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Characteristics of Agricultural Land in the Floodplain Area of the Tarusan Watershed, Pesisir Selatan, West Sumatra

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ABSTRACT

The numerous rivers and high rainfall in West Sumatra often lead to flooding, which affects several land uses such as settlements, plantations, and agriculture. During floods, water transports various materials from upstream to downstream, such as sand, mud, and clay, which are deposited in certain riverbanks. This study aimed to examine the soil fertility characteristics in the floodplain area. The method used in this research was a survey method with purposive random sampling at two soil depths: 0 – 30 cm and 30 – 60 cm. Samples were taken from two land uses: dryland agriculture and wetland agriculture. The parameters analyzed were texture, organic carbon, bulk density, total pore space, pH in H_2O, available P, total N, and exchangeable potassium. The results of the study for each parameter showed that the soil texture in dryland agriculture was sandy loam, while in wetland agriculture, it was clay loam. Organic carbon was classified as low (1.31%–1.62%). Wetland soils had higher porosity (57.67%–61.40%) and lower bulk density (1.01–1.10 g/cm³) compared to dryland soils. Soil pH was acidic (4.52–4.95). Available P, total N, and exchangeable potassium were higher in wetland soils than in dryland soils. In conclusion, the results of the study indicate that the soil properties, both physical and chemical, in wetland agriculture were better than in dryland agriculture, although no significant differences were found.

Keywords: depositing materials, floodplain, rainfall

INTRODUCTION

West Sumatra is situated between 98°36'–101°53' East longitude and 0°54' North latitude to 3°30' South latitude. The region covers a land area of approximately 42,297.30 km² and a sea area of around 186,580 km². The mainland coastline measures roughly 375 km, while the Mentawai Islands add an additional 1,003 km, resulting in a total coastline length of about 1,378 km. These waters are home to 375 islands of various sizes (DPPPA West Sumatra, 2022). Due to its geographical features, West Sumatra experiences significant annual rainfall, ranging from 1,980 mm to over 5,000 mm, with the western areas generally receiving more rain than the eastern regions and traversed by 606 rivers, some of which flow toward the West Coast and others toward the East Coast of Sumatra Island. These geographical and climatic conditions are some of the factors that cause a variety of parent material types and soil fertility.

The parent materials of soils in watershed areas are vital in determining the type of bedrock and the mineral content deposited along riverbanks. Composed of weathered rocks and organic matter, these materials shape the physical and chemical attributes of the resulting soils. The influence of parent materials on soil properties is significant, affecting mineral content and soil classification in watershed regions. The relationship between lithology and soil characteristics is critical, as demonstrated by studies emphasizing the impact of varying parent materials on soil formation. According to Gjoka *et al.* (2023), the mineral composition, particularly the presence of weatherable minerals, is a key factor in soil fertility and agricultural potential. Alluvial soils exhibit distinct weathering patterns across regions, which influence their nutrient availability. For instance, soils near the Mat River exhibit a higher weathering index, suggesting better conditions for nutrient release than those along the Drin River (Ilinskiy *et al.,* 2024). Highlight that flood sediments are essential contributors to the fertility of alluvial soils. In the Ryazan region, these sediments provided substantial amounts of nitrogen, phosphorus, and potassium, which are crucial for plant development.

The relationship between the proximity of alluvial deposits to the source of eroded material and soil texture generally indicates that soils near the source tend to have coarser textures due to the deposition of larger particles, while soils farther away exhibit finer textures as smaller particles are carried over greater distances before settling. This process is influenced by several factors, including the dynamics of sediment transport and the physical characteristics of the eroded material. Sharma *et al.* (2022), noted that as the distance from the source increases, finer particles become more dominant in the sediment composition, resulting in soils with finer textures. This trend is commonly observed in alluvial plains, where newer deposits are typically loam to clay loam, whereas older deposits consist mainly of clay. According to Jiang *et al.* (2018), sediment transport involves mechanisms such as suspension and bedload transport. During periods of heavy rainfall, coarser particles are more likely to be transported as bedload, while finer particles remain suspended in the water.

