1._Nutrient_dynamics_in_peat,_FIX.pdf

by Salahhudin Alfais

JEE Journal of Ecological Engineering

Journal of Ecological Engineering, 2025, 26(6), 162–169
https://doi.org/10.12911/22998993/202347 ISSN
2299–8993, License CC-BY 4.0

Received: 2025.02.17
Accepted: 2025.04.07
Published: 2025.04.15

Nutrient dynamics in peat soil application under water management planning: A case study of Perigi, South Sumatra, Indonesia

Bakri[1*], Momon Sodik Imanudin[1], Muh Bambang Prayitno[1],
A. Hermawan[1], As'ad Syazili[1], Leviana[1], Eunho Choi[2], Hyunyoung Yang[2]

[1] Faculty of Agriculture, Department of Soil Science, Jln. Inderlaya-Prabumulih, Sriwijaya University, KM.32, Inderalaya, 30662, Indonesia

[2] National Institute of Forest Science, Global Forestry Division, Future Forest Strategy Department, Seoul 02455, Republic of Korea

* Corresponding author's e-mail: bakri@fp.unsri.ac.id

ABSTRACT

The aim of this study was to systematically evaluate the effect of different seasons on dynamical of nutrients and the correlation between them in peat soil as a basic for water management plan. This study examined nutrient dynamics in peat soil facilitated by effective water management planning, focusing on a case study in Perigi, South Sumatra, Indonesia. Employing a combination of field observations and laboratory analyses, the research identified key nutrient fluctuations in various hydrological conditions. The different samples in each season (wet and dry) were collected based on the fluctuation of water table between 20–80 cm to identify the dynamics of nutrients. Results showed the positive correlation between pH and other nutrients which indicates the influence of ion H+ on enhancing the bond with other chemicals. The significant results of each nutrient between wet and dry seasons showed that increased rainfall can cause leaching of nutrients like nitrogen, phosphorus, and potassium. This will support the successful optimization of water management which can significantly increase the availability of nutrients and soil fertility, leading to improved agricultural outcomes. The findings emphasize the importance of sustainable water practices in peatland areas to promote ecological health and agricultural productivity, providing valuable insights for policymakers and land managers.

Keywords: peat soil, nutrients, water table.

INTRODUCTION

A form of soft soil known as peat is created when sedges, trees, mosses, and other flora that grows in marshes and wetland incompletely breaks down and disintegrates, leaving behind a high concentration of fibrous organic materials (Andriesse, 1988; Das *et al.,* 2024). Because of its high-water content, high compressibility, and low shear strength, this soil is frequently referred to as problematic (Ashraf *et al.,* 2017; Van der Laan *et al.,* 2024). Unfortunately, the effects of burning on peat soils are sporadic because soil organic matter (SOM) can provide long-term fuel and prolong the fire process (Moreno et al., 2010; Apori *et al.,* 2023; Natali *et al.,* 2023). The research states that peat smouldering can reach maximum temperatures of 700 °C, which gradually deteriorate SOM Kreye *et al.,* (2011) even though it is lower than that of flame combustion (1.500–1.800 °C) (Rein, 2009; Rein *et al.,* 2008). Yet, these marginal lands must be stabilized in order to fulfil growing demand because of the scarcity of land resources. Nutrient dynamics in peat soil are shaped by the unique environmental conditions of peatlands, which include high water content, low oxygen levels, and acidic pH (Kunarso *et al.,* 2022; Li *et al.,* 2024). These factors lead to a slow decomposition process, limited nutrient availability, and distinctive nutrient cycling patterns.

The water movement in the soil was significantly impacted by the high hydraulic conductivity of peat materials, which was an anisotropic and heterogeneous porous medium Rupngam and Messiga, 2024). Peat exhibits both horizontal (Kh) and vertical (Kv) saturated hydraulic conductivities, with the Kh value being greater than the Kv value. Such conditions, as noted by Widiarso *et al.,* (2020) can hasten the leaching of nutrients into drainage channels, a process made worse by excessive rainfall in tropical regions, which also accelerates the leaching of nutrients. Fertilizers are carried out of the root zone by water, which prevents plants from absorbing their nutrients.

