# Physicochemical Properties of Soil in Flood Affected and Non-affected Areas of Rajapur, Bardiya

R. Khaitu[1,*], R.A. Mandal[1], A.B. Mathema[1]

[1]School of Environmental Science and Management, Pokhara University, Lalitpur

(rakshyakhaitu1995@gmail.com)

## INTRODUCTION

- again in October 2021. A frequently occurring natural disaster, flood causes destruction of life and property in Terai region of Nepal due to heavy seasonal rainfall.
- Flood changes the soil quality by altering the nutrient composition.
- Nutrient contents dictate the type of vegetation and crop, by understanding the impact of flooding in soil, this research can aid in adaptive farming.
- Flood and landslide affected 72 districts across the country in the final week of August and

## OBJECTIVES

**General Objective:**

- To evaluate physicochemical properties of soil in the flood affected areas of Rajapur, Bardiya.

**Specific Objectives:**

- To undertake assessment of physical properties of soil in the flood affected and non-affected areas.
- To undertake assessment of chemical properties of soil in the flood affected and non-affected areas.
- To compare physical and chemical properties of soil in the flood affected and non-affected areas.

## MATERIALS AND METHOD

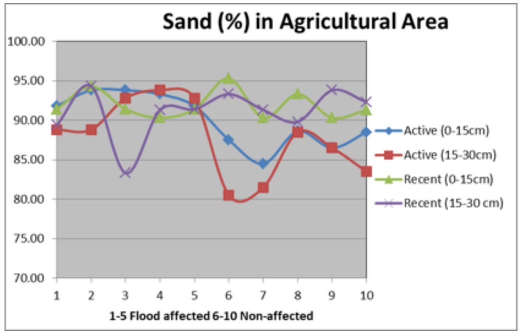
- Rajapur, Bardiya is a fertile Terai plain in mid-western region of Nepal. For this study, 47.4 km$^2$ area was selected depending on the proximity of Karnali river.
- 120 samples from Rajapur, Bardiya Nepal was collected from 0-15 cm and 15-30 cm from active alluvial plain and recent alluvial plain in flood-affected and non-affected areas.
- Samples were collected in November 2022 after rainy season.
- Physical and chemical properties of soil samples were analyzed and compared in the lab of School of Environmental Science and Management.
- T-test and Mann-Whitney test was applied to quantify the difference between flood-affected and non-affected areas.

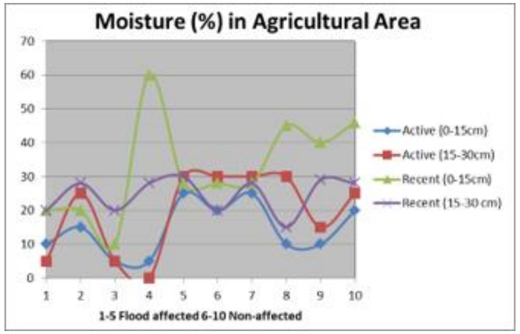
*Table 1: Soil properties and method of analysis*

| Soil Properties | | Method |
|---|---|---|
| Physical | Color | Munsell Soil Color Chart |
| | Texture | Bouyoucos hydrometer method (Bouyoucos, 1962) |
| | Moisture | Moisture Meter |
| Chemical | Total Nitrogen | Kjeldahl method (Bremner and Mulvaney, 1982) |
| | Available Phosphorous | Modified Olsen's Bicarbonate Method |
| | Available Potassium | Flame Photometric Method (Toth and Prince, 1949) |
| | pH | pH meter |
| | Soil carbon | Walkley-Black Method (Walkley and Black, 1934) |

## RESULTS AND DISCUSSION

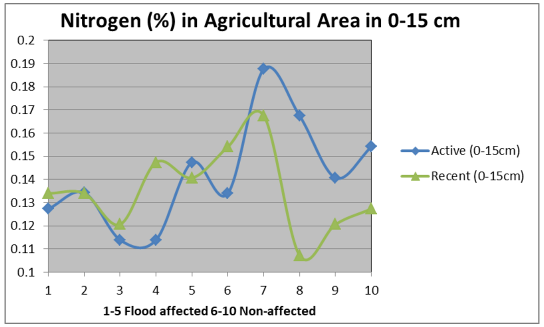
### 1. TEXTURE AND MOISTURE



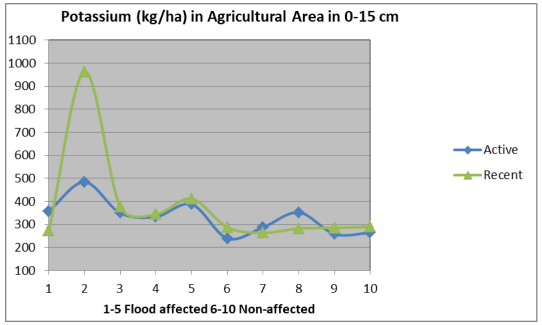

- Sand content and moisture have inverse relationship with each other.
- Regardless of landform and land use, sand content have consistent relationship with moisture.

### 2. TOTAL NITROGEN




- Nitrogen content was significantly lower in flood-affected areas especially in agricultural areas in active alluvial plain in both 0-15 cm and 15-30 cm depth.
- Effect was not consistent in forest area and grassland area.

### 3. AVAILABLE POTASSIUM




- Potassium showed anomalous relationship because it is higher in flood affected than in non-affected areas.
- Potassium value was 382.23 kg/ha in flood affected areas and 351.05 kg/ha in non-affected areas.

### 4. AVAILABLE PHOSPHOROUS , pH AND SOIL CARBON

- Phosphorus was significantly lower in flood-affected region in agricultural area.
- The effect was not significantly different in forest area and grassland.
- pH of soil was weakly to moderately acidic with value ranging from 5.0 - 6.0.
- Soil carbon decreased in flood affected agricultural area.
- The effect of flooding in soil carbon was not significant in forest and grassland in active alluvial plain.

## CONCLUSION

- Flood inevitably affects the physical and chemical properties of soil.
- The extent of impact is dependent on land use, land forms and depths.
- Agricultural area is more vulnerable to flood than forest and grassland.
- 0-15 cm depth were more affected by flood than 15-30 cm depth.
- Nitrogen and Phosphorus content were negatively affected and Potassium content was positively affected.

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Thesis for the Degree of Master of Science in Environmental Science and Management

# Physicochemical Properties of Soil in Flood Affected and Non-affected Areas of Rajapur, Bardiya

**Rakshya Khaitu**
**PU Registration No.: 2020-1-25-0022**
**Exam Roll No.: 20250048**

**School of Environmental Science and Management**
**Faculty of Science and Technology**
**Pokhara University, Nepal**

**February, 2023**

Thesis for the Degree of Master of Science in Environmental Science and Management

# Physicochemical Properties of Soil in Flood Affected and Non-affected Areas of Rajapur, Bardiya

**Supervised by Ram Asheshwar Mandal, PhD.**

A thesis submitted in partial fulfillment of the requirement for the Degree of Master of Science in Environmental Science and Management

**Rakshya Khaitu**
**PU Registration No.: 2020-1-25-0022**
**Exam Roll No.: 20250048**
**ENV691 Thesis Work**

**School of Environmental Science and Management**
**Faculty of Science and Technology**
**Pokhara University, Nepal**

**February, 2023**

# Dedication

I would like to dedicate this thesis to my loving parents

**Chandra Prasad Khaitu** and **Dil Maya Khaitu,**

Source of my inspiration and courage.

# Declaration

I hereby declare to School of Environmental Science and Management (SchEMS), affiliated to Pokhara University that this study entitled **“PHYSICOCHEMICAL PROPERTIES OF SOIL IN FLOOD AFFECTED AND NON-AFFECTED AREAS OF RAJAPUR, BARDIYA”** submitted as a partial fulfillment for the degree of Master of Science in Environmental Science and Management is based on my original research work. Related works on the topic by other researchers have been duly acknowledged. I owe all the liabilities relating to the accuracy and authenticity of the data and my other information included hereunder.

……………..

Name of the Student: Rakshya Khaitu

P.U. Registration Number: 2020-1-25-0022

Date: February, 2023

# Recommendation

This is to certify that this thesis entitled **"PHYSICOCHEMICAL PROPERTIES OF SOIL IN FLOOD AFFECTED AND NON-AFFECTED AREAS OF RAJAPUR, BARDIYA"** prepared and submitted by **Ms. Rakshya Khaitu** in partial fulfillment of the requirements of the degree of Master of Science in Environmental Science and Management awarded by Pokhara University, has been completed under my supervision. I recommend the same for acceptance by Pokhara University.

…………………

Name of the Supervisor: Ram Asheshwar Mandal, PhD

Organization: School of Environmental Science and Management (SchEMS)

Date: February, 2023

# Certification

This is to certify that the thesis entitled **"PHYSICOCHEMICAL PROPERTIES OF SOIL IN FLOOD AFFECTED AND NON-AFFECTED AREAS OF RAJAPUR, BARDIYA"** prepared and submitted by **Ms. Rakshya Khaitu** is examined and accepted for the award of the degree of Master of Science in Environmental Science and Management. The thesis in part or full is the property of School of Environmental Science and Management (SchEMS) and thereof should not be used for the property of awarding any academic degree in any other institutions.

…………………

Buddi Sagar Poudel, PhD

Chief of Climate Change and Management Division

Ministry of Forests and Environment

External examiner

…………………

Ram Asheshwar Mandal, PhD

Supervisor

School of Environmental Science and Management (SchEMS)

…………………

Mr. Ajay Bhakta Mathema

Principal

School of Environmental Science and Management (SchEMS)

# Letter of Approval

This dissertation paper submitted by **Ms. Rakshya Khaitu** entitled **"PHYSICOCHEMICAL PROPERTIES OF SOIL IN FLOOD AFFECTED AND NON-AFFECTED AREAS OF RAJAPUR, BARDIYA"** has been accepted for the partial fulfillment of Master of Science in Environmental Management from Pokhara University.

……………….

Mr. Ajay Bhakta Mathema,

Principal, SchEMS, Pokhara University

Date: February, 2023

# Acknowledgement

This thesis entitled **"PHYSICOCHEMICAL PROPERTIES OF SOIL IN FLOOD AFFECTED AND NON-AFFECTED AREAS OF RAJAPUR, BARDIYA"** was prepared as a partial fulfillment for the degree of Master of Science in Environmental Management by Pokhara University. I would like to take this moment to thank professors, lab technician and classmates, who helped me to complete this thesis.

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Signature: …………………

Name of Student: Rakshya Khaitu

P.U. Registration No.: 2020-1-25-0022

# Abstract

Flood is one of the most frequently occurring natural disasters that affect billions of people worldwide. In Nepal, flood causes destruction of life and property in Terai region due to heavy seasonal rainfall. Flood changes the soil quality by altering the nutrient composition and by heavy sediment transport. In Rajapur, Bardiya, Karnali River in the west causes floods and inundation in fertile and cultivable land. Specific objectives of this research were to assess the physicochemical and biological properties of soil and compare the properties in flood-affected areas and non-affected areas. Soil nutrients were analyzed in lab, using Kjeldahl method for nitrogen, Modified Olsen's bicarbonate method for phosphorus, Flame photometric method for potassium, Walkley and Black method for organic matter, pH meter for pH and moisture content, and Bouyoucos hydrometer method for soil texture.

In this research, the results showed that flood changes physicochemical properties in soil but the extent of the damage depends upon different factors like landforms, texture, and land use land cover. More specifically, the data reflected that nutrient contents were significantly different in agricultural area in active alluvial plain, where nitrogen decreased by 0.03 % in 0-15 cm depth, phosphorus decreased by 4.12 kg/ha in 0-15 cm depth and 6.8 kg/ha in 15-30 cm, potassium increased by 102.14 kg/ha in 0-15 cm depth, and organic carbon decreased by 0.29% in flood-affected areas. But the nutrients were not significantly different in recent alluvial plain. The conclusion showed that flood did not necessary decrease the nutrient content and the impact was not consistent across different landform. This research provided a brief picture of nutrient content in soil in Rajapur, Bardiya, which can be a valuable tool for local farmers to determine the type of crops and need of suitable fertilizer for desired outcome.


Keywords: *Flood, Soil, Nutrient Content, Impact of flood*

# Table of Contents

# List of Tables

# List of Figures

# List of Photo Plates

# List of Appendix

# List of Acronyms

| | |
|---|---|
| AR | Analytical Reagent |
| asl | above sea level |
| FAS | Ferrous ammonium sulphate |
| K | Potassium |
| kg/ha | kilogram/hectare |
| N | Nitrogen |
| NaF | Sodium Fluoride |
| NARC | Nepal Agricultural Research Council |
| NPK | Nitrogen, Phosphorus, Potassium |
| OC | Organic Carbon |
| OM | Organic Matter |
| P | Phosphorus |
| SchEMS | School of Environmental Science and Management |
| SD | Standard deviation |
| SE | Standard error |
| SOC | Soil Organic Carbon |
| SOM | Soil Organic Matter |
| SOTER | Soil and Terrain |
| SPSS | Statistical Package for Social Science |

# CHAPTER 1

## INTRODUCTION

### 1.1 Background

Flood is one of the most frequent natural disaster in the world with over 1.4 million people getting affected every year[1]. Flood causes immense destruction, loss of human and animal lives, infrastructures and many more. Flooding is a serious problem in the Terai region during monsoon months and per-monsoon period due to the continuous and intense rainfall [2], [1], [3], [4], [5]. Rajapur, Bardiya is located at the Terai region of Nepal along Karnali River. The major flood affected area in Rajapur is the lower part of the Karnali Basin. The upper part of Karnali River Basin lies within the hilly and mountainous area. Rajapur is prone to inundation primarily due to Kauralia river in the west. Rajapur area is a plain territory where the high flow of river spreads all over and the destruction begins by the heavy sediments load from the Lesser Himalayan and the Siwalik region of Nepal [6]. Besides that, extreme weather occurrence have become more frequent and more severe due to climate change increasing the impact in livelihood of people of Rajapur [7].

Among many impacts of flood and inundation, degradation in soil quality affects various aspects of civilization in Rajapur. Soil quality is a dynamic interaction between various physical, chemical and biological soil properties, which are influenced by many external factors [8]. Soil quality has been defined as "the capacity of specific kind of soil to function, within natural and managed ecosystem boundaries, to sustain plant and animal productivity, enhance water and air quality, and supports human health and habitation" [9]. Hence, it would seem to be good measure of sustainable land management because it helps determine general soil condition, management response, or resistance to natural and human-man forces [10].

There is a conscience that flood negatively impacts the soil quality, however, the phytoplanktonic productivity is high due to the comparatively abundant nutritional content of the soils flooded during reservoir formation. Usually, nutrient supply from the river basin is sufficient to support moderate-to-high primary production, despite the fact the nutrients tend to diminish over several years after floods [11].

## 1.2 Statement of Problem

Every year, the extreme precipitation during monsoon season from June to August causes flood in Nepal. Flooding can change the level of available nutrients in the soil. Depending upon the types of deposition of sediments from higher regions, flood may increase the level of nitrogen, phosphorus, potassium and silicon in the soil. The absence of link between flood and its impact on soil combined with the poor understanding of interaction of these two components leads to ground-level issues in the field of agriculture and forest. The extent of flood damage in terms of depth of soil is also poorly understood, and the time frame of soil recovery in Nepal has not been researched yet. The holistic research is absent and it is important to have bigger regional picture the flood carries sediment from Lesser Himalaya and Siwalik region of Nepal[12]. Thus, it is critical to understand the transport material from other geological regions of Nepal.

## 1.3 Research Questions

Leading from the statement from the problem, there are specific questions that this research will attempt to answer and justify. Few research questions that were addressed in the research are listed below:

- What are the physical properties of soil in agricultural area, forest and grassland on the basis of landforms (Active and Recent Alluvial Plain) and impact of flood (affected and non-affected) in Rajapur?
- What are the chemical properties of soil in agricultural area, forest and grassland on the basis of landforms (Active and Recent Alluvial Plain) and impact of flood (affected and non-affected) in Rajapur?
- Is there a significant difference in soil properties in flood affected and non-flooded area in Rajapur?