Although the general pattern suggests a correlation between soil texture and distance from the source, local conditions such as rainfall intensity and slope can greatly influence sediment characteristics and transport processes, causing variations in soil properties even at the same distance. This study aims to analyze the characteristics of soil fertility influenced by flood sediment material, in the floodplain of Tarusan watershed, West Sumatra.

MATERIALS AND METHODS

The study was conducted between August and December 2024 on agricultural lands within the floodplain of the Tarusan Watershed (DAS) in Pesisir Selatan Regency. The research focused on two distinct land use types: dryland and wetland farming. Soil fertility assessments were subsequently performed in the Laboratory of the Department of Soil Science and Land Resources, Faculty of Agriculture, Andalas University.

This study employed a survey methodology, with soil samples collected using purposive random sampling. Three sampling points were selected for each land use type at two soil depths (0–30 cm and 30–60 cm), yielding a total of 24 samples, consisting of 12 disturbed and 12 undisturbed samples. The collected soil samples were subjected to laboratory analysis to evaluate various soil fertility parameters. Disturbed samples were air-dried, ground, and sieved to prepare them for the analysis of physical and chemical properties.

The chemical properties analyzed included total nitrogen, available phosphorus, exchangeable potassium, and soil pH, whereas the physical properties assessed encompassed organic carbon (C-Organic), bulk density, total pore space, and soil texture. Data processing was performed using formula-based calculations and analysis in Microsoft Excel. The results were subsequently compared against standard criteria tables to determine the levels of the observed chemical and physical properties.

RESULTS AND DISCUSSION

General description of the research location

The research was conducted in the floodplain area of the Tarusan Watershed (DAS Tarusan) in Pesisir Selatan Regency, West Sumatra. This region is a strategically significant area characterized by a floodplain ecosystem influenced by river dynamics and high rainfall intensity. The Tarusan Watershed exhibits diverse topographical features, ranging from steep upstream areas to lowland downstream areas, which frequently serve as deposition zones for eroded materials such as sand, silt, and clay.

Within the study area, two primary types of land use are managed by the local community: dryland agriculture and wetland agriculture. Dryland agriculture is typically used for cultivating secondary crops or horticultural plants, requiring relatively low-input soil management. In contrast, wetland agriculture is predominantly utilized for paddy fields, which rely on irrigation systems or seasonal river flooding for water supply.

The research location's proximity to erosion-prone areas facilitates direct observation of sediment deposition and its effects on the physical and chemical properties of the soil. Dryland agricultural areas are situated closer to riverbanks than wetland agricultural areas, resulting in a higher proportion of coarse soil fractions in dryland areas compared to wetland areas.

Texture

The soil texture in the study area under dry-land use is primarily dominated by the sand fraction, ranging from 54.58% to 68.63%, categorized as sandy loam across both soil layers. In contrast, wetland use is predominantly characterized by the silt fraction, which varies between 31.73% and 46.60%, with a classification of clay loam (Table 1). The differences in sand, silt, and clay fractions between drylands and wetlands are significantly influenced by sediment dynamics during flooding events. In flood-prone areas like the Tarusan watershed, coarse particles are more likely to settle in drylands due to their proximity to river systems, whereas finer particles are primarily deposited in wetlands. This sedimentation process is crucial in determining soil composition and nutrient availability. As noted by Robinson *et al.* (2022), floods often deposit larger sediment particles in nearby drylands, enhancing the soil texture and nutrient content in those areas. On the other hand, wetlands function as reservoirs for finer sediments, which are essential for preserving soil organic matter and nutrient levels (Ren *et al.*, 2024). Floodwaters transport a variety of sediment sizes, with coarse materials settling in drylands and finer particles accumulating in wetlands (Ilinskiy *et al*., 2024).

