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**Journal of Occupation and Training (JOT)**
*Volume 9, Number 1 April, 2025*
**Print ISSN:** 3446 - 6290
**Electronic ISSN:** 2354 2756

**DOI:** 10.48028/iiprds/jot.v9.i1.06

# Effect of Flooding on Soil Physical and Chemical Properties in Nwagele L.G.A, Imo State, South Eastern Nigeria

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## Abstract

*The research was conducted to determine the effect of flooding on selected soil physical and chemical properties of flood meadows under different fallowed periods in Nwangele Local Government Area of Imo State, Nigeria. The control (dried land), cultivated flood meadow, a year fallowed flood meadow and more than a year fallowed meadow constitutes the experimental treatments. Each treatment was replicated four times and soil were analysed for aggregate stability, bulk density total porosity, moisture content, heavy metal (Pb, Cu, Zn and Fe), C, $NO_3^+$, $SO_4^{2-}$ and $NH_4^+$. Data obtained from laboratory analysis were subjected to analysis of variance and the difference between treatment means were obtained using F-LSD. There was a significant ($P<0.05$) difference among the different meadows and control studied. Control recorded the highest bulk density of 1.60gcm$^{-3}$. This observed bulk density in control was higher than the bulk density in cultivated flood meadow, a year fallowed flood meadow by 10, 17 and 23% respectively. The order of increase in aggregate stability, total porosity, moisture content, C, $SO_4^{2-}$, $NH_4^+$, Pb, Fe, Zn and Cu were more than a year fallowed flood meadow > a year fallowed flood meadow > cultivated flood meadow > control. Despite the disaster associated with flood with attendant damage to crops planted in flood meadow, the results showed that flood meadows have inherent ability to boost crop productivity and also reclaim the nutrient losses occasioned by leaching under flooding conditions.*

**Keywords:** *Flood Meadow, Fallow, Soil Properties.*

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**Journal URL:** https://internationalpolicybrief.org/journal-of-occupation-and-training-volume-9-number-1/

## Background to the Study

Flooding is a natural phenomenon with profound implications for soil ecosystems worldwide. From inundating vast agricultural plains to affecting urban landscapes, flooding events exert significant pressure on soil properties, disrupting their physical, chemical, and biological characteristics. Understanding the effects of flooding on soil is crucial, not only for sustainable land management but also for mitigating the consequences of climate change-induced extreme weather events. Flooding occurs when water exceeds the capacity of land to absorb it, leading to temporary or prolonged submersion. With climate change intensifying precipitation patterns and sea level rise, the frequency and severity of flooding events are escalating globally. Consequently, soils across diverse landscapes are increasingly subject to the transformative forces of flooding.

Increasing demand for land as a result of population increase and food scarcity has made farmers to farm in marginal lands such as lands susceptible to erosion and flooding (Quansah, 1997; Sanchez et al., 1997). Flood is defined as a very large amount of water that has overflowed from a source such as a river, a pond or a broken pipe to cover a previously dried area. It occurs when soil and vegetation cannot absorb all the water; water then runoff the land in quantities that cannot be carried in stream channels or retained in natural ponds and constructed reservoirs such as dams and levees (Njoku, 2013).

Flood can cause shortage of crops as a result of drowning and suffocation of crops on floodplains and meadows (Powell, 2009). It also contributes positively to soil properties through the provision of nutrients that may be lacking in the soil (Stephen, 1993; O'Connor et al., *Corresponding author e-mail: chimarco2001@yahoo.com. 2004). Wetting of the floodplains and meadows by floods releases immediate nutrients that were left over from the last flood and those that result from the rapid decomposition of organic matter that has accumulated during the flood. Njoku et al. (2011) showed that soil properties such as total porosity, moisture content, pH, and organic carbon where higher in a soil after flooding than before flooding whereas such properties like bulk density, available P and total N where lower in a soil after flooding than before flooding. Therefore, this study aimed at determining the effect of flooding on selected soil properties of flood meadows under different fallow periods in Nwagele L.G.A of Imo State South-Eastern Nigeria.