## 1.4 Research Objective

### 1.4.1 General Objective

The general objective of the study is to evaluate the physicochemical properties of soil in Rajapur, Bardiya.

### 1.4.2 Specific Objectives

- To assess physical properties of soil in flood affected and non-affected area.
- To assess chemical properties of soil in flood affected and non-affected area.
- To compare physical and chemical properties of soil in flood affected area and non-affected area.

## 1.5 Rationale of the Study

Nutrient content in the soil dictates the type of vegetation and crop. Thus, this research can help understand the variation in nutrient content and how it affects crop suitability. The traditional agricultural practices in Nepal are to use NPK fertilizer; however, this may not give desired results as the crops need a balanced supply of nutrients. Thus, the information from this research can be extensively used by municipality office to notify local people about the type of crop that should be harvested and recommend a suitable fertilizer for a superior result. The results from this research can also aid in adaptive farming.

This research can be used as a foundation for other researches that needs to fill the gap of sediment transport from higher geological regions of Nepal.

## 1.6 Limitation of the Study

The study that was conducted in Rajapur, Bardiya had following disadvantages.

- There was no distinct boundary between forest and grassland area in the field site, most of the expected grassland areas were heavily disturbed by human activity as pasture land. Thus, samples presented here in the study may not be precisely representative of the actual grassland.
- Biological properties were not studied in-depth. Although, soil samples were visually assessed, lack of macro-organisms in the samples made it difficult to analyze. Besides that, micro-organisms were not observed.

# CHAPTER 2

## LITERATURE REVIEW

### 2.1 Soil and Impact of Flood on Soil

The accumulation of alluvial deposits from the Himalayas and it constitutes a vast piedmont adjacent to and south of the Himalaya Range which formed the Terai-Gangetic plain. About 14 percent of the total land area in Nepal is covered with the fertile sediment soil [13].

The Terai region is sub divided into the following three units:

**Active alluvial plains**: The active alluvial plains cover 1.3 percent of land area of Nepal which is frequently flooded. Soil present in this plain is generally coarse and there is significantly less weathering. These lands are used for grazing and low-risk crops given the risks of monsoon floods.

**Recent alluvial plains**: It is known as the “bread basket” of Nepal which covers 7.9 percent of Nepal’s land area. Their soils are fertile and stable than the active alluvial plain and water table is not far from the surface.

**Older alluvium**: These covers 4.9 percent of the total land area, is made up of coarse textured soils on higher slope gradients. In the western Terai, there is settlement zones and areas of local uplifting [13].

Flood changes the soil properties in two board ways; i) transporting sediment from source, and ii) chemical and biological changes due to inundation. Variation in these two factors determines the extent of impact of flood on soil [14]. Transport of sediment whether, it is deposition or erosion is a fundamental component to assess the impacts of floods [15]. Short flood duration and resulting inundation causes minimal nutrient deterioration [14] and the regeneration of microbial activity is also quick [7].

However, monsoonal climates cause large floods. Large floods change the vegetation of the area by allowing common and ruderal species in the flood plain [16]. There is also an acceptance that the soil texture drives the extent of flood impact [17].

## 2.2 Changes in Physicochemical Properties of Soil

According to research carried out by Lee et al., the changes in soil texture immediately after the flood was observed in almost every region namely, Waterfront, Bank and plant species specific areas. The soil's pH value increased and but was not significant in waterfront. However, the changes in nutrient content before and after the flooding were not consistent and were dependent upon the site. For example, Bank region showed significant decrement in Nitrogen, phosphorus, and potassium (NPK) [16].

Another research highlighted significant decrement of Nitrate content ($NO_3$) but the value of decrement depends upon the type of flooding and time period of inundation [14]. Unger et al. observed an elevated deterioration in 5-week stagnant floods than in 3-week stagnant floods.

The research (Gelsomino et al., 2006) domain that the soil characteristic varied due to recurrent flooding and transport of alluvial sediments and some potential hazardous compounds. They also mentioned that there was significant variation in pH, Total Nitrogen, and microbial activity in the soil after flooding. They explained that the total nitrogen content in the soil decreased in flooded region and the soil became slight alkaline [17].

According to research carried out by (Hafeez et al., 2019), they explained that there were no significant changes in pH, and nutrient content especially nitrate and phosphorus. They observed insignificant drops in nitrate and phosphorus content in after flood samples. They associated the drop in nitrate with the presence of sandy-textured soil. They also claimed that flooding condition might have accelerated the $NO_3$ leaching. They also pointed out that the inorganic compounds and heavy metals concentration have decreased in study sites, which suggests that they have leached down the water table and hence causing underground pollution [18] .

## 2.3 Changes in the level of available nutrients

The flow of flood sediments may enhance the soil's contents of silicon, nitrogen, phosphorus, and potassium. Depending on slope and erosion of soil materials, the nutrient status of soils differs from place to place. In the rainy season due to the heavy rainfall, the large portions of soil nutrients are washed away by erosion. Thus, flood has variable effects on nutrients availability. Partial drying may reduce available N and P in the soil, but also the desiccation of sediments causes death of bacteria, which is flowed by N and P mineralization [19] . Moreover, alternation wetting and drying, which persist in Rajapur, there is significant loss of nutrients due to denitrification and volatile ammonia losses. On the other hand, loss of K in soil is caused by leaching and runoff [19] . Since, the flooding affects nutrient content of soil which ultimately makes agricultural area more vulnerable [20], [21].

### 2.4 Level of Organic Matter (OM)

Organic matter is a minor constituent in most sedimentary rocks [22]. The complex mixture termed as soil organic matter (SOM) affects a variety of soil characteristics and the cycling of nutrients. Land use, soil type, climate, and vegetation can have an impact on SOM in terms of kind and quantity. There is a significant amount of concern that, if SOM concentrations in soils are allowed to decrease too much, the physical qualities of the soil would deteriorate and the mechanisms for nutrient cycling in the soil is disrupted, posing a threat to agriculture's ability to produce [22].

The level of organic matter (OM) in soil below 2000 m. asl ranges from 0.5 to 3.0 percent and average slightly less than 1.0 percent on cultivated soils. The soil of forest has higher OM contents of 1 to 2 percent. The climatic and vegetation changes over 2000 m asl, results 2 to 3 percent higher OM contents for both cultivated soils and forest soils. In the Terai region, the new forest clearings may have 4 to 5 percent OM contents, but after few years of cultivation the levels of OM contents degrade to 2 percent [23].

### 2.5 Role of NPK in Soil

Nitrogen (N), phosphorus (P) and potassium (K) are primary nutrients for the survival and growth of plants. Deficiency of any of these nutrients negatively affects the development of plants. Nitrogen regulates chlorophyll synthesis and thus controls control vegetative growth of plants. Phosphorus stimulates cell division, root growth and flowering. Optimum level of NPK in soil is very critical in plant and should be determined prior to their application of NPK fertilizer [24].

Given the importance of NPK in soil, NPK fertilizer has been used through chemical processes since the 19$^{th}$ century. The first synthetic nitrogen fertilizer was synthesized in 1903 as calcium nitrate. Since 1913, availability of synthetic ammonia caused developed of new fertilizer [25]. However, the efficiency of application of fertilizer has been concerning issue because of loss of nutrition due to flooding, denitrification and volatile ammonia losses [26].

# CHAPTER 3

## METHODOLOGY

### 3.1 Study Area

The study site for the effects of flood on the different properties of soil is Rajapur, Bardiya whose co-ordinate is 28°26′N 81°05′E, and it lies in the south-western Nepal and shares southern border with Uttar Pradesh state, India. Geologically, Rajapur lies in the Indo-Gangetic Plain [12] .

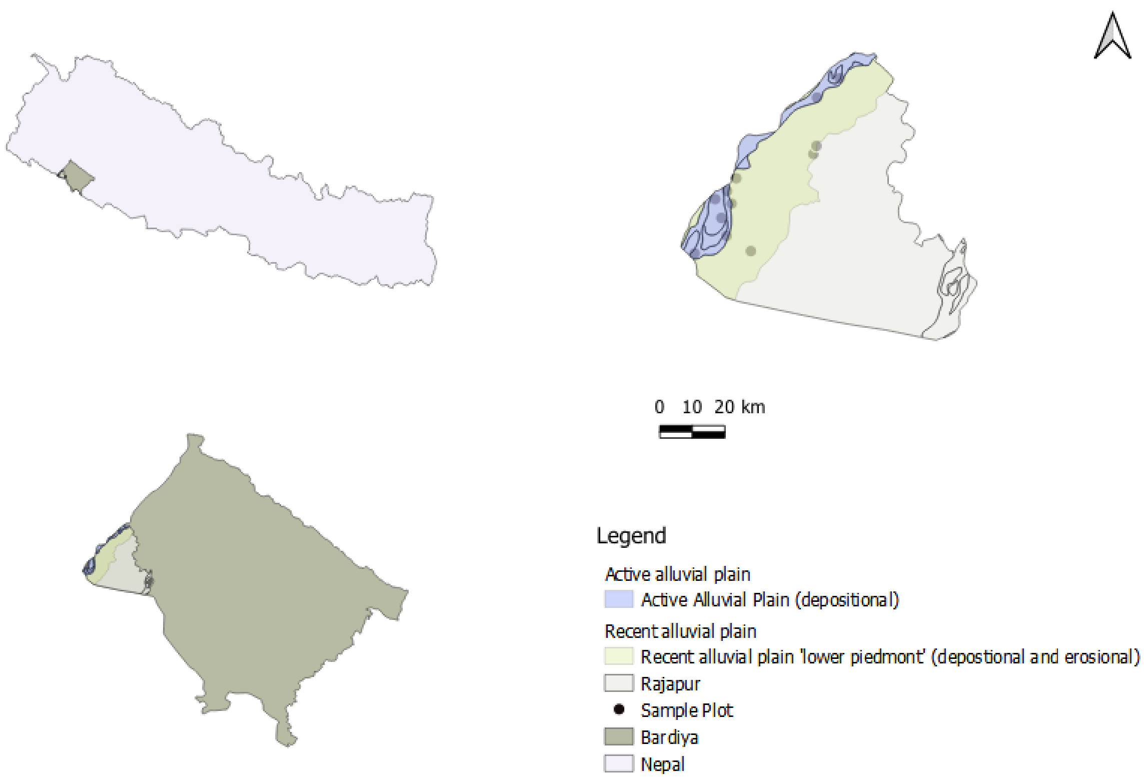


Figure 3.1: Map of Nepal with study site

The area of Rajapur is prone to flood and inundation primarily due to Karnali river in the west. Most of the high flood risk and bank cutting areas lie in the western part of the municipality. Thus, nearer area of Karnali river on the Western side was selected for the research. The combined area of four wards is 47.4 km$^2$.

## 3.2 Research Process

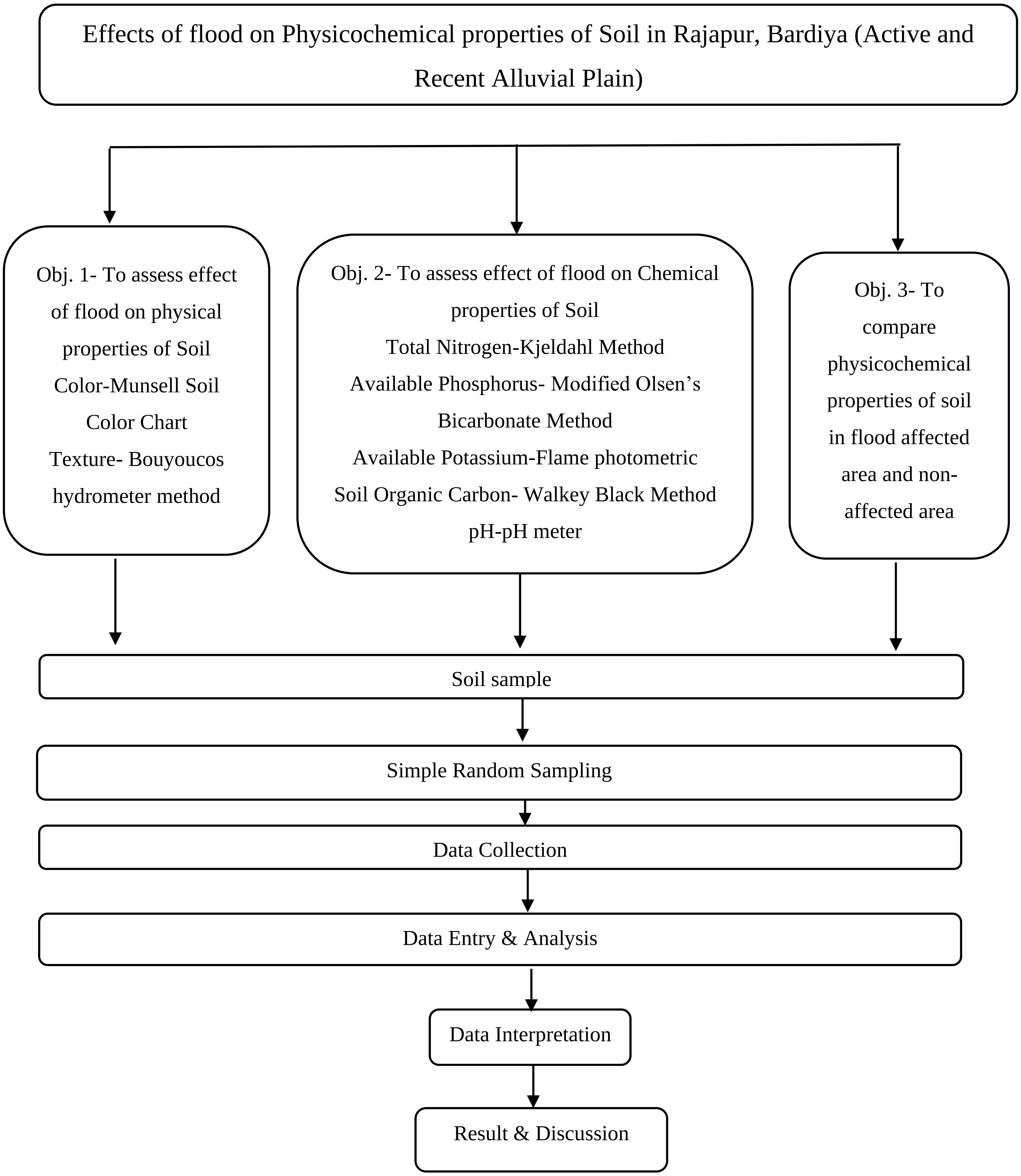


Figure 3.2: Layout of methodology

## 3.3 Methods of Data Collection

### 3.3.1 Primary Data Collection

Field measurement with random sampling method was used in this study to analyze the properties of soil. During the field visit, soil samples in the site were collected for the analysis of chemical properties and physical properties whereas some physical properties were assessed in the field directly.

**Soil Sampling**

Soil sampling is a critical phase for soil analysis. According to the Soil Classification based on Soil and Terrain (SOTER) of Rajapur [27], [28] soil samples are taken at the pre-selected setup. By default, each plot has five cardinal points (North-East, South-East, Center, South-West and North-West).

The SOTER concept is based on the relationship between the physiography (landform), parent materials and soils within a certain area. It identifies areas of land with a distinctive and often repetitive, pattern of landform, lithology, surface form, slope, parent material and soils [28].