Table 1. Soil fractions of the soil at the study site

No	Soil Depth (cm)	Soil Texture Value (%)					
		Land Use					
		Dry Land			Wet Land		
		sand	silt	clay	sand	silt	clay
1		62.65	28.01	9.34	30.77	46.15	23.08
2	0-30	63.37	27.47	9.16	21.07	46.43	32.50
3		54.58	31.79	13.63	34.92	27.89	37.19
4		63.86	22.59	13.55	25.47	46.58	27.95
5	30-60	63.97	27.02	9.01	17.91	45.60	36.48
6		68.63	22.40	8.96	32.02	31.73	36.26

Carbon-organic and soil organic matter

C-Organic values for both land uses at two different depths based on numbers that are between, 1.31 - 1.62 % but are in the same criteria of low. Soil organic matter was also categorized as low, ranging from 2.24 - 2.79 % (Table 2). The low levels of C-organic and soil organic matter in both land uses can be attributed to the study area's proximity to erosion-prone regions upstream of the river.

This location leads to the accumulation of a higher proportion of coarse soil fractions compared to finer particles. In general, floodplain areas tend to exhibit low levels of C-organic and organic matter due to various factors related to the physical and chemical properties of the soil. Sedimentation processes often result in the burial of organic matter within subsoil layers, thereby limiting its accessibility to soil microorganisms and reducing the availability of C-organic.

According to Dilliard & Siegwart (2023), microbial mineralization in the topsoil is primarily constrained by carbon availability, whereas microbial activity in the subsoil is co-limited by both carbon and nitrogen. This limitation affects microbial responses to organic matter inputs, as subsoil microbial communities are influenced by the fungi-to-bacteria ratio and specific soil characteristics, further restricting access to organic matter (Liu *et al*., 2023).

Table 2. Soil C-Organic and Organic Matter values at the study site

No	Soil Depth (cm)	Land Use			
		Dry Land		Wet Land	
		C-Organic (%)	Organic matter (%)	C-Organic (%)	Organic matter (%)
1		1.62_{l}	2.79	1.42_{l}	2.44
2	0-30	1.61_{l}	2.76	1.42_{l}	2.45
3		1.50_{l}	2.59	1.42_{l}	2.45
4		1.31_{l}	2.25	1.32_{l}	2.27
5	30-60	1.31_{l}	2.25	1.32_{l}	2.28
6		1.31_{l}	2.24	1.32_{l}	2.27

Notes: l = low

Floodplain soils frequently experience prolonged waterlogging, which creates anaerobic (oxygen-deficient) conditions. These conditions significantly slow the decomposition of organic matter and lead to the release of methane and carbon dioxide. Waterlogged soils experience oxygen deficiency, which slows down the decomposition of organic matter due to limited microbial respiration (Anderson *et al.*, 2024). Anaerobic bacteria thrive in these conditions, producing methane and hydrogen sulfide, which contribute to greenhouse gas emissions. Seasonal flooding alters microbial activity, with reduced oxidative enzyme abundance leading to the accumulation of complex organic compounds.

Additionally, floodplain soils are often cultivated with short-lived crops or species unable to grow optimally during the flood season. The absence of stable vegetation limits the input of organic matter into the soil.Repeated tillage further accelerates the loss of C-organic by disrupting soil structure and intensifying the oxidation of residual organic matter. Saint-Laurent *et al.* (2016) reported significantly lower total organic carbon levels in frequently flooded zones (1.74%) compared to non-flooded zones (3.54%), underscoring the impact of flooding on soil carbon content.

Floodplain areas that are frequently inundated with water often experience continuous water flow, which can wash away significant amounts of soil nutrients, including C-organic. Furthermore, water-saturated soils are prone to organic matter loss through erosion and leaching processes. (Rupngam & Messiga, 2024) water-saturated soils are prone to erosion, which can wash away topsoil rich in organic matter and nutrients. both erosion and leaching contribute to the depletion of organic matter, particularly carbon, from the soil. Additionally, the low levels of C-organic in land-use systems that undergo intensive tillage are primarily due to the accelerated decomposition of organic matter. This issue is further exacerbated by coarser soil fractions, which facilitate the loss of organic material. (Novick *et al.*, 2022) highlights that the degradation of soil organic matter caused by intensive tillage not only reduces carbon storage but also negatively affects soil quality and fertility, ultimately impacting agricultural productivity.