The dynamics of water table can directly influence soil nutrient status, such as ammonium-N, nitrate-N, and inorganic-N and organic C, as well as available K and P concentrations (Bai *et al.,* 2020; Zhang *et al.,* 2022). The research regarding the relationship between water table and the status of available soil nutrients in plant roots is still very rare, especially for peatlands. Peatlands with very porous soil characteristics characterized by high hydraulic conductivity clearly have a large influence on fertilization efficiency (Jurasinski *et al.,* 2020). Nutrient loss through air movement will be very fast towards water bodies. Therefore, appropriate water management must be developed so that the environmental impacts of fertilizers and agricultural activities can be controlled (Imanudin *et al.,* 2024).

The availability of soil nutrients is greatly influenced by the dynamics of the water table; flooded and dry conditions have a real influence on the availability of soil nutrients, especially mobile nutrients such as nitrogen and potassium. The construction of drainage canal causes a decrease in the water level and soil moisture and accelerates the decomposition process. This condition causes the composition of nutrient status in the soil to change (Laine *et al.,* 2021; Anggat *et al.,* 2024). the water dynamics, which can easily change, are a factor that influences the nutrient status in peat soil. Soil with high water conductivity will speed up the nutrient leaching process, thereby reducing fertilization efficiency (Anggat *et al.,* 2024). Apart from that, soil microbial activity is also influenced by water level dynamics. There is a decrease in bacterial populations with increasing soil wetness, which ultimately also affects nutrient availability (Rupngam and Messiga, 2024; Basuki, 2024). The efforts to control water levels are an important part of controlling the environmental impact of land that has already been reclaimed; interrupted wetting and maintaining a water level of 20-40 cm is the best option to maintain soil nutrient availability (Van der Laan *et al.,* 2024; Azis *et al.,* 2022). In the future, it is very important for farmers to know the dynamics of soil nutrients, especially for fertilizer applications. The efforts to reduce the leaching of nutrients in peat soil are the most important part besides the efforts to control the water level (Ngan *et al.,* 2023; Harpenslager *et al.*, 2024; Das *et* al., 2024). Increasing the water table was followed by increasing nutrient losses (Hashin *et al.,* 2019). However, only a few research studies regarding nutrient dynamics in tropical peat soils have been conducted. Therefore, studies of nutrient dynamics in wet and dry conditions in peat soils were very useful for developing recommendations on how to be maintaining the soil and water management for sustainable agriculture.

MATERIALS AND METHODS

Field sampling

This research was carried out in a peat swamp land in Perigi Village, Pangkalan Lapam District, Ogan Komering Ilir Regency. Perigi is a village in Pangkalan Lapam District, Ogan Komering Ilir Regency, South Sumatra. Perigi Village has an area of 13.299 Ha. and has a swamp area of 7.000 Ha. The area of Perigi Village, Pangkalan Lapam District is in the lowlands of 6–7 MDPL (Meters Above Sea Level). On the basis of the study area, Perigi Village is included in the peat hydrological unit area. The method used in this study was a survey method with direct observation in the field. It involved sticking wood into the peat swamp water to determine the depth of the peat (Basuki, 2024). Then, samples were taken which were subsequently tested for peat soil fertility to carry out pH, N-total, P-available, K-available, and CEC analyses which were then linked to the condition of the peat land and water management planning (Pulunggono *et al.,* 2023).

Treatments

The samples were taken in two periods divided to wet samples and dry samples; the purpose was to obtain the fluctuation of nutrients in each seasons. Four treatments (T) of water table were established in this experiment during the wet season; (i) T1: water table fluctuated at 0–20 cm, (ii) T2: water table fluctuated at 21–40 cm, (iii) T3, water table fluctuated at 41–60 cm, (iv) water table fluctuated at 680 cm. Each treatment found the water tale ranging from 40 to 45 cm below soil surface.

Data analysis

Soil sample analysis was carried out at the Soil Science Department, Chemistry and Soil Fertility Laboratory, Universitas Sriwijaya. The effects of treatments on soil parameter were tested using Independent Sample T-Test SPSS. Then, the correlation was tested using Pearson correlation test (Bevans, 2020).