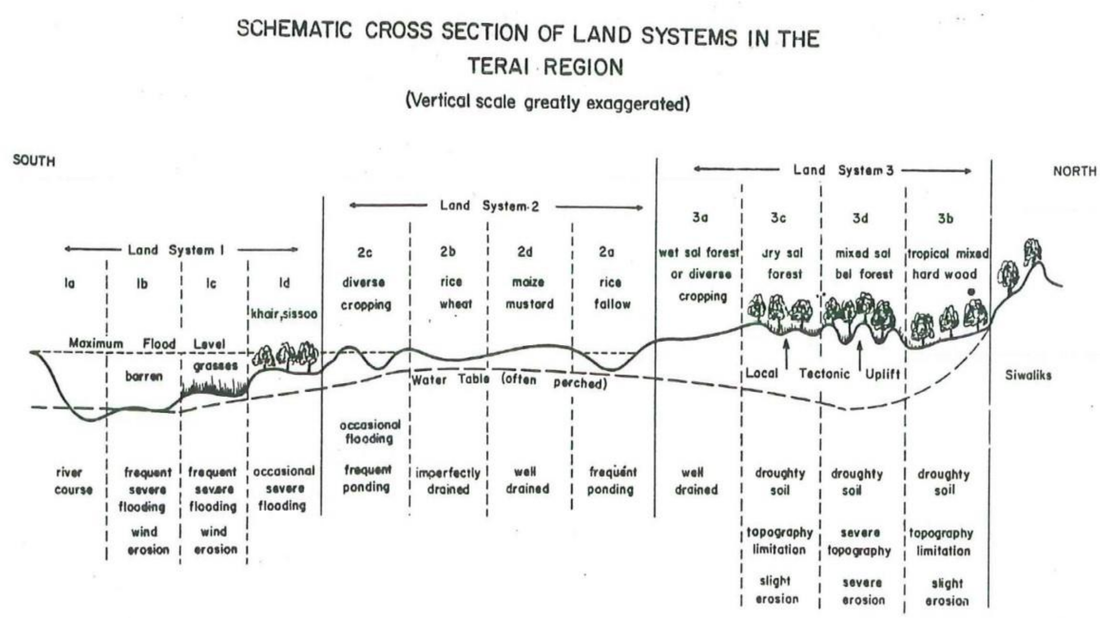


Figure 3.3: A systematic Cross-Section of Land Systems in the Terai Region

Table 1: Descriptive of Land Systems of Terai Regions

| Land forms | Land Unit | Dominant Soils | Dominant Slopes | Dominant Texture | Seasonal Range of Depth to Water Table | Drainage |
|---|---|---|---|---|---|---|
| Active alluvial Plain (depositional) | 1a present river channel | - | - | - | - | - |
| | 1b sand and gravel bars | Ustorthents Psamments | <1° | Sandy / Cobbly | 0 - 2m | subject to severe river flooding |
| | 1c low terrace | Ustifluvents Fluvaquents | <1° | Sandy | 0 - 2m | variable; subject to severe river flooding |
| | 1d higher terrace | Ustochrepts Haplaquepts | <1° | Loamy | 0 - 4m | variable; subject to occasional river flooding |
| Recent Alluvial Plain "Lower Piedmont" (depositional and erosional) | 2a depressional | Haplaquepts | <1/2° | Fine Loamy | 0 - 2m | poor |
| | 2b intermediate position; level | Haplaquepts (Aeric) | <1/2° | Loamy | 0 - 6m | imperfect |
| | 2c intermediate position, undulating | Haplaquepts Ustochrepts | <1° | variable | dependent on position | variable; low areas subject to flooding |
| | 2d high position | Haplustolls Ustochrepts | <1° | Loamy | 1 - 10m | moderately well |

In this research, the study site was broadly stratified into two landforms: active and recent alluvial plain. Active alluvial plain is frequently flooded area whereas recent alluvial plain is comparably fertile and stable plain. Each landform has been further categorized into agricultural, forest and grassland based on the land use land cover. Then, each of these categories was analyzed in terms of impacts of flooding: flood affected and non-affected areas. In total, there were 12 broad areas. The location was determined with the help of a GPS device. Furthermore samples were taken from two layers, 0-15 cm and 15-30 cm [29] by using soil corer and shovel. After that the collected samples were brought to the laboratory of SchEMS to determine the properties of soil. Since, five samples were taken from each area and layer, in total (60×2) = 120 samples were collected in November 2022.

### 3.3.2 Secondary Data Collection

Secondary data is the procedure of analyzing the existing data collected by others. The secondary information was collected from the published articles, documents, reports, journals and websites. The secondary data were collected from Department of Forests and Soil Conservation and other governmental offices like local ward office.

## 3.4 Data Analysis

Collection of primary and secondary data is only one third of the methodology because the data analysis carries as much value as the robustness in the data collection. Data analysis was carried out using Statistical Package for Social Science (SPSS) and Microsoft Excel. Descriptive statistics are used to produce tables, while t-test and Wilcoxon Mann-Whitney U-test were used to test the significant difference between unequal variables.

### 3.4.1 Soil Properties with their method of measurement

The different parameters were used to assess soil quality and nutrients content in the soil. Soil sample were analyzed in the lab of School of Environmental Science and Management (SchEMS) to assess the physicochemical properties of soil.

Table 2: Soil properties under study with their methods of measurement

| Soil Properties | | Method |
|---|---|---|
| Physical | Color | Munsell Soil Color Chart |
| | Texture | Bouyoucos hydrometer method (Bouyoucos, 1962) |
| | Moisture | Moisture Meter |
| Chemical | Total Nitrogen | Kjeldahl method (Bremner and Mulvaney, 1982) |
| | Available Phosphorus | Modified Olsen's Bicarbonate Method |
| | Available Potassium | Flame Photometric Method (Toth and Prince, 1949) |
| | pH | pH meter |
| | Soil carbon | Walkley-Black Method (Walkley and Black, 1934) |

### 3.4.2 Interpretation table for soil pH

In order to determine the level of soil pH and soil fertility interpretation chart developed by NARC was used which is shown in the table.

Table 3: Interpretation table for soil pH [30]

| pH | Range |
|---|---|
| <4.5 | Strongly acidic |
| 4.5-5.5 | Weakly acidic |
| 5.5-6.5 | Moderately acidic |
| 6.5-7.5 | Nearly neutral |
| >7.5 | Alkaline |

## 3.5 Lab Analysis

### 3.5.1 Nitrogen

Total Nitrogen

Kjeldahl Method (Bremner and Mulvaney, 1986)

**Apparatus used for soil nitrogen analysis**

- Conical flasks
- Burettes
- Pipettes

**Reagents**

- Sulphuric acid – $H_2SO_4$ (93-98%)
- Copper sulphate – $CuSO_4H_2O$ (AR grade)
- Potassium sulphate or anhydrous sodium sulphate (AR grade)

- 35% sodium hydroxide solution: Dissolve 350 g solid NaOH in water and dilute to one litre
- 0.1M NaOH: Prepare 0.1M NaOH by dissolving 4.0 g NaOH in water and make volume to 1 litre. Standardize against 0.1N potassium hydrogen phthalate or standard $H_2SO_4$
- 0.1M HCl or 0.1M $H_2SO_4$: Prepare approximately 0.1M acid solution and Standardize against 0.1M sodium carbonate
- Methyl red indicator
  Salicyclic acid for reducing $NO_3$ to $NH_4$, if present in the sample
- Devarda's alloy for reducing $NO_3$ to $NH_4$, if present in the sample.

**Procedure**

i. Weight 1 g sample of soil. Place in Kjeldahl flask.
ii. Add 0.7 g copper sulphate, 1.5 g $K_2SO_4$ and 30 ml $H_2SO_4$.
iii. Heat gently until frothing ceases. If necessary, add small amount of paraffin or glass beads to reduce frothing.
iv. Boil briskly until solution is clear and then continue digestion for at least 30minutes.
v. Remove the flask from the heater and cool, add 50 ml water and transfer to distilling flask.
vi. Take accurately 20–25 ml standard acid (0.1M HCl or 0.1M $H_2SO_4$) in the receiving conical flask so that there will be an excess of at least 5 ml of the acid. Add 2-3 drops of methyl red indicator. Add enough water to cover the end of the condenser outlet tubes.
vii. Add 30 ml of 35% NaOH in the distilling flask in such a way that the contents do not mix.
viii. Heat the contents to distil the ammonia for about 30-40 minutes.
ix. Remove receiving flask and rinse outlet tube into receiving flask with a small amount of distilled water.
x. Titrate excess acid in the distillate with 0.1M NaOH.
xi. Determine blank on reagents using same quantity of standard acid in a receiving conical flask.

**Calculation**

$$Percent\ N = \frac{1.401(V_1M_1 - V_2M_2) - (V_3M_1 - V_4M_2)}{W} \times df$$

Where,

V4- ml of standard NaOH used in titrating blank

M1 – Molarity of standard acid

M2 – Molarity of standard NaOH

W – Weight of sample taken (1 g)

df – Dilution factor of sample (if 1 g was taken for estimation, the dilution factor will be 100).

V1 – ml of standard acid taken in receiving flask for samples

V2 – ml of standard NaOH used in titration

V3 – ml of standard

Note: 1000 ml of 0.1 M HCl or 0.1 M H2SO4 = 1.401 g Nitrogen

### 3.5.2 Phosphorus

Modified Olsen's Bicarbonate Method

**Apparatus used for soil Phosphorus analysis**

- 100 ml polythene bottles
- Shaker
- Funnel
- Whatman No. 42 filter paper
- Volumetric Flask 50 ml
- Pipette 5 ml and 10 ml
- Beakers 50 ml and 100 ml

**Reagents**

- Extracting solution (0.5 N $NaHCO_3$ pH 8.5)
- 5N $H_2SO_4$
- Ammonium Molybdate
- Activated Charcoal
- Stannous chloride solution
- p-nitrophenol indicator 0.25%

**Procedure**

i. 2.5 gm of sieved sample was weighed and one teaspoon of Activated Charcoal was added with 50 ml of 0.5 N $NaHCO_3$ extraction.
ii. Shaked for 30 minutes in a shaker and filtered with Whatman No. 42 Filter paper.

iii. Aliquot of the filtrate in a 50 ml volumetric flask and acidify with 5N $H_2SO_4$ to pH 5.0 using p-nitrophenol indicator until the yellow color disappeared. Further, acid was added drop wise until the yellow color changes into colorless.
iv. Distilled water was added washing down the sides of volumetric flask to 40 ml followed by 8 ml of ammonium molybdate and shaken well.
v. The solution was allowed to sit for 10 minutes to obtain maximum intensity of blue color. Then reading was taken in spectrophotometer (690 nm).

**Calculation**

$$P(kg/ha) = \ ppm\ P\ in\ solution\ \times \frac{50}{10} \times \frac{50}{2.5} \times 2.24 \times 2.3$$

Where,

2.24 = conversion factor for ppm in soil to kg/ha in soil

2.3 = conversion factor for P to $P_2O_5$

**3.5.3 Potassium**

Flame Photometric method (Toth and Prince, 1949)

**Apparatus required for potassium analysis**

- Multiple Dispenser or automatic pipette – 25 ml
- Flasks and beakers – 100 ml
- Flame Photometer

**Reagents**

- Molar neutral ammonium acetate solution: Dissolve 77 g of ammonium acetate ($NH_4C_2H_3O_2$) in 1litre of water. Check the pH with bromothymol blue or with a pH meter. If not neutral, add either ammonium hydroxide or acetic acid as per the need to neutralize it to pH 7.0.
- Standard potassium solution: Dissolve 1.908 g pure KCl in 1 litre of distilled water. This solution contains 1 mg K/ml. Take 100 ml of this solution and dilute to 1 litre with ammonium acetate solution. This gives 0.1 mg K/ml as stock solution.
- Working potassium standard solutions: Take 0, 5, 10, 15 and 20 ml of the stock solution separately and dilute each to 100 ml with the M ammonium acetate solution. These solutions contain 0, 5, 10, 15 and 20 µg K/ml, respectively.

**Procedure**

i. Preparation of the Standard Curve: Set up the flame photometer by atomizing 0 and 20 μg K/ml solutions alternatively to 0 and 100 reading. Atomize intermediate working standard solutions and record the readings. Plot these readings against the respective potassium contents and connect the points with a straight line to obtain a standard curve.

ii. Extraction: Add 25 ml of the ammonium acetate extractant to conical flask fixed in a wooden rack containing 5 g soil sample. Shake for 5 minutes and filter.

iii. Determine potash in the filtrate with the flame photometer.

**Calculation**

$$K(kg/ha) = \frac{A}{5} \times \frac{25}{1000000} \times 2000000 = 10\text{A}$$

Where,

A = content of K (μg) in the sample, as read from the standard curve. Weight of 1 ha of soil up to a plough depth of 22 cm is approx. 2 million kg.

**3.4.5 Soil Organic Carbon**

The soil organic carbon was calculated using the method (Pearson et al. 2007).

$$\text{SOC} = \rho \times d \times \%\ \text{C}$$

Where,

SOC = soil organic carbon stock per unit area (t/ha)

ρ = soil bulk density ($gm/cm^3$)

d = total depth at which the sample was taken (cm)

% C = carbon concentration

Where, Soil bulk density ($gm/cm^3$) = (oven dry weight of soil) / (volume of soil in the core)

Organic matter in soil sample will be determined by Walkey-Black method.

**Detail procedure of lab analysis in determining Soil organic matter (SOC):**

Reagents Used

**Sodium Flouride (NaF):** AR grade sodium fluoride powdered was used.

**1N Potassium Dichromate ($K_2Cr_2O_7$) Solution:** 49.04gm of AR $K_2Cr_2O_7$ was kept at 105ºC in hot air oven for 1 hour. As it cools down, it was diluted to 1000ml volumetric flask.

**0.5N Ferrous ammonium sulphate (FAS):** 196gm of FAS was dissolved in 800ml of distilled water and added 20ml of conc. sulfuric acid, cooled and diluted to 1000ml.

**Diphenylamine Indicator:** Approximately 0.5gm of diphenylamine was dissolved in 20ml of distilled water and added 100ml of conc. Sulphuric acid.

**Procedure**

i. 0.5gm of 0.2 mm sieved sample was weighed and taken in 500ml conical flask.
ii. 10ml of 1N $K_2Cr_2O_7$ solution and 20ml of conc. $H_2SO_4$ was added and mixed with gentle rotation for one minute.
iii. The mixture stands for 30 minutes at 150ºC in hot air oven.
iv. The blank was run in the same manner.
v. After 30 minutes 200ml of distilled water and 2ml of diphenylamine indicator was added. Further 0.2gm of NaF was added.
vi. The amount of $K_2Cr_2O_7$ left against 0.5N FAS solution from burette was titrated. Then the volume of FAS consumed for back titration with the brilliant green end point was noted down.

**Calculation**

**Percentage Organic Matter:**

$$OM\% = 0.67 \times \frac{Normality\ of\ FAS \times Volume\ of\ FAS\ consumed}{Weight\ of\ soil\ sample}$$

**Normality of FAS (N):**

$$\text{Normality of FAS(N)} = \frac{Volume\ of\ potassium\ dichromate \times Normality\ of\ dichromate}{Volume\ of\ FAS\ consumed\ by\ blank\ sample}$$

**3.4.6 Percentage Organic Carbon**

$$OC\% = \frac{Soil\ Organic\ matter}{1.724}$$

**3.4.7 Texture**

**Apparatus used for soil texture**

- Soil hydrometer
- Hydrometer Jar
- Mechanical Stirrer
- Dispersion cup
- Beaker 250ml
- Pipette 10ml

**Reagents**

- Sodium Hexametaphosphate

**Procedure**

i. Weight 100 gm of soil sample in a 250 ml beaker and added sufficient water to cover the soil.
ii. Then, 20ml of sodium hexametaphosphate solution was added and stirred well with a glass rod.
iii. Transferred it in a dispersion cup and added sufficient water to fill two-third of the cup. Stirred for 10 minutes in the mechanical stirrer, then transferred in the hydrometer jar and making up the volume to the mark with the hydrometer in it.
iv. Hydrometer was removed and the jar was shaken upside down several times closing the mouth by cork. When the soil was well dispersed the time was noted immediately. The hydrometer was immersed in the jar and reading was taken at 40 sec. and after 3 hours.

**Calculation**

(Silt + Clay) % = Hydrometer reading at 40 sec. + 0.3 × (t – 20) ºC

Clay % = Reading at 3 hrs. + 0.3 × (t – 20) ºC

Sand % = 100 - % (Clay + Silt)

Silt % = % (Clay + Silt) - % Clay

**Analysis**

Combination of silt, sand and clay percentage is then used to compare in triangular chart to determine the texture of the soil.