Bulk density of soil:

Bulk density values of soil at the study site varied both by land use and by depth. Soil bulk density in dry land use was higher than that in wet land use, ranging from 1.12 - 1.34 g cm^{-3} at both depths with high criteria, while wet land use ranged from 1.01 - 1.10 g cm^{-3} at both depths with medium criteria (Table 3).

Table 3. Soil bulk density values at at the study site

No	Soil Depth (cm)	Soil bulk density values (g cm^{-3})	
		Land Use	
		Dry Land	Wet Land
1	0-30	1.34 h	1.03 m
2		1.28 h	1.01 m
3		1.25 h	1.05 m
4	30-60	1.17 h	1.06 m
5		1.12 m	1.04 m
6		1.21 h	1.10 m

Notes: h = high, m = medium

The higher bulk density (BD) values observed in dryland use compared to wetland use are influenced by several factors, one of which is the dominance of sand fractions in dryland soils, resulting in higher bulk density. Additionally, organic matter content is closely related to soil bulk density. Dryland soils generally contain less organic matter, which also contributes to the elevated BD values in these areas. Soils with a higher proportion of coarse fractions and lower organic matter content tend to exhibit higher BD values, as BD is influenced by both soil particle composition and organic matter levels. This aligns with the findings of (Paulo *et al.*, 2014), who noted that soils with higher proportions of coarse particles often have lower porosity, leading to increased BD. Coarse soil fractions, such as sand, contribute to higher BD due to their packing arrangement, while finer particles like clay and silt can lower BD when combined with organic matter. The balance between clay and organic matter is crucial; an increase in clay content has a lesser effect on increasing BD compared to the decrease in BD from organic matter loss (Rubinić & Safner, 2019). Higher organic matter content generally results in lower BD, as organic matter improves soil structure and porosity (Athira *et al.*, 2019). Studies indicate a negative correlation between organic matter and BD, with increases in organic matter leading to significant reductions in BD values (Ahad *et al.*, 2015).

Total Pore Space in soil

Total Pore Space in the soil at the study site for both land uses and at two soil depths ranged from 48.68 - 60.50% with low and medium criteria. The value of total pore space in dry land use is lower than wet land use (Table 4). The comparison of total porosity between dryland and wetland soils reveals significant differences, primarily influenced by variations in organic matter content and bulk density. Dryland soils typically exhibit lower total porosity, which is attributed to higher bulk density and reduced organic matter content. This results in denser soil structures that limit pore formation. In contrast, wetland soils generally contain higher levels of organic matter, which improves soil structure and enhances total porosity. (Robinson *et al.*, 2022) stated that dryland soils often have organic matter content of less than 20%, leading to poor porosity and higher bulk density.High bulk density in dryland agriculture causes soil compaction, reducing the total porosity

Table 4. Total value of soil pore space at the study site

No	Soil Depth (cm)	Total value of soil pore space (%)	
		Land Use	
		Dry Land	Wet Land
1	0-30	48.68 l	60.50 m
2		50.77 l	61.40 m
3		52.19 l	59.65 m
4	30-60	55.22 l	59.48 m
5		57.27 m	60.23 m
6		53.78 l	57.67 m

Notes: m = medium, l = low

available for air and water movement (Fitri *et al.*, 2023).

pH H_2O

Soil pH H_2O values showed varying values in each land use and also at each soil depth ranging from 4.52 - 4.95, but within the same criteria of being acidic (Table 5).