RESULTS AND DISCUSSION

Table 1 shows the descriptive data and Independent Sample T-test of soil chemical properties for each season and treatment whereas Table 2 demonstrates the correlation between variables.

The distribution and concentration of N, P, and K along the vertical peat profile were affected by the mixing of aerobic and anaerobic conditions through continual saturation, drying, and rewetting, in response to fluctuations in the water table in the peat profiles. In this study, soil samples of peat soil were identified as acidic with a pH between 3.86–4.77. According to Hikmatullah and Sukarman (2014); Imanudin *et al.,* (2022), variations in peatland use have been reported to impact soil pH, a critical component determining the biogeochemistry of peatlands. Land use changes cause organic acids, carbonates, bicarbonates, and hydroxides to be released into the soil solution faster than peat breakdown occurs (Aziz *et al.,* 2022). This procedure may lower the pH of the soil, affecting vegetation cover, microbiological activity, and nutritional availability of the ecosystems of peatlands. Due to the high H^+ ion content of soil and the presence of additional organic acids like fulvic and humic acids, which are products of the decomposition process, the highly acidic characteristics of peat are entirely reasonable (Das *et al.,* 2024). It is expected that the acidic environment in the peat profile (pH < 4) was the cause of the low concentration of key nutrients, particularly N, and exchangeable bases (K, Ca, Mg, and Na). It was widespread in lowland tropical environment (Jarukas *et al.,* 2021).

Prolonged water interruption caused water stress and altered the chemical characteristics of peat soil. Low soil water content made the hydrophobic qualities of peat more likely to occur. If so, its capacity to store water which is largely needed for metabolic processes and the translocation of nutrients would be determined by this situation

Table 1. Descriptive data and independent sample T-test of soil chemical properties

Soil properties	Treatment	Mean	Std Dev	Min	Max	F	Sig
pH	Wet	4.45	0.29	4.12	4.77	0.03	0.22
	Dry	4.14	0.35	3.86	4.64		
Total Nitrogen	Wet	0.19	0.02	0.17	0.2	8.46	0.02
	Dry	1.12	0.67	0.11	1.48		
Phospor	Wet	12.56	1.57	10.95	14.7	0.02	0.00
	Dry	21.83	1.59	20.55	24.15		
Kalium	Wet	0.35	0.03	0.32	0.38	8.65	0.00
	Dry	0.23	0.04	0.19	0.26		
CEC	Wet	61.03	1.66	58.73	62.25	1.75	0.00
	Dry	47.31	3.26	45.68	52.2		

Table 2. Correlation between variables

Soil properties	Total nitrogen	Phospor	Kalium	CEC
pH	0.33	0.457	0.231	0.642
Total Nitrogen		0.138	0.092	0.045
Phospor			0.853	0.95
Kalium				0.823

(Ngan *et al.,* 2024). The kinetics and absorption of nutrients are limited by the pH and CEC. Previous studies usually indicated that COOH and OH groups were depleted and reduced the ability of peat soil to retain nutrients and drain them as pH and CEC decreased (Lucas and Re, 1982).

The amount of N ranged between 0.11–1.48%, this value is in the range for oligotrophic peat (1–4%) (Imanudin *et al.,* 2022; Jayasekara *et al.,* 2025). The result showed that total nitrogen in dry season is lower compared to the rainy season, higher moisture content promotes the activity of microorganisms responsible for decomposing organic matter. This can lead to an increase in the release of nutrients, especially nitrogen, into the soil. During the dry season, the lack of moisture reduces microbial activity and slows down the decomposition of organic matter (Dettmann *et al.,* 2021). This results in less mineralization, which means fewer nutrients like nitrogen and phosphorus are available for plant uptake. The low concentration of K in this study is indicated to be caused by the dominance of acidic cations (H^+ and $Al3^+$), which is shown by the low pH of the soil, as well as the high mobility of K, making it easy to leach in soil solutions. While the latter was demonstrated by the large amount of K that leached from the column, the former was validated by the noteworthy correlation between pH and K.