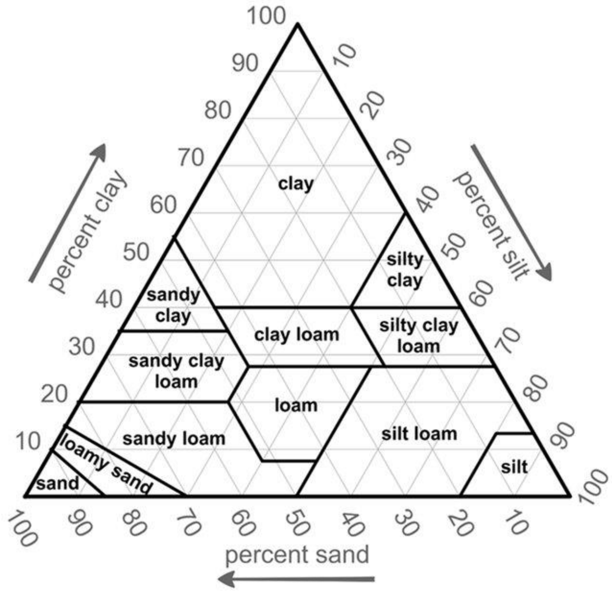


Figure 3.4: Triangular chart for texture determination [31]

# CHAPTER 4

## RESULTS AND DISSCUSSION

### 4.1 Physical Properties of Soil according to Land use and Land cover

### 4.1.1 Descriptive statistics of soil texture in land use land cover

The descriptive statistics showed the Mean ± SE, SD, Maximum and Minimum values of clay, sand, and silt content (%) in soil collected from agricultural, forest and grassland (shrubs) area in both active alluvial plain and recent alluvial plain on the basis of impact by flood as shown in table below.

Table 4: Descriptive statistics of clay, sand, and silt content in agricultural soil

| Land forms | Impact category | Soil Texture (%) | 0-15 cm | | | | 15-30 cm | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Descriptive Statistics | | | | | | | |
| | | | Mean ±SE | SD | Min | Max | Mean ±SE | SD | Min | Max |
| Active | Flood | Clay | 1.2±0 | 0.000 | 1.2 | 1.2 | 1.4±0.37 | 0.837 | 0.2 | 2.2 |
| | | Sand | 92.9±0.46 | 1.025 | 91.8 | 93.8 | 91.4±1.08 | 2.408 | 88.8 | 93.8 |
| | | Silt | 5.9±0.46 | 1.025 | 5 | 7 | 7.2±0.73 | 1.643 | 6 | 9 |
| | Non-affected | Clay | 3.3±0.37 | 0.837 | 2.5 | 4.5 | 3.3±0.37 | 0.837 | 2.5 | 4.5 |
| | | Sand | 87.12±0.76 | 1.695 | 84.5 | 88.6 | 84.1±1.50 | 3.362 | 80.5 | 88.5 |
| | | Silt | 10±0.63 | 1.414 | 9 | 12 | 12.6±1.54 | 3.435 | 8 | 16 |
| Recent | Flood | Clay | 2.38±0.19 | 0.432 | 1.7 | 2.7 | 2.18±0.32 | 0.726 | 1.2 | 2.7 |
| | | Sand | 91.76±0.67 | 1.498 | 90.3 | 94.3 | 89.94±1.84 | 4.104 | 83.3 | 94.3 |
| | | Silt | 5.86±0.50 | 1.126 | 4 | 7 | 7.88±1.70 | 3.794 | 4.5 | 14 |
| | Non-affected | Clay | 3±0.30 | 0.671 | 2.2 | 3.7 | 2.9±0.20 | 0.447 | 2.7 | 3.7 |
| | | Sand | 92.1±0.97 | 2.168 | 90.3 | 95.3 | 92.1±0.72 | 1.605 | 89.8 | 93.8 |
| | | Silt | 4.9±0.71 | 1.597 | 2.5 | 6 | 5±0.57 | 1.275 | 3.5 | 6.5 |

Table 5: Descriptive statistics of clay, sand, and silt content in forest soil

| Land forms | Impact category | Soil Texture (%) | 0-15 cm Mean ±SE | SD | Min | Max | 15-30 cm Mean ±SE | SD | Min | Max |
|---|---|---|---|---|---|---|---|---|---|---|
| Active | Flood | Clay | 2.1±0.00 | 0.000 | 2.1 | 2.1 | 2.24±0.21 | 0.467 | 1.6 | 2.7 |
| | | Sand | 90.34±1.80 | 4.033 | 83.9 | 95.1 | 90.14±1.68 | 3.753 | 83.9 | 94.1 |
| | | Silt | 7.56±1.80 | 4.033 | 2.8 | 14 | 7.62±1.81 | 4.040 | 3.8 | 14.5 |
| | Non-affected | Clay | 1.1±0.20 | 0.447 | 0.3 | 1.3 | 0.9±0.19 | 0.418 | 0.3 | 1.3 |
| | | Sand | 93.3±0.98 | 2.191 | 89.7 | 95.7 | 93.7±0.89 | 2.000 | 90.7 | 95.7 |
| | | Silt | 5.6±0.87 | 1.949 | 4 | 9 | 5.4±0.73 | 1.636 | 4 | 8 |
| Recent | Flood | Clay | 2.8 ± 0.24 | 0.548 | 2.2 | 3.7 | 2.9 ± 0.20 | 0.447 | 2.7 | 3.7 |
| | | Sand | 90.5 ± 0.58 | 1.304 | 89.3 | 92.3 | 90.5 ± 0.80 | 1.789 | 88.3 | 92.3 |
| | | Silt | 6.7 ± 0.49 | 1.095 | 5 | 8 | 6.6 ± 0.75 | 1.673 | 5 | 9 |
| | Non-affected | Clay | 0.64 ± 0.19 | 0.434 | 0.4 | 1.4 | 0.88 ± 0.26 | 0.576 | 0.4 | 1.6 |
| | | Sand | 97.64 ± 0.66 | 1.479 | 95.4 | 99.4 | 96.44 ± 1.85 | 4.136 | 89.4 | 99.4 |
| | | Silt | 1.72 ± 0.52 | 1.154 | 0.2 | 3.2 | 2.68 ± 1.64 | 3.673 | 0 | 9 |

Table 6: Descriptive statistics of clay, sand, and silt content in forest soil

| Land forms | Impact category | Soil Texture (%) | 0-15 cm Mean ±SE | SD | Min | Max | 15-30 cm Mean ±SE | SD | Min | Max |
|---|---|---|---|---|---|---|---|---|---|---|
| Active | Flood | Clay | 1.84 ± 0.43 | 0.953 | 1.3 | 3.5 | 1.74 ± 0.72 | 1.602 | 0.3 | 4.5 |
| | | Sand | 87.26 ± 2.28 | 5.106 | 79.5 | 91.7 | 87.56 ± 1.98 | 4.433 | 81.5 | 92.7 |
| | | Silt | 10.9 ± 1.89 | 4.219 | 7 | 17 | 10.7 ± 1.41 | 3.154 | 7 | 14 |
| | Non-affected | Clay | 1.8 ± 0.20 | 0.447 | 1.5 | 2.5 | 1.3 ± 0.20 | 0.447 | 0.5 | 1.5 |
| | | Sand | 92 ± 0.84 | 1.871 | 90.5 | 95 | 92.9 ± 0.60 | 1.342 | 91.5 | 94.5 |
| | | Silt | 6.2 ± 0.78 | 1.754 | 3.5 | 8 | 5.8 ± 0.58 | 1.304 | 4 | 7 |
| Recent | Flood | Clay | 0.4 ± 0.12 | 0.274 | 0.1 | 0.6 | 0.7 ± 0.24 | 0.548 | 0.1 | 1.6 |
| | | Sand | 95.94 ± 0.23 | 0.508 | 95.4 | 96.4 | 93.14 ±0.66 | 1.479 | 91.4 | 95.4 |
| | | Silt | 3.66 ± 0.14 | 0.321 | 3.3 | 4 | 6.16 ± 0.71 | 1.598 | 4 | 8.5 |
| | Non-affected | Clay | 3.8 ± 0.40 | 0.894 | 2.7 | 4.7 | 3.6 ±0.33 | 0.742 | 2.7 | 4.7 |
| | | Sand | 85.9 ± 1.47 | 3.286 | 82.3 | 88.3 | 85.4 ± 1.78 | 3.975 | 79.3 | 90.3 |
| | | Silt | 10.3 ± 1.11 | 2.490 | 8 | 13 | 11 ± 2.07 | 4.637 | 5 | 18 |

The table 4 shows that the dominant texture of soil in agricultural area regardless of landforms and impact of flood is sand and has lower percentage of silt and clay. The highest sand percentage 92.9 ± 0.46% (Mean± SE) was found in flood-affected active alluvial plain in 0-15 cm depth. Similarly, highest clay percentage 3.3 ± 0.37% was found in non-affected active alluvial plain in both 0-15 cm and 15-30 cm depth. Lastly, highest silt percentage was 12.6 ± 1.54% was found in non-affected active alluvial plain. On the other hand, the lowest sand percentage 84.1 ± 1.50% was found in non-affected active alluvial plain in 15-30 cm depth. The lowest clay percentage 1.2 ± 0.0% was found in flood-affected active alluvial plain in 0-15 cm depth. The lowest silt percentage was 4.9 ± 0.71% was found in non-affected recent alluvial plain

Similarly, table 5 shows that the texture of soil in forest is predominantly sand as the highest sand percentage is 97.64 ±0.66% in non-affected recent alluvial plain in 0-15 cm depth. On the contrary, soil in the forest contains least amount of clay with clay percentage reaching as low as 0.64 ±0.19% in non-affected recent alluvial plain in 0-15 cm depth.

However, table 6 shows that the texture in grassland is dominantly by loamy sand texture which suggests that percentage of sand and silt is comparatively higher than clay percentage. The highest sand percentage was 95.94 ±0.23% in flood-affected recent alluvial plain in 0-15 cm depth. Similarly, the highest silt percentage 11 ±2.07% in non-affected recent alluvial plain in 15-30 cm depth. On the other side, the soil in grassland had least amount of clay content which was low as 0.4 ±0.12% in flood-affected recent alluvial plain in 0-15 cm depth.

In summary, texture of soil in Rajapur was dominated by sand texture and some rare soil samples were loamy sand texture. Soil content in accordance to increasing percentage was clay, silt, and sand. Sandy textured soil have tendency to lose nitrate content after flooding and same phenomenon is observed in Rajapur although in lesser extent. However, there were no notable changes in texture between flood affected and non-affected areas in Rajapur. This observation is not in accordance with the results highlighted by Lee et al. 2014. Comparatively, clay percentage was slightly higher in recent alluvial plain than in active alluvial plain, which was evident in water retention property of soil discussed in 4.1.2.

### 4.1.2 Descriptive statistics of moisture content in land use land cover

Table 7: Moisture Content (%) in Soil

| Land use Land cover | Land form | Impact of flood | 0-15 cm | | | | 15-30 cm | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Descriptive Statistics | | | | | | | |
| | | | Mean | SD | Min | Max | Mean | SD | Min | Max |
| Agricultural | Active | Flood | 12±3.74 | 8.367 | 5 | 25 | 13±6.04 | 13.509 | 0 | 30 |
| | | Non-affected | 17±3.00 | 6.708 | 10 | 25 | 26±2.92 | 6.519 | 15 | 30 |
| | Recent | Flood | 27.6 ± 8.59 | 19.204 | 10 | 60 | 25.2 ± 2.15 | 4.817 | 20 | 30 |
| | | Non-affected | 37.4 ± 3.97 | 8.877 | 28 | 46 | 24 ± 2.77 | 6.205 | 15 | 29 |
| Forest | Active | Flood | 7 ± 2.00 | 4.472 | 0 | 10 | 13 ± 7.18 | 16.047 | 0 | 40 |
| | | Non-affected | 19.6 ± 3.26 | 7.301 | 10 | 28 | 10.8 ± 4.14 | 9.257 | 0 | 24 |
| | Recent | Flood | 41.2 ± 7.70 | 17.225 | 25 | 66 | 58.6 ± 8.18 | 18.298 | 40 | 78 |
| | | Non-affected | 18 ± 4.64 | 10.368 | 10 | 35 | 15 ± 7.07 | 15.811 | 0 | 40 |
| Grassland | Active | Flood | 24 ± 3.32 | 7.416 | 15 | 35 | 39 ± 4.00 | 8.944 | 30 | 50 |
| | | Non-affected | 23 ± 3.00 | 6.708 | 15 | 30 | 15 ± 6.52 | 14.577 | 5 | 40 |
| | Recent | Flood | 12 ± 3.74 | 8.367 | 0 | 20 | 7 ± 2.00 | 4.472 | 5 | 15 |
| | | Non-affected | 52.8 ± 8.31 | 18.580 | 38 | 76 | 56 ± 9.27 | 20.736 | 30 | 80 |

The table highlights that the highest moisture content in agricultural area was 37.4 ± 3.97% (Mean ± SE) in 0-15 cm depth in non-affected recent alluvial plain. In this category, standard deviation (SD), minimum, and maximum value were 8.87, 28, and 46% respectively. And, the lowest moisture content in agricultural area was 12.0 ±3.74% in 0-15 cm depth in flood-affected active alluvial plain. In the aforementioned category, standard deviation (SD), minimum, and maximum value were 8.36, 5, and 25% respectively.

In table 7, the highest moisture content in forest area was 58.6 ±8.18% in flood-affected recent alluvial plain in 15-30 cm depth. In this category, standard deviation, minimum, maximum values were 18.29, 40, and 78% respectively. And, the lowest moisture content 7 ±2.0% was found in flood-affected active alluvial plain in 0-15 cm depth. In this category, standard deviation, minimum and maximum values were 4.47, 0, and 10% respectively.

Besides that, the highest moisture content in grassland 56.0 ±9.27% was found in non-affected recent alluvial plain in 15-30 cm depth. Standard deviation, minimum and maximum for non-affected recent alluvial plain were 20.73, 30, and 80% respectively. And, the lowest moisture content was 7 ±2.0% in flood affected recent alluvial plain in 15-30 cm with standard deviation 4.47%, minimum value of 5% and maximum value of 15%.

In summary, table 7 reflects that the moisture content in active alluvial plain is comparably lower than the moisture content in recent alluvial plain. This may be due to higher clay content in recent alluvial plain. Besides that, soil from grassland category had higher moisture content than forest and agriculture. However, proximity of the Budi Khola near grassland area might have affected the moisture content while taking the reading.

### 4.1.3 Soil Color in land use land cover according to soil depth

Table 8: Soil Color in Rajapur according to land use and landform

| Land use Land Cover | Land forms | Impact of Flood | Soil Color | |
|---|---|---|---|---|
| | | | 0-15 cm | 15-30 cm |
| Agriculture | Active | Flood | Brown | Light Brownish Gray |
| | | | Light Brownish Gray | Grayish brown |
| | | Non-Affected | Gray | Dark Gray |
| | | | Dark Gray | Very Dark Gray |
| | Recent | Flood | Gray | Gray |
| | | | Light Gray | Light Gray |
| | | Non-Affected | Gray | Pale brown |
| | | | Dark Gray | Grayish brown |
| | | | Brown | Brownish Gray |
| Forest | Active | Flood | White | Light Gray |
| | | | Light Gray | Light Yellowish Brown |
| | | | Gray | Gray |
| | | Non-Affected | Yellowish Brown | Grayish Brown |
| | | | Brown | Light Gray |
| | | | Gray | Dark Gray |
| | Recent | Flood | Black | Very Dark Brown |
| | | Non-Affected | Dark Gray | Gray |
| | | | Light Gray | Light Gray |
| Grassland | Active | Flood | Dark Gray | Gray |
| | | | Light Brownish Gray | Light Gray |
| | | Non-Affected | Gray | Light Gray |
| | | | Light Brownish Gray | Gray |
| | Recent | Flood | Very Dark Grayish Brown | Dark Gray |
| | | | Light Gray | Gray |
| | | | Light Gray | Gray |
| | | Non-Affected | Very Dark Brown | Brown |
| | | | Dark Brown | Dark Gray |
| | | | Dark Gray | Dark Brown |

Soil color was determined using Munsell's soil color chart. According to which, in active agricultural area, soil was mostly gray to dark gray in color in 0-15 cm depth. In some flood-affected areas of active alluvial landforms in 0-15 cm depth, brown and light brownish gray color was also noted. However, very dark gray and gray color was dominant in non-affected active alluvial plain. Besides that, in agricultural recent alluvial landform, light gray and gray color was dominant in 0-15 cm depth. And in 15-30 cm depth, the color varied between gray, light gray and brownish gray.