Table 5. Soil pH (H_2O) Value at the study site

No	Soil Depth (cm)	Soil pH (H_2O) Value	
		Land Use	
		Dry Land	Wet Land
1	0-30	4.95 a	4.58 a
2		4.72 a	4.64 a
3		4.81 a	4.75 a
4	30-60	4.63 a	4.53 a
5		4.66 a	4.59 a
6		4.79 a	4.52 a

Notes : a = acid

Floodplains are often submerged for extended periods, creating anaerobic conditions (lack of oxygen) within the soil. These conditions hinder the ability of microorganisms to fully decompose organic matter, leading to the production of organic acids such as acetic acid, butyric acid, and propionic acid. These acids lower soil pH, making it more acidic. This observation aligns with Sao *et al*. (2023), who noted that microbial activity in waterlogged soils is inhibited, resulting in the production of organic acids like acetic, butyric, and propionic acids through fermentation processes. These acids contribute to soil acidification, affecting nutrient availability and microbial community dynamics. Similarly, Rupngam & Messiga (2024) reported that flooding alters soil properties, including pH, which initially becomes neutral but later turns more acidic due to the accumulation of organic acids.

Prolonged waterlogging significantly impacts soil chemistry, leading to a reduction process that dissolves elements like iron, manganese, and sulfur into acidic ions, such as H_2S. This process contributes to a decrease in soil pH, resulting in increased acidity. The following sections elaborate on the mechanisms and consequences of this phenomenon. Waterlogged conditions create anoxic environments, promoting the formation of sulfide minerals like pyrite, which upon oxidation, generate sulfuric acid, leading to increased acidity (Mendonça *et al.*, 2021). The dissolution of iron and manganese occurs, with studies showing increases in DTPA-extractable Mn (71%) and Fe (89%) in waterlogged soils (Khabaz-Saberi & Rengel, 2010). The resulting acidic ions contribute to a lower soil pH, which can adversely affect nutrient availability and crop growth.

In floodplain soils, the leaching of elements during flooding can significantly alter soil acidity. Various studies highlight how certain elements are removed while others, such as hydrogen ions, remain, leading to increased soil acidity. (Merino *et al.*, 2000) despite the leaching of base cations, hydrogen ions often remain in the soil, exacerbating acidity levels. For instance, in paddy soils, leaching with acidic rain resulted in a significant reduction of pH due to the loss of these base cations.

Soil Phosphorus-Available

Phosphorus (P) availability in soil is significantly affected by land use, soil depth, and soil pH. In acidic soils, P tends to bind with iron and aluminum oxides, which makes it less available for uptake by plants. This phenomenon was particularly evident in the study area, where P availability ranged from 4.16 to 7.67 mg P_2O_5 100 g^{-1}, indicating a low level of P availability (Table 6).

Table 6. Soil P-Available Value at the study site

No	Soil Depth (cm)	Soil P-Available (mg P_2O_5 100 g^{-1}	
		Land Use	
		Dry Land	Wet Land
1	0-30	5.11 l	6.35 l
2		5.04 l	7.67 l
3		4.32 vl	6.72 l
4	30-60	4.55 vl	5.92 l
5		4.51 vl	6.39 l
6		4.16 vl	5.30 l

Notes : l = low, vl = very low

The availability of phosphorus (P) in soil is significantly influenced by land use, soil depth, and soil pH. In acidic soils, P tends to bind with iron and aluminum oxides, making it less accessible for plant uptake. This phenomenon is evident in the study area, where P availability ranges from 4.16 to 7.67 mg P_2O_5 100 g^{-1}, indicating low P availability levels. Acidic conditions (pH < 6) inhibit P solubility, resulting in its retention in forms that are unavailable to plants.

Floodplain areas are significantly impacted by nutrient leaching, particularly phosphorus, during flood events. The movement of water can lead to the erosion of nutrient-rich soil layers, resulting in reduced phosphorus levels in the soil. This phenomenon is influenced by various factors, including sediment transport dynamics and land management practices. (Garnier *et al*., 2024) flood events can mobilize substantial amounts of phosphorus, with studies indicating that over 73% of total phosphorus loads are transported during such events. Flood sediments can replenish alluvial soils with essential nutrients, including phosphorus, nitrogen, and potassium, which can partially meet agricultural fertilizer needs (Ilinskiy *et al*., 2024). The sediment degree of phosphorus saturation (DPS) is correlated with human activity, indicating that anthropogenic influences can exacerbate phosphorus leaching during floods (Saint-Laurent *et al.*, 2016).