The impact of water management on nutrient dynamics on soil fertility conditions during the rainy season (sample collection) indicates that soil pH is classified as acidic. There are no significant qualitative differences at various levels of water table inundation. The land drainage condition is very poor, with a natural decrease in water table of only 1 cm/ha in the absence of rain. The high inundation treatments T1-T4 show that the pH under inundation conditions is better compared to dry soil conditions. Soil pH ranges from very acidic to acidic. This is consistent with the research by Lee *et al*. (2021), which suggests that soil drying can reduce soil acidity. Under wet soil conditions, the redox potential (Eh) decreases, which in turn increases the pH value. Furthermore, according to Imanudin *et al*. (2019), soil drying can sharply increase exchangeable acidity, such as $Al3^+$ or H^+, compared to rewetting. This condition can decrease soil pH. Similarly, [42] found that soil moisture and pH decrease as groundwater depth increases. Therefore, amelioration efforts in peatland cultivation are still necessary.

Cereal crops other than rice require the groundwater level to be between 30–40 cm, as at this level the groundwater condition remains sufficiently moist and can meet the plant's evapotranspiration needs. Water retention in tertiary channels at a water level of 60–80 cm is adequate to create groundwater conditions in the root zone at a depth of -40 cm, in accordance with soil management requirements. No sulfuric acid layers were found up to a depth of 1.5 meters in the area due to the peat thickness being greater than 2 meters. This condition prevents a sharp decrease in pH during groundwater level declines to -50 cm (September) (Zhang *et al.,* 2018). Once the rainy season begins, some toxic substances are leached out, and with increasing inundation, the soil pH rises again. This is consistent with Hashim *et al*. (2019) study, which found that soil in a reduced state (waterlogged soil) can raise soil pH, and the pH increases with the duration of waterlogging, although the increase is not very high. The reduction process involves the consumption of H+ ions equivalent to the amount of Fe^{2+} or H_2S formed. The overall effect of waterlogging is to increase soil pH, particularly in acidic soils. The significant impact of waterlogging is similar to liming, achieving an optimal pH range that allows for the availability of most nutrients. Reduction is considered most important as it can raise pH, increase phosphorus availability, and replace cations in the exchange sites.

Research shows that under high groundwater conditions, nutrient leaching occurs, resulting in lower macro-nutrient values in the soil samples taken from waterlogged conditions. This is consistent with Imanudin *et al. (*2022), which states that under waterlogged conditions, there is a significant decrease in soil nutrients due to leaching. Conversely, when the groundwater level decreases to 40–80 cm, leaching decreases, leading to an increase in nutrient availability for plants (Damanik *et al.,* 2023).

Managing water levels below 30–40 cm will also significantly affect the availability of several macro-nutrients in the soil. This is in line with the research by Zhang *et al*. (2018), which indicates that groundwater dynamics influence nutrient availability in the plant root zone. Figure 1 shows an increase in nitrogen and phosphorus as a result of the decrease in groundwater level. Under the conditions where the soil experiences air accumulation (anoxic) due to an increase in the ground water level, this will accelerate the accumulation of nitrogen in the soil. Next, nitrogen

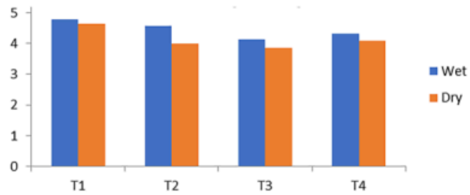

Figure 1. The soil reaction on peat soil at wet and dry soil sampling condition

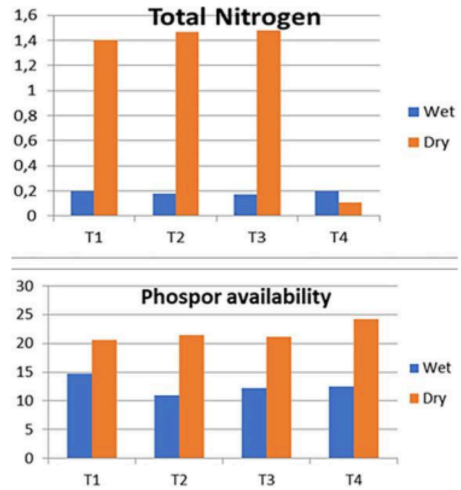

Figure 2. Dynamics of macro-nutrients nitrogen and phosphorus under wet and dry conditions