In forest area, active alluvial plain, which was affected by flood, was dominated by light gray color in both 0-15 cm and 15-30 cm depths. But in non-affected areas, variable color like yellowish brown, gray, light gray and dark color persisted in both 0-15 and 15-30 cm depths. Interestingly, recent alluvial plain in forest area was dominated by black and very dark brown color in flooded areas and light gray and gray color were noted in non-affected areas.

On the other hand, in grassland land cover, dark gray, gray and light brownish gray was dominant color in both active and recent landforms regardless of impact of flooding. In summary, there was no comparable difference in color of soil based on flooding and land cover. However, in forest area, there was stark difference in flood-affected and non-affected area because darker soil was present in flooded areas.

## 4.2 Chemical Properties of Soil according to Land use and Land cover

### 4.2.1 Status of chemical properties of Agricultural Area

The descriptive statistics showed the Mean ± SE, standard deviation, minimum and maximum values of soil pH, nitrogen, potassium, phosphorus, organic matter and total organic Carbon in agricultural area in two different landforms named active alluvial plain and recent alluvial plain based on impact of flooding that is affected area and non-affected area.

Table 9: Chemical properties of soil collected in agricultural area in Rajapur

| Landforms | Impact of flood | Chemical Properties | (0-15) cm | | | | (15-30) cm | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Descriptive Statistics | | | | | | | |
| | | | Mean ± SE | SD | Min | Max | Mean ± SE | SD | Min | Max |
| Active | Flood | N (%) | 0.13±0.01 | 0.01 | 0.11 | 0.15 | 0.13±0.01 | 0.02 | 0.11 | 0.16 |
| | | P (kg/ha) | 9.1±0.6 | 1.34 | 7.10 | 10.65 | 8.63±0.63 | 1.41 | 7.20 | 10.65 |
| | | K (kg/ha) | 382.23±26.86 | 60.06 | 333.31 | 483.84 | 351.05±38.2 | 85.42 | 239.23 | 440.83 |
| | | OM (%) | 1.27±0.06 | 0.14 | 1.14 | 1.47 | 1.31±0.11 | 0.24 | 1.07 | 1.61 |
| | | OC (%) | 0.74±0.04 | 0.08 | 0.66 | 0.86 | 0.76±0.06 | 0.14 | 0.62 | 0.93 |
| | | pH | 6.4±0.11 | 0.24 | 6.00 | 6.60 | 6.44±0.23 | 0.52 | 5.80 | 7.00 |
| | Non-affected | N (%) | 0.16±0.01 | 0.02 | 0.13 | 0.19 | 0.16±0.01 | 0.02 | 0.15 | 0.18 |
| | | P (kg/ha) | 13.22±0.64 | 1.43 | 11.30 | 15.30 | 15.43±0.89 | 2.00 | 13.70 | 18.05 |
| | | K (kg/ha) | 280.09±19.59 | 43.82 | 239.23 | 352.13 | 251.6±8 | 17.89 | 231.17 | 279.55 |
| | | OM (%) | 1.57±0.1 | 0.22 | 1.34 | 1.88 | 1.59±0.07 | 0.17 | 1.47 | 1.81 |
| | | OC (%) | 0.91±0.06 | 0.13 | 0.78 | 1.09 | 0.93±0.04 | 0.10 | 0.86 | 1.05 |
| | | pH | 6.36±0.07 | 0.17 | 6.20 | 6.60 | 6.04±0.12 | 0.26 | 5.80 | 6.40 |
| Recent | Flood | N (%) | 0.14±0 | 0.01 | 0.12 | 0.15 | 0.13±0.01 | 0.02 | 0.11 | 0.17 |
| | | P (kg/ha) | 11.12±0.66 | 1.49 | 9.30 | 12.75 | 12.25±0.98 | 2.19 | 9.80 | 14.65 |
| | | K (kg/ha) | 473.09±124.46 | 278.30 | 271.49 | 962.30 | 302.13±15.32 | 34.25 | 271.49 | 354.82 |
| | | OM (%) | 1.35±0.04 | 0.10 | 1.21 | 1.47 | 1.33±0.1 | 0.23 | 1.07 | 1.68 |
| | | OC (%) | 0.79±0.03 | 0.06 | 0.70 | 0.86 | 0.77±0.06 | 0.13 | 0.62 | 0.97 |
| | | pH | 5.86±0.38 | 0.85 | 4.40 | 6.60 | 6.04±0.07 | 0.17 | 5.80 | 6.20 |
| | Non-affected | N (%) | 0.14±0.01 | 0.02 | 0.11 | 0.17 | 0.14±0 | 0.02 | 0.12 | 0.17 |
| | | P (kg/ha) | 9.99±1.12 | 2.49 | 7.20 | 13.90 | 9.04±1.63 | 3.64 | 3.80 | 14.05 |
| | | K (kg/ha) | 281.59±4.72 | 10.54 | 263.42 | 289.76 | 297.29±19.64 | 43.91 | 252.67 | 354.82 |
| | | OM (%) | 1.35±0.11 | 0.25 | 1.07 | 1.68 | 1.42±0.08 | 0.19 | 1.21 | 1.68 |
| | | OC (%) | 0.79±0.06 | 0.14 | 0.62 | 0.97 | 0.83±0.05 | 0.11 | 0.70 | 0.97 |
| | | pH | 5.48±0.22 | 0.50 | 5.00 | 6.00 | 6.1±0.1 | 0.22 | 6.00 | 6.50 |

Table 9 shows that the highest N value 0.16±0.01% (Mean ± SE) was found in non-affected active alluvial plain in both 0-15 cm and 15-30 cm depths. The lowest N percentage 0.13±0.01% was found in flood-affected active alluvial plain in 0-15 cm and 15-30 cm depths and also in flood-affected recent alluvial plain in 15-30 cm depth. In non-affected active alluvial plain, the highest P content 15.43±0.89 kg/ha was found in 15-30 cm depth whereas, the lowest P content 8.63±0.63 kg/ha was in flood-affected active alluvial plain in 15-30 cm depth . The highest K value 473.09±124.46 kg/ha was in flood-affected recent alluvial plain in 0-15 cm depth. Besides that, the lowest K value 251.6±8 kg/ha was in non-affected active alluvial plain in 15-30 cm depth.

On the other hand, the highest OM content 1.59±0.07% was in non-affected active alluvial plain in 15-30 cm depth and the lowest OM content 1.27±0.06% was in flood-affected active alluvial plain. The highest OC content was 0.93±0.04% in non-affected active alluvial plain in 15-30 cm depth and the lowest OC content was 0.74±0.04% in flood-affected active alluvial plain in 0-15 cm depth. Most of soil samples were moderately acidic with value ranging from 5.86-6.44. However, in non-affected recent alluvial plain, soil was weakly acidic with value of 5.48.

In summary, the nutrient contents like N, P, OM and OC were comparatively higher in non-affected active alluvial plain and lower in flood-affected active alluvial plain. This result suggested that the flooding caused nutrient contents to deteriorate. Besides that, there was variable relationship in recent alluvial plain on the basis of impact of flooding. Apart from the value of K, the results indicated that the flood decreases the nutrient content in soil in active alluvial plain.

#### 4.2.2 Status of chemical properties of forest land

Table 10 explained that the descriptive statistics Mean ± SE, standard deviation, minimum and maximum values of soil pH, nitrogen, potassium, phosphorus, organic matter and total organic carbon of forest in two different landforms, active alluvial plain and recent alluvial plain based on impact of flooding, flood affected area and non-affected area.

The highest N in active alluvial plain was in non-affected 0.18±0.04% in 0-15 cm depth and the lowest N was also in non-affected area with value of 0.14±0.01% in 15-30 cm. In recent alluvial plain, the highest N 0.27±0.02% was in non-affected in 0-15 cm and lowest was in 0.15±0.02% in flood-affected in 15-30 cm depth.

Table 10: Chemical properties of soil collected in forest area in Rajapur

| Land forms | Impact of flood | Chemical Properties | (0-15) cm | | | | (15-30) cm | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Descriptive Statistics | | | | | | | |
| | | | Mean | SD | Min | Max | Mean | SD | Min | Max |
| Active | Flood | N (%) | 0.16±0.02 | 0.05 | 0.11 | 0.23 | 0.15±0.02 | 0.03 | 0.11 | 0.20 |
| | | P (kg/ha) | 6.11±0.7 | 1.57 | 4.75 | 8.35 | 6.8±1.19 | 2.67 | 4.75 | 11.30 |
| | | K (kg/ha) | 305.89±20.62 | 46.11 | 258.05 | 368.26 | 275.79±26.83 | 60 | 217.7 | 349.4 |
| | | OM (%) | 1.62±0.24 | 0.53 | 1.14 | 2.35 | 1.46±0.16 | 0.35 | 1.07 | 2.01 |
| | | OC (%) | 0.94±0.14 | 0.31 | 0.66 | 1.36 | 0.85±0.09 | 0.20 | 0.62 | 1.17 |
| | | pH | 6.72±0.08 | 0.18 | 6.60 | 7.00 | 6.48±0.29 | 0.64 | 5.40 | 7.00 |
| | Non-affected | N (%) | 0.18±0.03 | 0.06 | 0.10 | 0.27 | 0.14±0.01 | 0.03 | 0.10 | 0.17 |
| | | P (kg/ha) | 11.92±0.64 | 1.44 | 10.50 | 14.00 | 11.35±0.9 | 2.00 | 9.20 | 13.90 |
| | | K (kg/ha) | 277.4±17.49 | 39.11 | 223.10 | 327.94 | 245.68±16.8 | 37.56 | 209.6 | 303.7 |
| | | OM (%) | 1.8±0.27 | 0.60 | 1.01 | 2.68 | 1.38±0.11 | 0.25 | 1.01 | 1.68 |
| | | OC (%) | 1.04±0.16 | 0.35 | 0.58 | 1.56 | 0.8±0.07 | 0.15 | 0.58 | 0.97 |
| | | pH | 6.16±0.07 | 0.17 | 6.00 | 6.40 | 6.56±0.13 | 0.30 | 6.20 | 7.00 |
| Recent | Flood | N (%) | 0.16±0.04 | 0.08 | 0.06 | 0.25 | 0.15±0.02 | 0.04 | 0.09 | 0.18 |
| | | P (kg/ha) | 11.63±0.92 | 2.06 | 9.35 | 14.50 | 11.3±0.48 | 1.08 | 9.70 | 12.70 |
| | | K (kg/ha) | 411.8±84.71 | 189.42 | 215.04 | 725.76 | 302.67±47.41 | 106.01 | 163.9 | 456.9 |
| | | OM (%) | 1.65±0.38 | 0.84 | 0.60 | 2.55 | 1.49±0.16 | 0.36 | 0.94 | 1.81 |
| | | OC (%) | 0.96±0.22 | 0.49 | 0.35 | 1.48 | 0.86±0.09 | 0.21 | 0.55 | 1.05 |
| | | pH | 5.16±0.41 | 0.91 | 3.80 | 6.00 | 4.8±0.49 | 1.09 | 3.20 | 5.80 |
| | Non-affected | N (%) | 0.27±0.02 | 0.05 | 0.21 | 0.34 | 0.16±0.02 | 0.03 | 0.13 | 0.20 |
| | | P (kg/ha) | 7.76±0.6 | 1.34 | 6.55 | 9.85 | 8.11±0.39 | 1.54 | 6.65 | 10.50 |
| | | K (kg/ha) | 246.22±18.48 | 41.32 | 188.16 | 301.06 | 252.13±24.89 | 55.66 | 169.3 | 319.8 |
| | | OM (%) | 2.71±0.22 | 0.49 | 2.14 | 3.35 | 1.65±0.15 | 0.34 | 1.34 | 2.01 |
| | | OC (%) | 1.57±0.13 | 0.28 | 1.25 | 1.95 | 0.96±0.09 | 0.20 | 0.78 | 1.17 |
| | | pH | 6.28±0.19 | 0.41 | 5.60 | 6.60 | 6.48±0.22 | 0.48 | 5.80 | 7.00 |

In active alluvial plain, the highest P content was in non-affected with the value of 11.92±0.64 kg/ha in 0-15 cm depth and conversely, the lowest P content of 6.11±0.7kg/ha was in flood-affected area in 0-15 cm depth. However, in recent alluvial plain, the opposite phenomenon was observed because the highest P content was in flood-affected areas with the value of 11.63±0.92 kg/ha in 0-15 cm depth and lowest P content was 7.76±0.6% in non-affected area in 0-15 cm depth. Like in agricultural area, flood has increased the K content in soil in forest areas. In active alluvial plain, the highest P content was in flood-affected area with the value of 305.89±20.62 kg/ha in 0-15 cm depth and lowest K content 245.68±16.8 kg/ha in non-affected area in 15-30 cm depth. Similarly in recent alluvial plain, the highest K content was

411.8±84.71 kg/ha in flood-affected in 0-15 cm and the lowest was 246.22±18.48 kg/ha was in non-affected area in 0-15 cm depth.

Apart from that, the highest OM content in active alluvial plain was 1.8±0.27% in non-affected area in 0-15 cm depth and the lowest was 1.38±0.11% in non-affected area in 15-30 cm depth. In recent alluvial plain, the highest OM content was 2.71±0.22 in non-affected areas in 0-15 cm depth and the lowest OM percentage was 1.49±0.16% in flood-affected area in 15-30 cm depth. Similarly, in active alluvial plain, the highest OC content was 1.04±0.16% in non-affected area in 0-15 cm depth and lowest OC content was 0.8±0.07%, which was also in non-affected area but in 15-30 cm depth. In recent alluvial plain, the highest OC content was in non-affected area in 0-15 cm depth with the value of 1.57±0.13%. And the lowest OC content was 0.86±0.09% in flood-affected area in 15-30 cm depth.

Talking about pH of soil in active alluvial plain in forest area, 3 out of 4 categories were neutral with values ranging from 6.5- 6.72, however, one in non-affected area in 0-15 cm depth was moderately acidic with value of 6.16. In recent alluvial plain in forest, weakly acidic soil was found in flood-affected area but moderately acidic soil was found in non-affected area.

To sum up the findings of chemical properties of soil in forest, the results replicate the trend of agricultural soil, most of the soil nutrients like N, P, OM and OC are higher in non-affected areas and lower in flood-affected areas. The K value however contradicts because the value of K is higher in flood-affected areas and lower in non-affected areas, which is similar to findings in agricultural area. In summary, there is a difference in recent and active alluvial plain because, the decrease in nutrient content in soil due to flooding is clearer in active than in recent alluvial plain.

### 4.2.3 Status of Chemical parameters of Grassland

Table 11 shows that the descriptive statistics mean ± SE, standard deviation, maximum and minimum values of soil pH, nitrogen, potassium, phosphorus, organic matter and total organic carbon of grassland (shrubs) in two different landforms, active alluvial plain and recent alluvial plain on the basis of impact of flooding, flood affected area and non-affected area.