## Study Area

The study was carried out at the flood meadows along Nwangele L.G.A of Imo State. Nwangele is a Local Government Area of Imo State, Nigeria. The name was derived from the popular Nwangele river which marks the boundary between Amaigbo and Umuozu Isu. The river which is believed to have originated from Isiekenesi town passes through several villages in Amaigbo and empties into Oramiriukwa a tributary of Imo River (Anudike, Duru & Uhuegbu, 2019). It headquarters is in Amaigbo. These flood meadows are among the major sources of dry season vegetable crops for Nwangele people especially those residing at Nwangele. Nwangele lies at latitude 6 o 15'N and longitude 80 5'E in the derived savannah of South-Eastern Nigeria. The two distinct seasons within the zone are rainy season which lasts from April to October and dry season which lasts from November to March. The minimum and maximum temperatures of the area are 270C and 310C, respectively (Ofomata, 1975). The relative humidity of the area is between 60 to 80 percent. The annual rainfall of the area ranged between 1500 – 2000mm and the soil of the area belongs to the order ultisol classified as typic Haplustult (Federal Department of Agriculture and Land Resources, 1985). Nwangele is strategically located along the Ihiala Orlu Anara Road. It shares boundaries on the north with Nkwerre Local Government Area, on the South with Isiala Mbano Local Government, on the East with Ideato-South and Onuimo Local government Areas and on the West with Isu Local Government Area (Anudike, Duru & Uhuegbu, 2019).

**Site Selection and Soil Sampling**

Flood meadows under different fallow periods were surveyed along Nwangele river and the following were selected: Control (Dried land); cultivated flood meadow; a year fallowed flood meadow and more than a year fallowed flood meadow. Four replicate soil (auger and core) samples were collected at flood meadow at the depth of 0 – 20 cm.

**Laboratory analysis**

Fresh undisturbed core soil samples were weighed and oven dried at 110°C for 24 hours. They were then weighed again to get the oven dry weight and were used for the determination of the aggregate stability bulk density, moisture content and total porosity. Bulk density was determined as described by Blake and Hartage (1986). Moisture content was determined as outlined by Obi (2000). Total porosity was calculated from bulk density using the formular: Tp = 100 (1 – Db/Dp). Where: Dp is particle density assumed to be 2.65 gcm-3; Db is bulk density; Tp is Total porosity (Obi, 2000). The NH4 + content of the soil samples was also determined using the Indol-phenol blue colorimetric method (O'Dell, 1993). Nitrate (NO3 - ) was determined using the colorimetric method (O'Dell, 1993). The sulphate content of soil samples was determined using the turbidimetric method (Tabatabai, 1974). The soil contents of Fe, Zn and Cu were determined from the soil samples using atomic absorption spectrophotometer after digestion with concentrated HNO3 (Clayton and Tiller 1979).

**Data Analysis**

Statistical analysis of the data was carried out using the General Linear Model of SAS software for Randomized Complete Block Design (SAS Institute Inc, 1999).

**Result and Discussion**

Effect of Flooding on Aggregate Stability, Soil Bulk Density, Moisture Content and Total Porosity

**Table 1:** Effect of Flooding on Soil Bulk Density, Aggregate Stability Moisture Content and Total Porosity'

| Treatment | Bulk density ($gcm^{-3}$) | Aggregate Stability (%) | Moisture Content (%) | Total Porosity (%) |
|---|---|---|---|---|
| Control | 1.60 | 4.80 | 10.60 | 39.62 |
| Cultivated flood meadow | 1.42 | 12.50 | 16.68 | 46.42 |
| A year fallowed flood meadow | 1.30 | 16.70 | 22.43 | 50.94 |
| More than a year fallowed flood meadow | 1.21 | 24.12 | 30.05 | 54.34 |
| **F-LSD** | **0.076** | | **0.571** | **1.896** |

The effect of flooding on soil bulk density, moisture content and total porosity is shown in table 1. There was a significant ($P < 0.05$) difference in bulk density, moisture content and total porosity among all the flood meadows and control studied. Control recorded the highest bulk density of 1.60gcm-3. This observed bulk density in control was higher than the bulk density in cultivated flood meadow, a year fallowed flood meadow and more than a year fallowed flood meadow by 9, 17 and 23%, respectively. The order of increase in total porosity and moisture content were more than a year fallowed flood meadow > a year fallowed flood meadow > cultivated flood meadow > control. This lower bulk density and higher total porosity aggregate stability and moisture content in flood meadows compared to control may be as a result of materials such as debris, silt and microscopic organisms that were brought to the flood meadow by flood that help to improve properties of flood meadow soil. Similarly, the improved in soil properties in order of fallowed periods may be attributed to the presence of vegetations which regained back the leached nutrient through root absorption and decomposition of plant residues.