mineralization and nitrification occur in the soil oxidation layer at the groundwater interface under submerged conditions. Denitrification and ammonia evaporation are the main mechanisms resulting in the loss of nitrogen in the topsoil in an alkaline environment. In addition, tidal water cycles from river basins and surface runoff, will carry large amounts of suspended material as well as carry plant waste, which can affect nitrogen retention (Hashim *et al.,* 2019). The availability of nitrogen macronutrients mostly hangs in the soil with a thickness of the top 20 cm. According to Striling *et al*. (2020); Imanudin *et al*. (2022), maintaining ground water table under 50 cm is the optimum operation for providing nutrient availability, and crop growth environment. Consistent with the research by Imanudin *et al*. (2022), experiments with oil palm seedlings show nutrient loss occurs at shallow groundwater levels (0–25 cm) and at levels greater than 75 cm. The optimal nutrient absorption value is found at a depth of 50 cm (Kassim and Yaacob, 2019).

Soil phosphorus content is also influenced by fluctuations in groundwater level (Figure 2). Analysis results show that phosphorus levels are low under wet conditions and moderate under dry conditions (groundwater level -40 cm). This is consistent with the research by Obour *et al*. (2011), which states that phosphorus levels significantly increase at a groundwater depth of 40 cm below the soil surface. Similarly, Rupngam and Messiga (2024), found that fluctuating groundwater levels during the dry-wet seasons lead to increased phosphorus flux from the Bh horizon, enhancing phosphorus availability in the plant root zone.

Analysis results show that cation exchange capacity (CEC) decreases with a lowering groundwater depth. The CEC value during sampling under wet conditions ranged from 58–62 me/100 g, while in moist soil (groundwater depth 40–45 cm, representing the water table during the dry season) the CEC value ranged from 45–52 me/100 g. Although qualitatively, the peat soils in the Perigi area have very high CEC values. This is consistent with Becher *et al*. (2020), exchange capacity. This is suspected to be due to moisture levels at varying groundwater heights affecting the organic carbon content, which shows an increase in organic carbon values. Organic carbon values indicate that the organic matter in peat soils has already decomposed. According to Kassim and Yaacob (2019), soil cation exchange capacity is greatly influenced by soil organic matter content. Decomposed organic matter has functional groups ($COOH^-$) that can contribute negative charges, thereby enhancing cation exchange in peat soils, making the CEC higher with greater organic carbon content. Therefore, controlling groundwater levels is crucial for agricultural practices in peatlands. Maintaining the water table at -40 cm is the best option for providing crop nutrients. Nitrogen and phosphorus are more available at a groundwater level of 40 cm (Suryani *et al.,* 2022) (Figure 3).

The CEC of soil depends on soil texture, the type of clay minerals, and organic matter content. The higher the clay content or the finer the texture, the greater the CEC. Similarly, higher soil organic matter content results in a higher CEC Hannu *et al*. (2024), In agricultural practice, measuring the actual CEC and pH of the soil can help farmers determine the appropriate type and dosage of fertilizers for their crops. By understanding the soil's CEC and pH, farmers can optimize plant growth and avoid damage from over-fertilization or

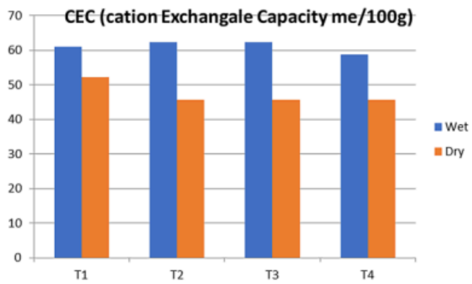

Figure 3. Dynamics of soil cation exchange capacity (CEC) under wet and dry conditions (groundwater level -45 cm)

under-fertilization. Measuring CEC and soil pH helps maintain the balance of soil chemical properties and ensures optimal plant growth (Chen *et al.,* 2024). CEC is crucial for plant productivity because it affects how many nutrients are retained and available in the soil. Soils with low CEC cannot retain and hold essential nutrients like ammonium (NH_4^+), Ca_2^+, Mg_2^+, K^+, and Na^+ effectively.