Table 11: Chemical properties of soil collected in grassland area in Rajpur

| Land forms | Impact of flood | Chemical Properties | (0-15) cm | | | | (15-30) cm | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Descriptive Statistics | | | | | | | |
| | | | Mean | SD | Min | Max | Mean | SD | Min | Max |
| Active | Flood | N (%) | 0.17± 0.01 | 0.02 | 0.14 | 0.18 | 0.16±0.01 | 0.02 | 0.12 | 0.18 |
| | | P (kg/ha) | 14.43± 0.86 | 1.91 | 12.55 | 17.00 | 15.05±1.19 | 2.66 | 12.15 | 18.25 |
| | | K (kg/ha) | 386.53± 36.32 | 81.21 | 282.24 | 497.28 | 333.31±11.44 | 25.57 | 306.43 | 365.57 |
| | | OM (%) | 1.68± 0.07 | 0.16 | 1.41 | 1.81 | 1.55±0.11 | 0.25 | 1.21 | 1.81 |
| | | OC (%) | 0.97± 0.04 | 0.10 | 0.82 | 1.05 | 0.9±0.06 | 0.14 | 0.70 | 1.05 |
| | | pH | 6.2± 0.15 | 0.35 | 5.60 | 6.40 | 5.52±0.12 | 0.27 | 5.20 | 5.80 |
| | Non-affected | N (%) | 0.17± 0.01 | 0.03 | 0.13 | 0.20 | 0.15±0.01 | 0.03 | 0.10 | 0.19 |
| | | P (kg/ha) | 14.12± 1 | 2.24 | 10.65 | 16.55 | 11.6±0.42 | 0.93 | 10.90 | 13.20 |
| | | K (kg/ha) | 314.5± 12.81 | 28.64 | 282.24 | 341.38 | 344.6±44.39 | 99.26 | 228.48 | 494.59 |
| | | OM (%) | 1.72± 0.13 | 0.29 | 1.34 | 2.01 | 1.54±0.15 | 0.33 | 1.01 | 1.88 |
| | | OC (%) | 1± 0.08 | 0.17 | 0.78 | 1.17 | 0.9±0.09 | 0.19 | 0.58 | 1.09 |
| | | pH | 6.08± 0.12 | 0.27 | 5.80 | 6.40 | 6.36±0.25 | 0.55 | 5.40 | 6.80 |
| Recent | Flood | N (%) | 0.04 ±0.00 | 0.01 | 0.03 | 0.05 | 0.03±0.01 | 0.01 | 0.01 | 0.04 |
| | | P (kg/ha) | 11.59 ±0.79 | 1.76 | 8.65 | 13.40 | 10.96±0.72 | 1.62 | 9.20 | 13.60 |
| | | K (kg/ha) | 398.9 ±25.17 | 56.27 | 322.56 | 475.78 | 402.12±17.43 | 38.98 | 354.82 | 456.96 |
| | | OM (%) | 0.36 ±0.03 | 0.08 | 0.27 | 0.47 | 0.25±0.05 | 0.11 | 0.13 | 0.40 |
| | | OC (%) | 0.21 ±0.02 | 0.04 | 0.16 | 0.27 | 0.15±0.03 | 0.06 | 0.08 | 0.23 |
| | | pH | 6.52 ±0.15 | 0.33 | 6.20 | 7.00 | 6.72±0.08 | 0.18 | 6.40 | 6.80 |
| | Non-affected | N (%) | 0.15 ±0.01 | 0.03 | 0.13 | 0.19 | 0.12±0.02 | 0.04 | 0.08 | 0.18 |
| | | P (kg/ha) | 12.98 ±0.82 | 1.83 | 10.80 | 15.25 | 13.5±1.51 | 3.39 | 10.45 | 19.20 |
| | | K (kg/ha) | 362.34 ±13.82 | 30.91 | 341.38 | 413.95 | 288.69±47.64 | 106.53 | 147.84 | 443.52 |
| | | OM (%) | 1.5 ±0.13 | 0.30 | 1.27 | 1.94 | 1.21±0.17 | 0.38 | 0.80 | 1.81 |
| | | OC (%) | 0.87 ±0.08 | 0.17 | 0.74 | 1.13 | 0.7±0.1 | 0.22 | 0.47 | 1.05 |
| | | pH | 5.16 ±0.44 | 0.98 | 4.00 | 6.00 | 4.6±0.58 | 1.29 | 3.00 | 6.00 |

In active alluvial plain, 0.17±0.01% was the highest N content in both flood affected and non-affected areas in 0-15 cm depth. The lowest N was 0.15±0.01% in non-affected area in 15-30 cm depth. The highest P content was 15.05±1.19 kg/ha in flood-affected in 15-30 cm depth and the lowest P content was 11.6±0.42 kg/ha in non-affected in 15-30 cm depth. Similarly, the highest content of K 386.53±36.32 kg/ha was in flood-affected in 0-15 cm depth and the lowest content of K 314.5±12.82 kg/ha was in non-affected area in 0-15 cm depth. The highest OM percentage was found in non-affected in 0-15 cm depth with the value of

1.72±0.13%. And the lowest OM percentage was 1.54±0.15%, which was also in non-affected area in 15-30 cm depth. The highest OC percentage was 1±0.08% in non-affected area in 01-5 cm depth. However, the lowest OC percentage was in both non-affected and flood-affected with the value 0.9±0.09% in 15-30 cm and 0.9±0.06% in 15-30 cm depth respectively. In active alluvial plain, soil in every category was moderately acidic with value ranging from 5.52±0.12 to 6.36±0.25.

In recent alluvial plain, 0.15±0.01% was the highest N content in non-affected area in 0-15 cm and the lowest N content was 0.03±0.01% in flood-affected area in 15-30 cm depth. The highest P content was 13.5±1.51 kg/ha in non-affected area in 15-30 cm and the lowest P content was 10.96±0.72 kg/ha in flood-affected in 15-30 cm depth. Similarly, the highest K content was 402.12±17.43 kg/ha in flood-affected in 15-30 cm depth whereas, the lowest K was 288.69±47.64 kg/ha in non-affected area in 15-30 cm depth. The highest OM percentage 1.5±0.13% was in non-affected area in 0-15 cm depth and the lowest OM percentage was 0.25±0.05% in flood-affected in 15-30 cm depth. Then, the highest OC content was in non-affected area in 0-15 cm depth with the value of 0.87±0.08% whereas, the lowest OC content was 0.15±0.03% in flood-affected in 15-30 cm depth. In recent alluvial plain, the soil in non-affected area was weakly acidic with the value of 4.6±0.58 in 15-30 cm depth and 5.16±0.44 in 0-15 cm depth. However, the soil was nearly neutral in flood-affected area with the value of 6.52±0.15 in 0-15cm depth and 6.72±0.08 in 15-30 cm depth.

In summary, grassland land cover showed contrasting results than in agricultural area and forest area in term of major nutrient contents like N and P. Unlike agricultural and forest area, the result showed that the N, P and even K content was higher in flood-affected area and lower in non-affected areas. However, there was a slight difference in recent alluvial plain as there was higher N content in non-affected area than in flood-affected area. Besides that, there was no clear difference in OM and OC content between flood-affected and non-affected areas.

### 4.4 Comparison of Physicochemical Properties in flood affected and non-affected Area

#### 4.4.1 Comparison of Physicochemical Properties in Agricultural Area

Table 12: Test of significance in active and recent alluvial plain in agricultural area

| Parameters | Depth (cm) | Active | | | Recent | | |
|---|---|---|---|---|---|---|---|
| | | Difference in mean | Applied Test | p-value | Difference in mean | Applied Test | p-value |
| Nitrogen | 0-15 | 0.03 | t-test | 0.038* | 0.00 | t-test | 0.99 |
| | 15-30 | 0.03 | U-test | 0.169 | 0.01 | t-test | 0.498 |
| Phosphorus | 0-15 | 4.12 | t-test | 0.002* | 1.13 | t-test | 0.415 |
| | 15-30 | 6.8 | t-test | 0.000* | 3.21 | t-test | 0.138 |
| Potassium | 0-15 | 102.14 | t-test | 0.017* | 191.50 | t-test | 0.199 |
| | 15-30 | 99.45 | t-test | 0.059 | 4.84 | t-test | 0.851 |
| Organic Carbon | 0-15 | 0.29 | t-test | 0.038* | 0.00 | t-test | 0.99 |
| | 15-30 | 0.28 | U-test | 0.169 | 0.09 | t-test | 0.498 |
| pH | 0-15 | 0.17 | t-test | 0.772 | 0.00 | t-test | 0.419 |
| | 15-30 | 0.17 | t-test | 0.175 | 0.06 | U-test | 0.906 |

*means it is statistically significant different at 95% confidence level

Table 12 showed p-value after the application of t-test or Wilcoxon Mann-Whitney test when comparing the values in flood-affected and non-affected areas in active and recent alluvial plain in agricultural area. In active alluvial plain, two independent sample t-test showed that there was significant difference in nitrogen (p-value = 0.038) in 0-15 cm depth which is less than 0.05. Wilcoxon Mann Whitney U test showed that there was no significant difference in nitrogen (p-value = 0.169) in 15-30 cm depth which is more than 0.05.

In active alluvial plain, the table showed that there was significant difference in the value of phosphorus in 0-15 cm, and 15-30 cm, potassium in 0-15 cm, and organic carbon in 0-15 cm depth at 95% level of confidence. It also showed that there was no significant difference in potassium in 15-30 cm, organic carbon in 15-30 cm, and pH in both 0-15 cm and 15-30 cm depth at 95% level of confidence.

According to the table, in recent alluvial plain only organic carbon had significantly different values in flood-affected and non-affected areas at 95% level of confidence as the p-value 0.000 in 0-15 cm depth and p-value 0.001 in 15-30 cm depth, which is less than 0.05. However, all other nutrient contents like N, P, and K were not significantly different.

In summary, it was evident that flood affects the nutrient content in soil because majority of nutrient content like N (in 0-15 cm depth), P (both in 0-15 cm and 15-30 cm depth), and K (in 0-15 cm depth) were significantly different in flood-affected and non-affected areas in active alluvial plain but not in recent alluvial plain. Since, the active alluvial plain were more affected by flood than the recent alluvial plain, this results further signified that flood affects the available nutrients in soil and as per table 9, the nutrients contents like N, P, OM and OC have decreased in flood-affected areas while K has increased in flood-affected areas.

#### 4.4.2 Comparison of Physicochemical Properties in Forest

Table 13 showed the p-values for different nutrient contents like N, P, K, and OC and indicator like pH after the application of t-test at 95% level of confidence when comparing the values in flood-affected and non-affected areas in recent alluvial plain active alluvial plain in forest area.

Table 13: Test of significance in active and recent alluvial plain in forest area

| Parameters | Depth (cm) | Active | | | Recent | | |
|---|---|---|---|---|---|---|---|
| | | Difference in mean | Applied Test | p-value | Difference in mean | Applied Test | p-value |
| Nitrogen | 0-15 | 0.02 | t-test | 0.64 | 0.11 | t-test | 0.048* |
| | 15-30 | 0.01 | | 0.688 | 0.02 | | 0.488 |
| Phosphorus | 0-15 | 5.81 | | 0.000* | 3.87 | | 0.010* |
| | 15-30 | 4.55 | | 0.017* | 3.19 | | 0.006* |
| Potassium | 0-15 | 28.49 | | 0.324 | 165.58 | | 0.123 |
| | 15-30 | 30.11 | | 0.375 | 50.53 | | 0.381 |
| Organic Carbon | 0-15 | 0.17 | | 0.64 | 1.06 | | 0.041* |
| | 15-30 | 0.08 | | 0.687 | 0.16 | | 0.488 |
| pH | 0-15 | 0.10 | | 0.001* | 0.62 | | 0.049* |
| | 15-30 | 0.05 | | 0.809 | 0.09 | | 0.022* |

*means it is statistically significant different at 95% confidence level

According to table 13, in active alluvial plain, only phosphorus was significantly different because p-value 0.000 in 0-15 cm depth and p-value 0.017 in 15-30 cm depth is less than 0.05

at 95% level of confidence. Other nutrient contents like N, K and OC were not significantly different at 95% level of confidence. Phosphorus' trend replicated the agricultural area but all other nutrient contents didn't follow the trend.

Likewise, in recent alluvial plain, nitrogen content was significantly different in flood-affected area and non-affected areas in 0-15 cm depth because the p-value 0.048 is less than 0.05. Similarly, phosphorus content in 0-15 cm (p-value = 0.010) and 15-30 cm (p-value = 0.006) and organic carbon content in 0-15 cm depth (p-value = 0.041) were significantly different in flood-affected and non-affected areas. However, nitrogen content in 15-30 cm, potassium content in both 0-15 cm and 15-30 cm depths, organic carbon in 15-30 cm depth were not significantly different in flood-affected and non-affected areas. Besides that, the value of pH in both 0-15 cm depth (p-value = 0.049) and 15-30 cm depth (p-value = 0.022) were significantly different at 95% level of confidence. Results in table 13 suggested that the effect of flood varies with the land use.

### 4.4.3 Comparison of Physicochemical Properties in Grassland

Table 14 showed p-values for different nutrient contents, like nitrogen, phosphorus, potassium and organic carbon and indicator like pH value, when comparing the values in flood-affected and non-affected areas in active alluvial plain in grassland area at 95% level of confidence.

Table 14: Test of significance in active and recent alluvial plain in grassland area

| Parameters | Depth (cm) | Active | | | Recent | | |
|---|---|---|---|---|---|---|---|
| | | Difference in mean | Applied Test | p-value | Difference in mean | Applied Test | p-value |
| Nitrogen | 0-15 | 0.00 | t-test | 0.798 | 0.11 | t-test | 0.001* |
| | 15-30 | 0.00 | | 0.944 | 0.1 | | 0.004* |
| Phosphorus | 0-15 | 0.31 | | 0.820 | 1.39 | | 0.257 |
| | 15-30 | 3.45 | | 0.041* | 2.54 | | 0.183 |
| Potassium | 0-15 | 72.04 | | 0.121 | 36.56 | | 0.249 |
| | 15-30 | 11.29 | | 0.816 | 113.43 | | 0.075 |
| Organic Carbon | 0-15 | 0.04 | | 0.798 | 1.14 | | 0.000* |
| | 15-30 | 0.01 | | 0.944 | 0.95 | | 0.004* |
| pH | 0-15 | 0.02 | | 0.558 | 0.66 | | 0.033* |
| | 15-30 | 0.01 | | 0.024* | 0.55 | | 0.02 |

* means it is statistically significant different at 95% confidence level

As per the table in active alluvial plain, only phosphorus content in 15-30 cm depth was significantly different in flood-affected and non-affected areas. On the other side, nitrogen content in both 0-15 cm and 15-30 cm depths, phosphorus in 0-15 cm depth, potassium content in both 0-15 cm and 15-30 depths, organic carbon in both 0-15 cm and 15-30 depths and pH in were not significantly different.

However, in recent alluvial plain, table 14 showed that the nitrogen content in both 0-15 cm depth (p-value = 0.001) and in 15-30 cm depth (p-value = 0.004), which were less than 0.05, were significantly different in flood-affected and non-affected areas in recent alluvial grassland in grassland area. Similarly, the potassium content in 15-30 cm depth and organic carbon content in 0-15 cm and 15-30 cm depths were significantly different in flood-affected and non-affected areas. However, phosphorus content in 0-15 cm and 15-30 cm depths, potassium content in 0-15 cm depth, and pH values in both 0-15 cm and 15-30 cm depths were not significantly different in flood-affected and non-affected areas.

**4.5 Discussion**

The results obtained from field observation, laboratory analysis, and statistical analysis showed that flooding has variable impacts on soil nutrients and quality. However, the extent and variability of impact depends upon various factors. In this study, the physicochemical properties were observed on the basis of landforms, land use, and impact of flooding. In agricultural area, the changes in nutrient levels were pronounced in active alluvial landforms because, the independent sample t-test showed that there was significant changes in nitrogen content (p-value = 0.038) at 0-15 cm depth, phosphorus content (p-value = 0.002) at 0-15 cm depth and (p-value = 0.00) at 15-30 cm depth, potassium content (p-value = 0.017) at 0-15 cm depth and (p-value = 0.034) at 15-30 cm depth, and organic carbon (p-value = 0.038) at 0-15 cm depth at 95% confidence level. The result showed that the nitrogen, phosphorus and organic carbon decreased in flood-affected areas while only potassium value increased. Nitrogen decreased in post-flood condition in two ways, firstly, the dissolution of nitrate due to influx of water and secondly, soil denitrification caused by anaerobic condition in flooded water. Similarly, the decrease in phosphorus content is due to increase in phosphorus solubility due to anaerobic conditions which cause leaching (Lee et al., 2014, Gelsomino et al., 2006, Hafeez et al., 2019). Especially Hafeez et al. (2019) suggested that the nitrogen and phosphorus were most affected because of flood in the soil while the research shows increase in potassium at alluvial soil (Lee et al., 2014, Gelsomino et al., 2006). But Gonzalez et al. (2016) suggested the increase in potassium content might be due to the influx of potassium-rich sediment during flooding.

Lee et al. (2014) also reported that the changes in nutrient content were dependent on the landforms like Waterfront, Bank, and plant-specific areas. This trend was lined with our study at Rajapur because the changes in nutrient level in flood affected areas and non-affected areas were not consistent across recent and active alluvial landforms and so as in agricultural area, forest area, and grassland area as well. In recent alluvial plain in agricultural area, all the nutrient contents except for organic carbon were not significantly different. This result replicated the trend explained by Hafeez et al. (2019) in which they mentioned that the nutrient contents were not significantly different in flood-affected and non-affected areas.