In low-floodplain areas, the availability of phosphorus is significantly affected by anaerobic conditions, which facilitate the formation of insoluble phosphate complexes with iron and aluminum. These conditions reduce phosphorus mobility; although anaerobic respiration processes release phosphorus, they also strongly bind it to minerals, rendering it less available for plant uptake. (Warrinnier *et al.*, 2020) anaerobic respiration in soils can lead to the reductive dissolution of iron-bound phosphorus, increasing its mobility initially. However, prolonged anaerobic conditions result in the formation of stable complexes, such as Fe (III) phosphates, which are not readily available for plant uptake (Aeppli *et al.*, 2022).

Nitrogen-total

Soil N-total in dryland and wetland use differed by both numbers and criteria. In dry land use it ranged from 0.17 to 0.33% with predominantly low criteria, while in wet land use it ranged from 0.22 - 0.36% with moderate criteria from the two depths observed (Table 7).

Table 7. Soil Nitrogen-total value at the study site

No	Soil Depth (cm)	Soil Nitrogen-total (%) Land Use	
		Dry Land	Wet Land
1	0-30	0.17 l	0.29 m
2		0.18 l	0.22 m
3		0.33 m	0.26 m
4	30-60	0.13 l	0.31 m
5		0.17 l	0.27 m
6		0.17 l	0.36 m

Notes : l = low, m = medium

The low to moderate levels of total nitrogen (N -total) in floodplain areas are largely shaped by environmental factors such as extended periods of waterlogging, which hinder the decomposition of organic matter, and chemical processes that convert nitrogen into forms inaccessible to plants. Brunet *et al.* (2008) prolonged waterlogging creates anaerobic conditions, slowing the mineralization of organic nitrogen and leading to lower nitrate production. High water levels can inhibit the oxidation of ammonium to nitrate, further reducing nitrogen availability.

In floodplain areas, soils are often in anaerobic conditions (low oxygen levels). Under these conditions, denitrifying microorganisms can convert nitrogen in the form of nitrate (NO_3^-) into nitrogen gas (N_2), which is released into the atmosphere. (Lucas *et al.*, 2024) the anaerobic soil volume is a key predictor of denitrification activity, as denitrification often occurs in anoxic microsites associated with particulate organic matter (POM). This denitrification process reduces the total nitrogen content in the soil. Additionally, floodwaters can leach soluble nitrogen, carrying this nutrient to rivers or the ocean. Floodwaters can leach soluble nitrogen, transporting it to rivers and oceans (Hallberg *et al.*, 2024). This leaching can occur alongside denitrification, where the balance between nitrogen removal and mobilization of other nutrients, like phosphorus, is critical.

Consequently, the amount of nitrogen available in the soil decreases. The high moisture levels in these areas also slow down the activity of decomposer microorganisms, leading to the accumulation of partially decomposed organic matter, which further reduces nitrogen availability. (Bogati *et al.*, 2024) high moisture levels enhance microbial diversity and enzyme activity, but excessive moisture can lead to anaerobic conditions, reducing microbial efficiency in nitrogen cycling. Soil microbial respiration is regulated by moisture, with increased humidity leading to stoichiometric imbalances that can limit nitrogen availability (Li *et al.*, 2021). In wet conditions, the decomposition of organic matter is slowed, resulting in the accumulation of partially decomposed materials, which can further immobilize nitrogen (Jiang, 2023). The presence of high moisture can also alter the effectiveness of nitrification inhibitors, leading to increased nitrogen losses as N_2O emissions (Ribeiro *et al.*, 2024).

Potassium-exchangeable

The exchangeable potassium values observed in the study area under two different land uses, namely dryland and wetland, exhibited numerical variation; however, the differences were not statistically significant. The values ranged from 0.19 to

0.55 cmol kg^{-1} across the two soil depths. Dryland areas consistently demonstrated low exchangeable potassium values across all sampling points and depths, whereas wetland areas exhibited moderate exchangeable potassium values (Table 8).