CONCLUSIONS

Soil nutrient dynamics show a decrease in pH values when the soil dries out, it means that the pH during the rainy season is higher than under the dry conditions. This is inversely proportional to the Nitrogen nutrient in the season dry season has higher levels than the rainy season. Likewise, it is followed by phosphorus content. Only the CEC and K-dd values in the rainy season have values which is higher compared to the dry season.

The data on nutrient dynamics and groundwater levels is important for farmers to understand when to apply fertilizer appropriately and plan land use in the future. Proper water management by maintaining a water level of 40–50 cm can increase fertilizer efficiency.

Acknowledgments

The research was funded by collaboration research between National Institute of Forest Science (NIFoS) Republic of Korea and Sriwijaya University Indonesia. The authors would like to acknowledge Deasy. M.Irfan support, and Sumantri and Agus Prihanto for the field assistance during the field survey

REFERENCES

1. Andriesse, J. P. (1988). *Nature and management of tropical peat soils*. Food & Agriculture Organization.
2. Anggat, F. U., Lim, S. F., Mah, Y. S., Busman, N. A., Maie, F., Sangok, F., & Melling, L. (2024). Long-term rainfall and water table influence on groundwater nutrient dynamics from an oil palm plantation. *Water Science, 38*(1), 569–586.
3. Apori, S. O., Giltrap, M., & Tian, F. (2023). Topsoil organic carbon and soil pH across different peatland use types in Co-Offaly, Ireland. *Soil Science Annual, 74*(4), 1–7. https://doi.org/10.37501/soilsa/183768
4. Ashraf, M. A., Othman, R., & Ishak, C. F. (2017). *Soils of Malaysia*. CRC Press.
5. Azis, A., Rauf, A., Hanum, H., & Agus, F. (2022). Dynamics of nutrition peat soil due to the biochar of oil palm empty bunches application and nitrogen and potassium. *IOP Conference Series: Earth and Environmental Science, 977*, 012097.
6. Bai F., Qi X., Li P., Qiao D., Wang J., Du Z., She Y., Guo W., Lu H. (2020). Depression of Groundwater Table and Reduced Nitrogen Application Jointly Regulate the Bacterial Composition of *nir*S-Type and *nir*K-Type Genes in Agricultural Soil. *Water*. *12*(12), 3459. https://doi.org/10.3390/w12123459
7. Basuki, I. (2024). *Measurement of Hydrological Characteristics of Peat Ecosystems. Community Forest System Support Consortium*. Program: Integrated Management Of Peat Forest Ecosystems In Kahayan Hilir District. 56.
8. Becher, M., Pakuła, K., & Jaremko, D. (2020). Phosphorus accumulation in the dehydrated peat soils of the Liwiec River Valley. *Journal of Ecological Engineering, 21*(5), 213–220.
9. Bevans, R. 2020. One-Way ANOVA. When and How to Use It (with example). Downloaded in http://www/scribbr.com/statistics/one-way-anova/
10. Chen Q, Song Y, An Y, Lu Y, Zhong G. (2024). Soil microorganisms: Their role in enhancing crop nutrition and health. *Diversity*. *16*(12), 734. https://doi.org/10.3390/d16120734
11. Damanik, Z., Jaya, A., Radjagukguk, B., & Adam, C. (2023). Influence of water table and peat thickness on dissolved organic carbon of tropical peat soil with sulfidic substratum from Central Kalimantan, Indonesia. *Journal of Multidiscipline Applied Natural Science, 4*(1), 76–89. https://doi.org/10.47352/jmans.2774-3047.189
12. Das, S., Mohapatra, A., Sahu, K., Panday, D., Ghimire, D., & Maharjan, B. (2024). Nitrogen dynamics as a function of soil types, compaction, and moisture. *PLoS ONE, 19*(4), e0301296. https://doi.org/10.1371/journal.pone.0301296
13. Dettmann, U., Kraft, N. N., Rech, R., Heidkamp, A.,

Tiemeyer, B. (2021). Analysis of peat soil organic carbon, total nitrogen, soil water content and basal respiration: Is there a 'best' drying temperature? *Geoderma, 403*, 1–10. https://doi.org/10.1016/j.geoderma.2021.115231