## Effect of Flooding on Soil $NH_4^+$, C, $NO_3^-$ and $SO_4^{2-}$

**Table 2:** Effect of Flooding on Soil $NH_4^+$, C, $NO_3^-$ and $So_4^{2-}$

| Treatment | $NH_4^+$ ($mgkg^{-1}$) | C(g/kg ) | $NO_3^-$ ($mgkg^{-1}$) | $SO_4^{2-}$ ($g100g^{-1}$) |
|---|---|---|---|---|
| Control | 0.20 | 0.5 | 0.04 | 0.07 |
| Cultivated flood meadow | 0.37 | 1.01 | 0.12 | 0.64 |
| A year fallowed flood meadow | 0.59 | 1.25 | 0.20 | 0.95 |
| More than a year fallowed flood meadow | 0.72 | 1.52 | 0.34 | 1.32 |
| **F-LSD** | **0.018** | **0.04** | **0.026** | **0.026** |

Where $NH_4^+$ = Ammonium, C = Carbon, $NO_3^-$ = Nitrate & $SO_4^2$ = Suphate

The result of the study indicated significant ($p < 0.05$) differences among the treatments in $NH_4^+$, $NO_3^-$ and $SO_4^{2-}$ (table 2). The order of increase in $NH_4^+$, $NO_3^-$ and $SO_4^{2-}$ were more than a year fallowed flood meadow > a year fallowed flood meadow > cultivated flood meadow >

control. Nathan (2002) observed that flooding generally increased the availability of plant nutrients to crops. Also, Stephen (1993) and O'Connor et al. (2004) have reported that wetting of the flood meadows releases immediate nutrients that were left over from the last flood and those that result from the rapid decomposition of organic matter that has accumulated during the flood.

### Effect of Flooding on Selected Soil Heavy Metals

**Table** 3: Effect of Flooding on Soil Heavy Metals ($mgkg^{-1}$).

| Treatment | Pb | Fe | Zn | Cu |
|---|---|---|---|---|
| Control | 0.05 | 0.10 | 0.92 | 0.84 |
| Cultivated flood meadow | 0.30 | 0.16 | 2.45 | 1.62 |
| A year fallowed flood meadow | 0.33 | 0.17 | 2.52 | 1.67 |
| More than a year fallowed flood meadow | 0.35 | 1.00 | 3.62 | 3.16 |
| **F-LSD** | **0.32** | **0.42** | **0.025** | **0.05** |

Where: Pb = Lead, Fe = Iron, Zn = Zinc & Cu = Copper

Table 3 shows significant ($p < 0.05$) differences Pb in Fe, Zn and Cu studies. Control recorded the lowest Fe content of $0.10mgkg^{-1}$. This observed value in the control was lower than Fe content in cultivated flood meadow, a year fallowed flood meadow and more than a year fallowed flood meadow by 25, 33 and 7083%. The lowest Zn content of $0.92mgkg^{-1}$ was observed in control while that of flood meadows ranged between 2.45 – 3.62 $mgkg^{-1}$. The order of increase in Cu studied was more than a year fallowed flood meadow > a year fallowed flood meadow > cultivated flood meadow > control. This is in line with the study of Powell (2009) which reported that despite the fact that flood causes shortage of foods as a result of drowning and suffocation of crops during flooding, it makes soil more fertile by providing nutrients that are deficient in the soils.

### Conclusion

The study aimed at determining the effect of flooding on selected soil properties of flood meadows under different fallow periods in Nwagele L.G.A of Imo State, Nigeria. It is observed from the study that the greater the number of years under flood meadow condition the better the improvement on the soil physical and chemical properties. Despite the fact that flooding can cause shortage of food crops as a result of drowning and suffocation of crops during floods, it can also, bring benefits to the soils by making soils more fertile and provides nutrients required for crop production. Leaching of nutrients that occur during flood can be regained back through fallowing the flood meadow as shown in this study.

### Recommendations

Based on the findings, the study made the following recommendations:

i. Water tolerant plants should be planted on the flood meadow such as rice
ii. Drainage channels should be built to take away excess water.
iii. There should be careful planning and management which can help mitigate these

impacts and even harness the benefits of flooding for improved soil fertility and productivity.

iv. Government and community leaders should implement techniques such as terracing, contour farming, and crop rotation to help reduce soil erosion in the area.

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