Tabel 8. Potassium-exchangeable value of soil at the study site

No	Soil Depth (cm)	Potassium-exchangeable (cmol kg^{-1})	
		Land Use	
		Dry Land	Wet Land
1	0-30	0.26 l	0.49 m
2		0.30 l	0.55 m
3		0.22 l	0.47 m
4	30-60	0.23 l	0.40 m
5		0.30 l	0.51 m
6		0.19 l	0.40 m

Notes : l = low, m = medium

Exchangeable potassium levels in dryland areas consistently remain low across all sampling points and depths. This condition is attributed to several influencing factors, including frequent waterlogging and inadequate organic matter content, which together hinder the development of optimal soil conditions in dryland environments. According to Ferrando & Barbazán (2022), frequent waterlogging can create anaerobic conditions, thereby reducing potassium solubility and its availability in the soil. Additionally, insufficient organic matter limits the soil's nutrient retention capacity, including potassium, which is essential for supporting plant growth (Ren *et al*., 2024).

Floodplain areas, which are often submerged for prolonged periods, tend to exhibit reduced nutrient solubility, including potassium. During inundation, potassium may detach from cation exchange sites and dissolve in water, subsequently decreasing its availability to plants (Islam *et al*., 2015). Prolonged waterlogging can also result in significant potassium leaching losses, with studies reporting losses ranging from 35.22 to 42.01 kg ha^{-1} during the growing season. The mineral composition of floodplain soils, particularly the presence of micas, plays a critical role in potassium retention and availability (Biswas, 2008). In hydromorphic soils, potassium deficiency is further aggravated by leaching and fixation processes, especially in highly weathered soils (Igwe *et al*., 2008). Additionally, the cation exchange capacity (CEC) tends to decline under reduced conditions, which can further limit potassium availability to plants (Biswas, 2008).

As a water-soluble nutrient, potassium is highly susceptible to leaching from the soil and can be carried away by floodwaters, resulting in substantial nutrient loss. According to Goulding *et al*. (2021), potassium can infiltrate deeper soil layers or surface waters due to its high solubility, particularly during heavy rainfall or flooding events. Additionally, water erosion can transport potassium bound to soil particles, contributing to significant nutrient depletion (Kuncheva *et al*., 2022). Research indicates that conventional tillage practices exacerbate these losses compared to minimal tillage methods. Nelson & Shigihara (2023) reported that flooding events can mobilize nutrients, including potassium, from agricultural lands into surface waters. Studies conducted in the aftermath of Hurricane Florence demonstrated that nutrient concentrations in floodwaters varied considerably, influenced by land use and proximity to pollution sources.

Furthermore, floodplain soils typically exhibit low organic matter content, which restricts their cation exchange capacity (CEC) and diminishes their ability to retain potassium. According to Ramos *et al*. (2018), organic matter plays a crucial role in enhancing CEC by serving as a reservoir for cationic nutrients, including potassium. In floodplain soils, the deficiency of organic matter leads to a reduced CEC, thereby limiting the soil's capacity to retain essential nutrients.

In addition, the potassium concentration in floodwaters can be low, depending on the source. When floodwaters originate from regions with low potassium levels, the amount of potassium supplied to the soil becomes limited, potentially impacting plant health and productivity (Igwe *et al*., 2008). Exchangeable potassium in soils is often minimal, particularly in highly weathered soils, which are prevalent in floodplain areas (Firmano *et al*., 2020).

CONCLUSION

Research conducted in the floodplain of the Tarusan watershed revealed significant differences in the physical and chemical properties of soils between dryland and wetland areas. Dryland soils are predominantly composed of the sand fraction, characterized by low organic carbon (C-organic) content and high bulk density (BD) values. In contrast, wetland soils exhibit a higher silt fraction, moderate C-organic content, and lower BD values. Waterlogging in wetland areas slows the decomposition of organic matter, reduces C-organic levels, and immobilizes nitrogen (N) and phosphorus (P) in forms that are not readily available to plants. Exchangeable potassium values are low in drylands but moderate in wetlands, reflecting the superior water retention capacity of wetland soils.

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