14. Hannu Hökkä, H., Palviainen, M., Stenberg, L., Heikkinen, J., & Laurén, A. (2024). Changing role of water table and weather conditions in diameter growth of Scots pine in drained peatlands. *Canadian Journal of Forest Research. 55*. https://doi.org/10.1139/cjfr-2024-0011

15. Harpenslager, S. F., van de Riet, B. P., van Dijk, G., Boonman, J., Weideveld, S. T. J., Hefting, M. M., & Smolders, A. J. P. (2024). Rewetting drained peatlands through subsoil infiltration stabilizes redox-dependent soil carbon and nutrient dynamics. *Geoderma, 442*, 116787. https://doi.org/10.1016/j.geoderma.2024.116787

16. Hashim, S. A., Teh, C. B. S., & Ahmed, O. H. (2019). Influence of water table depths, nutrients leaching losses, subsidence of tropical peat soil and oil palm (Elaeis guineensis Jacq.) seedling growth. *Malaysian Journal of Soil Science, 23*, 13–30.

17. Hikmatullah and Sukarman. (2014). Physical and chemical properties of cultivated peat soils in four trial sites of ICCTF in Kalimantan and Sumatra, Indonesia. *Journal Tropical Soils, 19*, 3, 131–141 https://doi.org/10.5400/jts.2014.19.3.131

18. Imanudin, M. S., Bakri, M. E., & Saputra, A. (2022). Analysis of limiting factors for food agriculture development in peatland areas. *IOP Conference Series: Earth and Environmental Science, 1025*, 012029. https://doi.org/10.1088/1755-1315/1025/1/012029

19. Imanudin, M. S., Bakri, S. J., Priatna, M. E., Armanto, M. E., Madjid, A., & Mardiansyah, E. (2024). Controlled drainage option for rice water management in tidal lowland reclamation areas of South Sumatra, Indonesia. *Journal of Wetlands Environmental Management, 12*(2), 1–20. http://dx.doi.org/10.20527/jwem.v12. i2.20568

20. Imanudin, M. S., Satria, J. P., Said, M., & Rahmat, R. (2019). Land and water management in pineapple and Albizia chinensis agroforestry systems in peatland. *Sriwijaya Journal of Environment, 4*(2), 52–58.

21. Jarukas, L., Ivanauskas, L., Kasparaviciene, G., Baranauskaite, J., Marksa, M., & Bernatoniene, J. (2021). Determination of organic compounds, fulvic acid, humic acid, and humin in peat and sapropel alkaline extracts. *Molecules, 26*(10), 2–10.

22. Jayasekara, C., Leigh, C., Shimeta, J. *et al*. (2025). Organic matter decomposition in mountain peatlands: effects of substrate quality and peatland degradation. *Plant Soil 506*, 639–654. https://doi.org/10.1007/s11104-024-06725-4

23. Jurasinski G, Ahmad S, Anadon-Rosell A, Berendt J, Beyer F, Bill R, Blume-Werry G, Couwenberg J, Günther A, Joosten H, et al. (2020). From Understanding to Sustainable Use of Peatlands: The WETSCAPES Approach. *Soil Systems 4*(1), 14. https://doi.org/10.3390/soilsystems4010014

24. Kassim, N. Q. B., & Yaacob, A. (2019). Nutrient dynamics in peat soil: Influence of fluctuating water table. *IOP Conference Series: Earth and Environmental Science, 327*(1), 012024.

25. Kreye, J. K., Varner, J. M., & Knapp, E. E. (2011). Effects of particle fracturing and moisture content on fire behaviour in masticated fuelbeds burned in a laboratory. *International Journal of Wildland Fire, 20*(2), 308.

26. Kunarso, A., Bonner, M. T. L., Blanch, E. W., & Grover, S. (2022). Differences in tropical peat soil physical and chemical properties under different land uses: A systematic review and meta-analysis. *Journal of Soil Science and Plant Nutrition, 22*, 4063–4083. https://doi.org/10.1007/s42729-022-01008-2

27. Laine, A. M., Korrensalo, A., Nicola, A. K., Kokkonen, E. S., & Tuittila, S. (2021). Impact of long-term water level drawdown on functional plant trait composition of northern peatlands. *Functional Ecology, 35*, 2342–2357.