The results from grassland area and agricultural area were contrasting each other because the recent alluvial plain in grassland showed that majority of nutrient content like nitrogen (p-value = 0.001) at 0-15 cm depth and (p-value = 0.004) at 15-30 cm depth, and organic carbon (p-value = 0.000) at 0-15 cm depth and (p-value = 0.004) at 15-30 cm depth were significantly different in flood-affected and non-affected area. But in active alluvial plain in grassland, only phosphorus (p-value = 0.041) at 15-30 cm depth was significantly different in flood-affected and non-affected areas. This phenomenon in grassland could be because of land covered by grassland as Lee et al. (2014) discussed that plant-specific areas were resistant to changes in nutrient level due to flooding. Besides that, in forest area, only phosphorus content (p-value = 0.000) at 0-15 cm depth and (p-value = 0.017) at 15-30 cm depth was significantly different in flood-affected areas and non-affected areas in active alluvial plain. However, in recent alluvial plain, phosphorus (p-value = 0.010) at 0-15 cm depth and (p-value = 0.006) at 15-30 cm depth along with organic carbon (p-value = 0.041) at 0-15 cm depth was significantly different.

Besides the physicochemical properties, biological components were also briefly observed and it was found that the macro-organisms were found only in recent alluvial plain. Since, recent alluvial plain had more time to recover from flood than active alluvial plain, organisms recovered in recent alluvial plain, which is in accordance to the finding of Gonzalez et al.

(2016), who pointed that biomass and microbial activity resembled pre-flooding state after interval of three months.

Table 15: Summary of changes in physicochemical properties

| Parameters | Changes | |
|---|---|---|
| Texture | Increase in sand content especially in active alluvial plain | |
| Moisture | Decrease in moisture content in flood affected area of active alluvial plain | |
| Nitrogen | Agriculture | Decrease in N% in flood affected active alluvial plain |
| | Forest | Decrease in N% in flood affected recent alluvial plain but not in active alluvial plain |
| | Grassland | Decrease in N% in flood affected recent alluvial plain but not in active alluvial plain |
| Phosphorus | Agriculture | Decrease in P% in flood affected active alluvial plain |
| | Forest | Decrease in P% in flood affected active alluvial plain but increase in P% in recent alluvial plain |
| | Grassland | Increase in P% in flood affected active alluvial plain |
| Potassium | Agriculture | Increase in K% in flood affected active alluvial plain |
| | Forest | No significant changes observed in flood affected and non-affected area |
| | Grassland | No significant changes observed in flood affected and non-affected area |
| Organic Carbon | Agriculture | No significant changes in flood affected active alluvial plain |
| | Forest | Decrease in OC% in flood affected recent alluvial plain |
| | Grassland | Decrease in OC% in flood affected recent alluvial plain |

In the bigger picture, the results from the study agrees with the conclusion by Green (2004) and Dewan (2015) that the agricultural areas are more vulnerable to flooding and changes in nutrient level than forest and grassland, which showed no significant changes in flood-affected and non-affected areas. Since, the local people rely on agricultural land, where they cultivated food crops like, rice, mustard and potato would be adversely affected by flooding.

To sum up the findings, flooding inevitably impacts the nutrient content in soil but the extent of impact is dependent upon the landforms and also land use land cover. More importantly, flooding does not necessarily decrease all the nutrient content because as the result showed nutrients like potassium can potentially increase due to transport of nutrient-rich sediment during flooding.

# CHAPTER 5

## CONCLUSION AND RECOMMENDATION

### 5.1 Conclusion

In conclusion, physicochemical properties were assessed in Rajapur on the basis of landforms, land use land cover and the impact of flooding in two vertical scales, 0-15 cm and 15-30 cm. After the assessment, it is clear that flooding affects the physicochemical properties in soil but the impact of flooding varies and is dependent upon landform, land use and land cover and also vertical scale. The results also reflected that flooding does not necessarily decrease the nutrient content although most of nutrients like nitrogen, phosphorus, organic matter and organic carbon decreased due to flooding but potassium increased after the flooding. The findings were not consistent across different landforms and land use, which was expected.

Most importantly, only agricultural area had significantly different nutrient contents due to flooding in active alluvial plain but not in recent alluvial plain. Opposite phenomenon was noted in grassland area, which showed majority of nutrient content had significantly different contents due to flooding in recent alluvial plain but not in active alluvial plain. Besides that, soils in forest area did not have significantly different nutrient content in active and recent alluvial plain except for phosphorus content, which was significantly different at 95% level of confidence in both active and recent alluvial plain.

### 5.2 Recommendation

Every project and every research serve a purpose to the society and people. After the completion of this report, few recommendations have been made, which are as follows:

1) The report showed that extent of impact on nutrient content is not consistent across landform; this will be reference for academician and discussion maker.
2) The chemical properties of soil showed that the nutrient values in flood-affected and non-affected areas and site-specific further research is needed.

3) It is highly recommended to assess the soil in periodic term to maintain track of changing nutrient level.
4) The changes in nitrogen and phosphorus content were not consistent with the changes in potassium, which suggests that the need to assess the sediment transport from higher geological regions.

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# APPENDICES

Appendix 1: Active Alluvial Plain Agricultural Area

Hypothesis

Ho: There is no significant difference in the Physicochemical properties of active alluvial plain soil in flood affected and non-affected agricultural area.

H1: There is significant difference in the Physicochemical properties of active alluvial plain soil in flood affected and non-affected agricultural area.

**t-test of N**

a) 0-15 cm depth

**Tests of normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Affected | .228 | 5 | .200* | .910 | 5 | .469 |
| Non-affected | .173 | 5 | .200* | .958 | 5 | .794 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -2.550 | .034 |
| Equal variances not assumed | -2.550 | .038 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Affected | .269 | 5 | .200* | .857 | 5 | .218 |
| Non-affected | .365 | 5 | .028 | .743 | 5 | .026 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Mann-Whitney Test

| Test Statistics[a] | |
|---|---|
| | VAR00007 |
| Mann-Whitney U | 6.000 |
| Wilcoxon W | 21.000 |
| Z | -1.375 |
| Asymp. Sig. (2-tailed) | .169 |
| Exact Sig. [2*(1-tailed Sig.)] | .222[b] |

a. Grouping Variable: VAR00006

b. Not corrected for ties.

**t-test of P**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Affected | .182 | 5 | .200* | .975 | 5 | .904 |
| Non-affected | .236 | 5 | .200* | .947 | 5 | .719 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -4.712 | .002 |
| Equal variances not assumed | -4.712 | .002 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | Df | Sig. |
| Affected | .272 | 5 | .200* | .917 | 5 | .512 |
| Non-affected | .305 | 5 | .144 | .833 | 5 | .147 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -6.211 | .000 |
| Equal variances not assumed | -6.211 | .000 |

**t-test of K**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | Df | Sig. | Statistic | Df | Sig. |
| Affected | .268 | 5 | .200* | .825 | 5 | .129 |
| Non-affected | .248 | 5 | .200* | .879 | 5 | .306 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | 3.072 | .015 |
| Equal variances not assumed | 3.072 | .017 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | Df | Sig. | Statistic | df | Sig. |
| Affected | .240 | 5 | .200* | .920 | 5 | .528 |
| Non-affected | .217 | 5 | .200* | .943 | 5 | .690 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | 2.548 | .034 |
| Equal variances not assumed | 2.548 | .059 |

**t-test of OC**

a) 0-15cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Affected | .228 | 5 | .200* | .910 | 5 | .469 |
| Non-affected | .173 | 5 | .200* | .958 | 5 | .794 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

b.

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -2.550 | .034 |
| Equal variances not assumed | -2.550 | .038 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Affected | .270 | 5 | .200* | .860 | 5 | .229 |
| Non-affected | .365 | 5 | .028 | .743 | 5 | .026 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Mann-Whitney Test

| | VAR00022 |
|---|---|
| Mann-Whitney U | 6.000 |
| Wilcoxon W | 21.000 |
| Z | -1.375 |
| Asymp. Sig. (2-tailed) | .169 |
| Exact Sig. [2*(1-tailed Sig.)] | .222[b] |

a. Grouping Variable: oc1530

b. Not corrected for ties.

**t-test of pH**

a) 0-15cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | Df | Sig. | Statistic | df | Sig. |
| Affected | .300 | 5 | .161 | .833 | 5 | .146 |
| Non-affected | .231 | 5 | .200* | .881 | 5 | .314 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | .302 | .771 |
| Equal variances not assumed | .302 | .772 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Affected | .221 | 5 | .200* | .915 | 5 | .501 |
| Non-affected | .221 | 5 | .200* | .902 | 5 | .421 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | 1.543 | .161 |
| Equal variances not assumed | 1.543 | .175 |

Appendix 2: Recent Alluvial Plain Agricultural Area

Hypothesis

Ho: There is no significant difference in the Physicochemical properties of recent alluvial plain soil in flood affected and non-affected agricultural area.

H1: There is significant difference in the Physicochemical properties of recent alluvial plain soil in flood affected and non-affected agricultural area.

**t-test of N**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Affected | .246 | 5 | .200* | .956 | 5 | .777 |
| Non-affected | .218 | 5 | .200* | .959 | 5 | .804 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | .000 | 0.99 |
| Equal variances not assumed | .000 | 0.99 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | Df | Sig. | Statistic | df | Sig. |
| Affected | .192 | 5 | .200* | .961 | 5 | .814 |
| Non-affected | .267 | 5 | .200* | .939 | 5 | .656 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -.711 | .497 |
| Equal variances not assumed | -.711 | .498 |

**t-test of P**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | Df | Sig. | Statistic | df | Sig. |
| Affected | .232 | 5 | .200* | .903 | 5 | .429 |
| Non-affected | .219 | 5 | .200* | .946 | 5 | .710 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | .871 | .409 |
| Equal variances not assumed | .871 | .415 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Affected | .243 | 5 | .200* | .876 | 5 | .290 |
| Non-affected | .263 | 5 | .200* | .930 | 5 | .599 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | 1.691 | .129 |
| Equal variances not assumed | 1.691 | .138 |

**t-test of K**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Affected | .388 | 5 | .013 | .729 | 5 | .019 |
| Non-affected | .324 | 5 | .092 | .795 | 5 | .074 |

*. This is a lower bound of the true significance.

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | 1.537 | .163 |

| | | |
|---|---|---|
| Equal variances not assumed | 1.537 | .199 |

a) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Affected | .193 | 5 | .200* | .904 | 5 | .431 |
| Non-affected | .211 | 5 | .200* | .917 | 5 | .514 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | .194 | .851 |
| Equal variances not assumed | .194 | .851 |

**t-test of OC**

a) 0-15cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Affected | .246 | 5 | .200* | .956 | 5 | .777 |
| Non-affected | .227 | 5 | .200* | .943 | 5 | .687 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | .000 | 0.99 |
| Equal variances not assumed | .000 | 0.99 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Affected | .192 | 5 | .200* | .961 | 5 | .814 |
| Non-affected | .267 | 5 | .200* | .939 | 5 | .656 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -.711 | .497 |
| Equal variances not assumed | -.711 | .498 |

**t-test of pH**

a) 0-15cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Affected | .366 | 5 | .028 | .794 | 5 | .073 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Non-affected | .250 | 5 | .200* | .814 | 5 | .105 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | .863 | .413 |
| Equal variances not assumed | .863 | .419 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Affected | .231 | 5 | .200* | .881 | 5 | .314 |
| Non-affected | .473 | 5 | .001 | .552 | 5 | .000 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Mann Whitney

**Test Statistics[a]**

| | VAR00033 |
|---|---|
| Mann-Whitney U | 12.000 |
| Wilcoxon W | 27.000 |
| Z | -.118 |
| Asymp. Sig. (2-tailed) | .906 |
| Exact Sig. [2*(1-tailed Sig.)] | 1.000[b] |

a. Grouping Variable: pH1530

b. Not corrected for ties.

Appendix 3: Active Alluvial Plain Forest

Hypothesis

Ho: There is no significant difference in the Physicochemical properties of active alluvial plain soil in flood affected and non-affected forest.

H1: There is significant difference in the Physicochemical properties of active alluvial plain soil in flood affected and non-affected forest.

**t-test of N**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | Df | Sig. |
| VAR00003 | .304 | 5 | .148 | .866 | 5 | .250 |
| VAR00004 | .221 | 5 | .200* | .952 | 5 | .749 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -.486 | .640 |
| Equal variances not assumed | -.486 | .640 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | Df | Sig. | Statistic | Df | Sig. |
| VAR00007 | .285 | 5 | .200* | .924 | 5 | .557 |
| VAR00008 | .244 | 5 | .200* | .950 | 5 | .735 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | .418 | .687 |
| Equal variances not assumed | .418 | .688 |

**t-test of P**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00011 | .274 | 5 | .200* | .869 | 5 | .263 |
| VAR00012 | .188 | 5 | .200* | .933 | 5 | .620 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|

| | | |
|---|---|---|
| Equal variances assumed | -6.086 | .000 |
| Equal variances not assumed | -6.086 | .000 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00015 | .278 | 5 | .200* | .822 | 5 | .121 |
| VAR00016 | .255 | 5 | .200* | .911 | 5 | .473 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -3.050 | .016 |
| Equal variances not assumed | -3.050 | .017 |

**t-test of K**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00019 | .232 | 5 | .200* | .928 | 5 | .581 |

| | | | | | | |
|---|---|---|---|---|---|---|
| VAR00020 | .135 | 5 | .200* | .997 | 5 | .998 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | 1.054 | .323 |
| Equal variances not assumed | 1.054 | .324 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00023 | .222 | 5 | .200* | .884 | 5 | .329 |
| VAR00024 | .254 | 5 | .200* | .892 | 5 | .368 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | .951 | .369 |
| Equal variances not assumed | .951 | .375 |

**t-test of OC**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00027 | .304 | 5 | .148 | .866 | 5 | .250 |
| VAR00028 | .221 | 5 | .200* | .952 | 5 | .749 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -.486 | .640 |
| Equal variances not assumed | -.486 | .640 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00031 | .285 | 5 | .200* | .924 | 5 | .557 |
| VAR00032 | .244 | 5 | .200* | .950 | 5 | .735 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|

| | | |
|---|---|---|
| Equal variances assumed | .418 | .687 |
| Equal variances not assumed | .418 | .688 |

**t-test of pH**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00035 | .349 | 5 | .046 | .771 | 5 | .046 |
| VAR00036 | .231 | 5 | .200* | .881 | 5 | .314 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | 5.112 | .001 |
| Equal variances not assumed | 5.112 | .001 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00039 | .291 | 5 | .193 | .816 | 5 | .110 |

| | | | | | | |
|---|---|---|---|---|---|---|
| VAR00040 | .246 | 5 | .200* | .956 | 5 | .777 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -.253 | .807 |
| Equal variances not assumed | -.253 | .809 |

Appendix 4: Recent Alluvial Plain Forest

Hypothesis

Ho: There is no significant difference in the Physicochemical properties of recent alluvial plain soil in flood affected and non-affected forest.

H1: There is significant difference in the Physicochemical properties of recent alluvial plain soil in flood affected and non-affected forest.

