollution of the soil.

5.2. Recommendation

For the protection of the ecosystem from overexploitation of land the following practices are recommended

- Soil research was needed within small time frame in order to closely understand the pattern of pollution across the study area.
- Compelling car wash owners inside and outside cities to establish units for treating wastewater effluent and its reuse in car washing and cleaning purposes.
- Use of diesel in car wash stations inside and outside the city ought to be prevented.

- The consent of the Gilgit Urban Planning and Development Authority (GUPDA) for all activities must be sought for in the future for the master plan to its long-term objectives.
- The government can also establish a layout for car wash workers if treatment is required to sustain normal life is too expensive for them and channel their effluents to sewage treatment plant to avoid its usage for domestic and irrigation purposes.

References

Abdulsalam, W. A., & Ajiboso, O. O. (2003). Environmental impact assessment of Bida abattoir on receiving stream. *Nigerian Journal of Engineering and Applied Technology, 1*(1), 15–18.

Alam, S. I., Hammoda, H., Khan, F., Al Enazi, R., & Goktepe, I. (2020). Electrical conductivity, pH, organic matter and texture of selected soils around the Qatar University campus. *Research in Agriculture, Livestock and Fisheries, 7*(3), 403–409.

Bazrafshan, E., KordMostafapoor, F., Soori, M. M., & Mahvi, A. H. (2012). Application of combined chemical coagulation and electrocoagulation process to car wash wastewater treatment. *Fresenius Environmental Bulletin, 21*(9a), 2694–2701.

Baddour, M. I. (2012). *Treatment plants book (1)*. Institutes of Technological Engineering and Institutes of Technical Auditors, Ministry of Higher Education, Syria.

Barnes, L. L. (2016). *Best management practices for commercial car washes*. Great Lakes Pollution Prevention Round Table, United States Environmental Protection Agency.

Boluarte, I. A. R., Andersen, M., Pramanik, B. K., Chang, C. Y., Bagshaw, S., Farago, L., & Shu, L. (2016). Reuse of car wash wastewater by chemical coagulation and membrane bioreactor treatment processes. *International Biodeterioration & Biodegradation, 113*, 44–48.

Doran, J. W., & Parkin, T. B. (1994). Defining and assessing soil quality. *Soil Science Society of America, 35*, 3–21.

Elbagerma, M. A., Alkog, M., Alajtal, A., & Edwards, H. (2021). Assessment of the total petroleum hydrocarbons and heavy metal concentrations in soils around car washing stations in Misurata, Libya. *International Journal of New Chemistry, 8*(4), 453–473.

Environmental Protection Agency (EPA). (1995). *Federal Register Part XIV: Final National Pollutant Discharge Elimination System Storm Water Multi-Sector General Permit for Industrial Activities Notice.*

Gautam, P. K., Gautam, R. K., Banerjee, S., Chattopadhyaya, M. C., & Pandey, J. D. (2016). Heavy metals in the environment: Fate, transport, toxicity and remediation technologies. *Nova Science Publishers, 60*, 101–130.

Gregory, E. G., Carter, M. R., Angers, D. A., Monreal, C., & Ellert, B. H. (1994). Towards a minimum data set to assess soil organic matter quality in agricultural soils. *Canadian Journal of Soil Science, 74*(4), 367–385.

Hajjar, S., & Farhoud, N. (2012). *Treatment of hazardous waste*. University Directorate of Books and Publications, University of Aleppo, Syria.

Horst, M. (1995). Mineral nutrition of higher plants. *Acta Physiologiae Plantarum, 17*, 393.

Ishaq, S., Begum, F., Ali, K., Ahmed, S., Ali, S., Ali, H., & Ali, S. (2015). Soil quality assessment using selected physico-chemical indicators in Altit Hunza, Gilgit-Baltistan. *Journal of Biodiversity and Environmental Sciences, 6*, 454–459.

Karlen, D. L., Andrews, S. S., Wienhold, B. J., & Zobeck, T. M. (2008). Soil quality assessment: Past, present, and future. *Journal of Integrative Biosciences, 6*(1).

Keesstra, S. D., Geissen, V., Mosse, K., Piiranen, S., Scudiero, E., Leistra, M., & Schaik, L. V. (2012). Soil as a filter for groundwater quality. *Current Opinion in Environmental Sustainability, 4*, 507–516.

Komatsuzaki, M., & Ohta, H. (2007). Soil management practices for sustainable agro-ecosystems. *Sustainability Science, 2*(1), 103–120.

Larcher, W. (1980). *Physiological plant ecology* (2nd ed.). Springer-Verlag.

Larson, W. E., & Pierce, F. J. (1991). Conservation and enhancement of soil quality. *Evaluation for Sustainable Land Management in the Developing World.*

Marschner, H. (Ed.). (2011). *Marschner's mineral nutrition of higher plants*. Academic Press.

Moen, J. E. T. (1988). Soil protection in The Netherlands. *Contaminated Soil, 88*, 1495–1503.

Morgan, R. (2013). Soil, heavy metals, and human health. *Soils and Human Health*, 59–82.

Morugán-Coronado, A., Cerdà, A., & García-Orenes, F. (2014, May). The impact of land use on biological activity of agriculture soils: A state-of-the-art review. *EGU General Assembly Conference Abstracts*, 2499.

Parr, J. F., Papendick, R. I., Hornick, S. B., & Meyer, R. E. (1992). Soil quality: Attributes and relationship to alternative and sustainable agriculture. *American Journal of Alternative Agriculture, 7*(1–2), 5–11.

Rai, R., Sharma, S., Gurung, D. B., Sitaula, B. K., & Raut, N. (2018). Assessment of environmental impacts of vehicle wash centres at Olakha, Thimphu, Bhutan. *International Research Journal of Environmental Sciences, 7*, 1–10.

Ritchie, G. D., Still, K. R., Rossi, J., Bekkedal, M. Y. V., Bobb, A. J., & Arfsten, D. P. (2003). Biological and health effects of exposure to kerosene-based jet fuels and performance additives. *Journal of Toxicology and Environmental Health – Critical Reviews, 6*, 357–451.

Sangodoyin, A. Y. (1993). Considerations on contamination of groundwater by waste disposal systems in Nigeria. *Environmental Technology, 14*(10), 957–964.

Shukla, M. K., Lal, R., & Ebinger, M. (2006). Determining soil quality indicators by factor analysis. *Soil and Tillage Research, 87*(2), 194–204.

Sims, J. T., Cunningham, S. D., & Sumner, M. E. (1997). Assessing soil quality for environmental purposes: Roles and challenges for soil scientists. *Journal of Environmental Quality, 26*(1), 20–25.

Thomas, G. W., & Hargrove, W. L. (1984). The chemistry of soil acidity. *Soil Acidity and Liming, 12*, 3–56.

Usman, M. K. (2018). An assessment of the impact of car wash operations on surrounding soils in Katsina City. *Katsina*

Journal of Natural and Applied Sciences, 7(2).