**t-test of N**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00003 | .243 | 5 | .200* | .887 | 5 | .340 |
| VAR00004 | .170 | 5 | .200* | .970 | 5 | .872 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -2.435 | .041 |
| Equal variances not assumed | -2.435 | .048 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00007 | .215 | 5 | .200* | .887 | 5 | .340 |
| VAR00008 | .256 | 5 | .200* | .795 | 5 | .074 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -.727 | .488 |
| Equal variances not assumed | -.727 | .488 |

**t-test of P**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |

| | | | | | | |
|---|---|---|---|---|---|---|
| VAR00011 | .220 | 5 | .200* | .956 | 5 | .780 |
| VAR00012 | .276 | 5 | .200* | .887 | 5 | .344 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | 3.525 | .008 |
| Equal variances not assumed | 3.525 | .010 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00015 | .226 | 5 | .200* | .942 | 5 | .679 |
| VAR00016 | .289 | 5 | .199 | .892 | 5 | .367 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | 3.796 | .005 |
| Equal variances not assumed | 3.796 | .006 |

**t-test of K**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00019 | .312 | 5 | .124 | .862 | 5 | .236 |
| VAR00020 | .182 | 5 | .200* | .989 | 5 | .975 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | 1.910 | .093 |
| Equal variances not assumed | 1.910 | .123 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00023 | .196 | 5 | .200* | .972 | 5 | .887 |
| VAR00024 | .180 | 5 | .200* | .973 | 5 | .892 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | .944 | .373 |

| | | |
|---|---|---|
| Equal variances not assumed | .944 | .381 |

**t-test of OC**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00027 | .243 | 5 | .200* | .887 | 5 | .340 |
| VAR00028 | .170 | 5 | .200* | .970 | 5 | .872 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -2.435 | .041 |
| Equal variances not assumed | -2.435 | .048 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00031 | .215 | 5 | .200* | .887 | 5 | .340 |
| VAR00032 | .256 | 5 | .200* | .795 | 5 | .074 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -.727 | .488 |
| Equal variances not assumed | -.727 | .488 |

**t-test of pH**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00035 | .230 | 5 | .200* | .876 | 5 | .293 |
| VAR00036 | .224 | 5 | .200* | .842 | 5 | .171 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -2.504 | .037 |
| Equal variances not assumed | -2.504 | .049 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00039 | .221 | 5 | .200* | .904 | 5 | .434 |

| | | | | | | |
|---|---|---|---|---|---|---|
| VAR00040 | .198 | 5 | .200* | .957 | 5 | .787 |

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -3.161 | .013 |
| Equal variances not assumed | -3.161 | .022 |

Appendix 5: Active Alluvial Plain Grassland

Hypothesis

Ho: There is no significant difference in the Physicochemical properties of active alluvial plain soil in flood affected and non-affected grassland.

H1: There is significant difference in the Physicochemical properties of active alluvial plain soil in flood affected and non-affected grassland.

**t-test of N**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00003 | .300 | 5 | .161 | .833 | 5 | .146 |
| VAR00004 | .242 | 5 | .200* | .900 | 5 | .410 |

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -.267 | .796 |
| Equal variances not assumed | -.267 | .798 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00007 | .186 | 5 | .200* | .943 | 5 | .687 |
| VAR00008 | .257 | 5 | .200* | .895 | 5 | .382 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | .072 | .944 |
| Equal variances not assumed | .072 | .944 |

**t-test of P**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00011 | .231 | 5 | .200* | .914 | 5 | .491 |

| | | | | | | |
|---|---|---|---|---|---|---|
| VAR00012 | .245 | 5 | .200* | .932 | 5 | .611 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | .235 | .820 |
| Equal variances not assumed | .235 | .820 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00015 | .218 | 5 | .200* | .910 | 5 | .466 |
| VAR00016 | .343 | 5 | .055 | .786 | 5 | .062 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | 2.741 | .025 |
| Equal variances not assumed | 2.741 | .041 |

**t-test of K**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00019 | .189 | 5 | .200* | .984 | 5 | .954 |
| VAR00020 | .281 | 5 | .200* | .813 | 5 | .102 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | 1.871 | .098 |
| Equal variances not assumed | 1.871 | .121 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00023 | .228 | 5 | .200* | .919 | 5 | .525 |
| VAR00024 | .185 | 5 | .200* | .972 | 5 | .885 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -.246 | .812 |

| | | |
|---|---|---|
| Equal variances not assumed | -.246 | .816 |

**t-test of OC**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00027 | .300 | 5 | .161 | .833 | 5 | .146 |
| VAR00028 | .242 | 5 | .200* | .900 | 5 | .410 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -.267 | .796 |
| Equal variances not assumed | -.267 | .798 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00031 | .186 | 5 | .200* | .943 | 5 | .687 |
| VAR00032 | .257 | 5 | .200* | .895 | 5 | .382 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | .072 | .944 |
| Equal variances not assumed | .072 | .944 |

**t-test of pH**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00035 | .318 | 5 | .109 | .701 | 5 | .010 |
| VAR00036 | .273 | 5 | .200* | .852 | 5 | .201 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | .612 | .557 |
| Equal variances not assumed | .612 | .558 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00039 | .273 | 5 | .200* | .852 | 5 | .201 |

| | | | | | | |
|---|---|---|---|---|---|---|
| VAR00040 | .329 | 5 | .082 | .778 | 5 | .053 |

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -3.047 | .016 |
| Equal variances not assumed | -3.047 | .024 |

Appendix 6: Recent Alluvial Plain Grassland

Hypothesis

Ho: There is no significant difference in the Physicochemical properties of recent alluvial plain soil in flood affected and non-affected grassland.

H1: There is significant difference in the Physicochemical properties of recent alluvial plain soil in flood affected and non-affected grassland.

**t-test of N**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00003 | .237 | 5 | .200* | .961 | 5 | .814 |
| VAR00004 | .305 | 5 | .144 | .827 | 5 | .133 |

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -8.308 | .000 |
| Equal variances not assumed | -8.308 | .001 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00007 | .287 | 5 | .200* | .914 | 5 | .490 |
| VAR00008 | .300 | 5 | .161 | .908 | 5 | .453 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -5.430 | .001 |
| Equal variances not assumed | -5.430 | .004 |

**t-test of P**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00011 | .336 | 5 | .067 | .852 | 5 | .200 |

| | | | | | | |
|---|---|---|---|---|---|---|
| VAR00012 | .198 | 5 | .200* | .948 | 5 | .725 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -1.222 | .257 |
| Equal variances not assumed | -1.222 | .257 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00015 | .315 | 5 | .118 | .891 | 5 | .363 |
| VAR00016 | .300 | 5 | .161 | .855 | 5 | .211 |

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -1.513 | .169 |
| Equal variances not assumed | -1.513 | .183 |

**t-test of K**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00019 | .158 | 5 | .200* | .994 | 5 | .992 |
| VAR00020 | .293 | 5 | .186 | .784 | 5 | .059 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | 1.273 | .239 |
| Equal variances not assumed | 1.273 | .249 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00023 | .207 | 5 | .200* | .958 | 5 | .797 |
| VAR00024 | .204 | 5 | .200* | .967 | 5 | .854 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | 2.236 | .056 |
| Equal variances not assumed | 2.236 | .075 |

**t-test of OC**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00027 | .237 | 5 | .200* | .961 | 5 | .814 |
| VAR00028 | .305 | 5 | .144 | .827 | 5 | .133 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -8.308 | .000 |
| Equal variances not assumed | -8.308 | .001 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00031 | .287 | 5 | .200* | .914 | 5 | .490 |

| | | | | | | |
|---|---|---|---|---|---|---|
| VAR00032 | .300 | 5 | .161 | .908 | 5 | .453 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | -5.430 | .001 |
| Equal variances not assumed | -5.430 | .004 |

**t-test of pH**

a) 0-15 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00035 | .231 | 5 | .200* | .881 | 5 | .314 |
| VAR00036 | .273 | 5 | .200* | .803 | 5 | .086 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | 2.926 | .019 |
| Equal variances not assumed | 2.926 | .033 |

b) 15-30 cm depth

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| VAR00039 | .473 | 5 | .001 | .552 | 5 | .000 |
| VAR00040 | .224 | 5 | .200* | .924 | 5 | .554 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Independent Samples t-test

| Categories | t-values | Sig. (2-tailed) |
|---|---|---|
| Equal variances assumed | 3.644 | .007 |
| Equal variances not assumed | 3.644 | .020 |

Appendix 7: Data Collection Sheet

**Plot no-** **Date – 2079/**

**Name of Place-**

**Land forms- Active Alluvial Plain / Recent Alluvial Plain**

**Area-**

i) Forest ☐

Flooded ☐ Non-flooded ☐

Condition (covered by big trees, pole sized, regeneration)

Dominate with

ii) Agricultural ☐

Flooded ☐ Non-flooded ☐

Condition (paddy, wheat, ……….

iii) Grassland ☐

Flooded ☐ Non-flooded ☐

Condition (Tall grass, small grass)

**GPS Co-ordinate**

**X Co-ordinate-**

**Y Co-ordinate-**

**Soil - silt / clay**

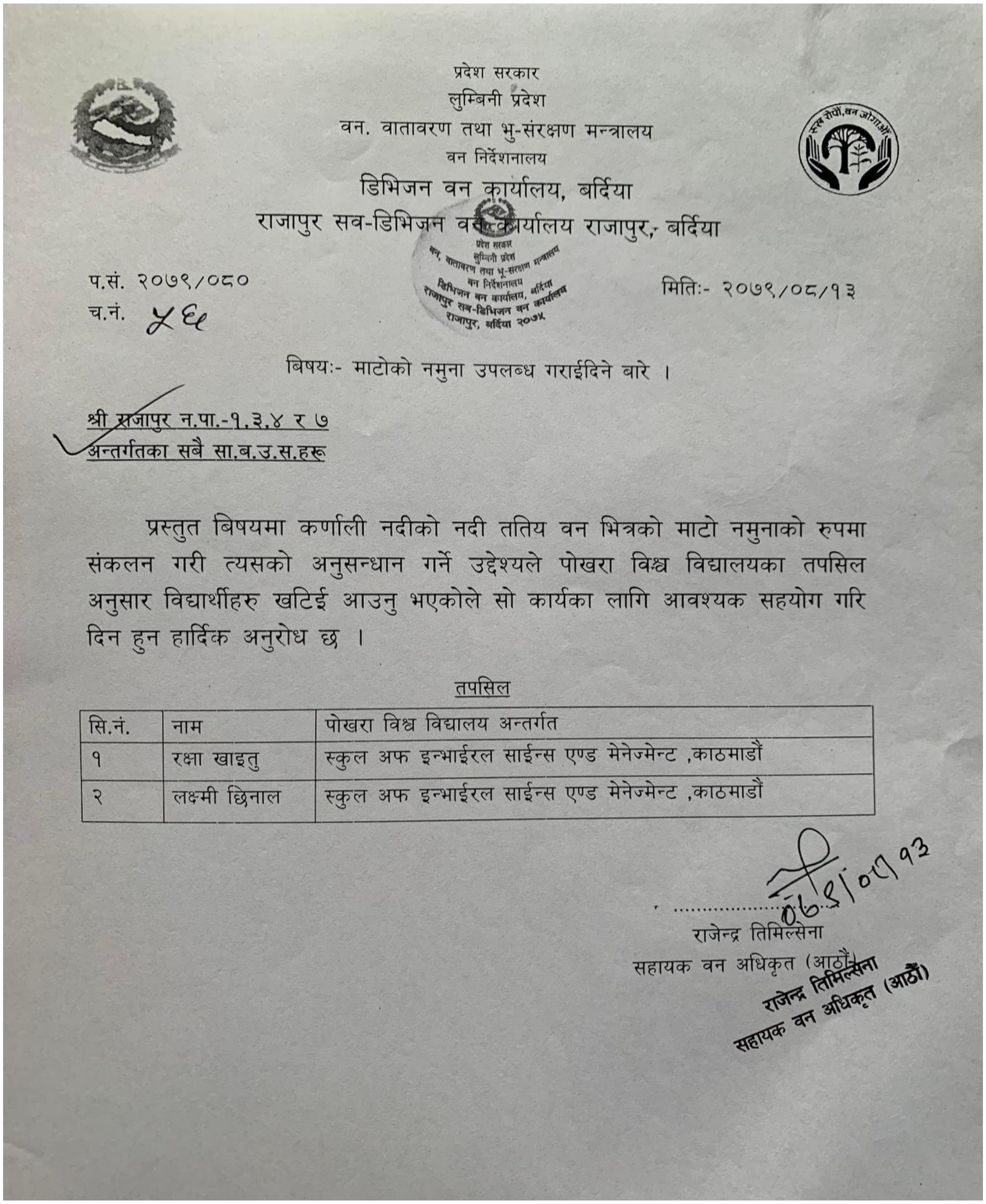
**No. of Macro-organism: None / 1 / 2 / 3 / 4 / 5 / more**

**Name of macro-organism: (earthworm, beetles, snail, …………**

**Soil moisture – dry / moist**

**Geographic – near from the river / far from the river)**

| Depth | 0-15cm | 15-30 cm |
|---|---|---|
| Color | | |
| Texture | | |
| pH value | | |
| Moisture content | | |
| Fresh weight | | |



प्रदेश सरकार
लुम्बिनी प्रदेश
वन. वातावरण तथा भु-संरक्षण मन्त्रालय
वन निर्देशनालय
डिभिजन वन कार्यालय, बर्दिया
राजापुर सव-डिभिजन वन कार्यालय राजापुर, बर्दिया

प.सं. २०७९/०८०
च.नं. ५६

मितिः- २०७९/०८/१३

बिषयः- माटोको नमुना उपलब्ध गराईदिने बारे ।

श्री राजापुर न.पा.-१,३,४ र ७
अन्तर्गतका सबै सा.ब.उ.स.हरू

प्रस्तुत बिषयमा कर्णाली नदीको नदी ततिय वन भित्रको माटो नमुनाको रुपमा संकलन गरी त्यसको अनुसन्धान गर्ने उद्देश्यले पोखरा विश्व विद्यालयका तपसिल अनुसार विद्यार्थीहरु खटिई आउनु भएकोले सो कार्यका लागि आवश्यक सहयोग गरि दिन हुन हार्दिक अनुरोध छ ।

तपसिल

| सि.नं. | नाम | पोखरा विश्व विद्यालय अन्तर्गत |
|---|---|---|
| १ | रक्षा खाइतु | स्कुल अफ इन्भाईरल साईन्स एण्ड मेनेज्मेन्ट ,काठमाडौं |
| २ | लक्ष्मी छिनाल | स्कुल अफ इन्भाईरल साईन्स एण्ड मेनेज्मेन्ट ,काठमाडौं |

०७९/०८/१३

राजेन्द्र तिमिल्सेना
सहायक वन अधिकृत (आठौं)

राजेन्द्र तिमिल्सेना
सहायक वन अधिकृत (आठौं)

Appendix 8: Permission from Rajapur Sub-division Forest office-Bardiya to collect soil samples

Photo Plate 1: Community engagement about flood in Rajapur

Photo Plate 2: Collecting soil samples from forest area

Photo Plate 3: Collecting soil samples from agricultural area

Photo Plate 4: Rajapur sub-division Forest office

Photo Plate 5: Collecting soil samples from agricultural area

Photo Plate 6: Collecting soil samples from agricultural area

Photo Plate 7: Collecting soil samples from forest area

Photo Plate 8: Soil samples in lab

Photo Plate 9: Conducting experiment to calculate Organic matter content in soil

Photo Plate 10: Storing samples for Potassium assay

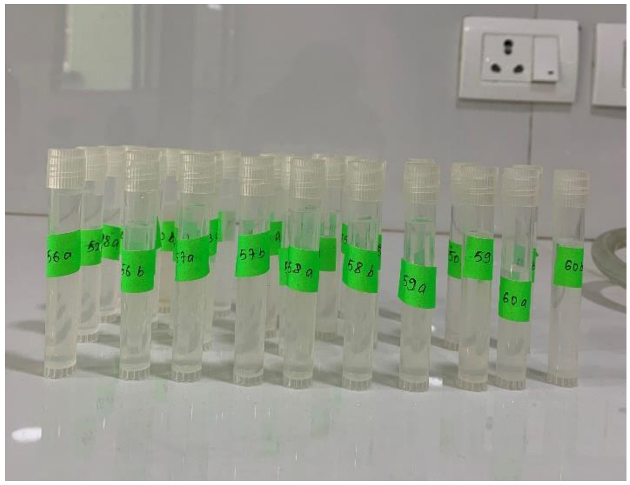


Photo Plate 11: Stored vial for Potassium assay

Photo Plate 12: Filtering samples for K analysis


Photo Plate 13: Taking reading of potassium in Flame photometer

Photo Plate 14: Conducting laboratory procedure to calculate phosphorus content


Photo Plate 15: Taking reading of phosphorus in Spectrophotometer

Photo Plate 16: Taking reading for Texture by using Soil Hydrometer