28. Lee, S. Y., Kim, E. G., Park, J. R., Ryu, Y. H., Moon, W., Park, G. H., Ubaidillah, M., Ryu, S. N., Kim, K. M. 2021. Effect on chemical and physical properties of soil each peat moss, elemental sulfur, and sulfur-oxidizing bacteria. *Plants (Basel). 10*(9), 1901. https://doi.org/10.3390/plants10091901. PMID: 34579434; PMCID: PMC8469801.

29. Li, Y., Henrion, M., Moore, A., Lambot, S., Opfergelt, S., Vanacker, V., Jonard, F., & Van Oost, K. (2024). Factors controlling peat soil thickness and carbon storage in temperate peatlands based on UAV high-resolution remote sensing. *Geoderma, 449*, 117009. https://doi.org/10.1016/j.geoderma.2024.117009

30. Lucas, R., & Re, L. (1982). *Organic soils (Histosols) formation, distribution, physical and chemical properties and management for crop production*. Michigan State University Agricultural Experiment Station.

31. Moreno, L., Jiménez, M., Aguilera, H., Jiménez, P., & De La Losa, A. (2010). The 2009 smouldering peat fire in Las Tablas de Daimiel National Park (Spain). *Fire Technology, 47*(2), 519–538. https://doi.org/10.1007/s10694-010-0172-y

32. Natali, C., Ferrari, M., Bragagni, A., Bianchini, G., Salani, G. M., Avanzinelli, R., & Ghiotto, M. (2023). The trace element distribution in peat soils affected by natural burning events: A proxy of the original composition and metals mobility assessment. *Science of The Total Environment, 905*, 167826. https://doi.org/10.1016/j.scitotenv.2023.167826

33. Ngan, N. V. C., Thao, H. V., & Giang Nam, N. D. (2023). Nutrient dynamics in water and soil under

conventional rice cultivation in the Vietnamese Mekong Delta. *F1000 Research, 10*, 1145. https://doi.org/10.12688/f1000research.73904.2 v2

34. Obour, A. K., Silveira, M. L., Vendramini, J. M. B., Sollenberger, L. E., & O'Connor, G. A. (2011). Fluctuating water table effect on phosphorus release and availability from a Florida Spodosol. *Nutrient Cycling in Agroecosystems, 91*(2), 207–217.
35. Pulunggono, H. B., Gusman, O., Zulfajrin, M., Nurazizah, L. L., Anwar, S. (2023). Driving mechanism controlling cultivated tropical peat physicochemical characteristics and stoichiometry: Case study of a microtopographical sequence. *Celebes Agricultural*. *4*(1), 1–20. https://doi.org/10.52045/jca.v4i1.588
36. Rein, G. 2009. Smouldering Combustion Phenomena in Science and Technology, *International Review of Chemical Engineering,* 1, 3–18. http://www.era.lib.ed.ac.uk/handle/1842/1152
37. Rein, G., Cleaver, N., Ashton, C., Pironi, P., & Torero, J. L. (2008). The severity of smouldering peat fires and damage to the forest soil. *CATENA, 74*(3), 304–309.
38. Rupngam, T., & Messiga, A. J. (2024). Unraveling the interactions between flooding dynamics and agricultural productivity in a changing climate. *Sustainability, 16*(14), 6141. https://doi.org/10.3390/su16146141
39. Striling, E., Fitzpatrick, R.W., Mosley, L. (2020). Drought effects on wet soils in inland wetlands and peatlands Earth-Science Reviews 210(3) https://doi.org/10.1016/j.earscirev.2020.103387
40. Suryani, E., Pratamaningsih, M. M., Muslim, R. Q., Erwinda, Hati, D. P., Kricella, Nugroho, E.S., Subandiono, R. E. & Anda, M. (2022). Variations in peat soil properties at the west coast of Sumatra Island. *IOP Conf. Series: Earth and Environmental Science 1025*(2022) 012025. https://doi.org/10.1088/1755-1315/1025/1/012025
41. Van der Laan, A., van Dijk, J., Rebel, K. T., et al. (2024). Rewet without regret? Nutrient dynamics in fen peat exposed to different rewetting degrees. *Biogeochemistry, 167*, 705–721. https://doi.org/10.1007/s10533-024-01139-x
42. Widiarso, B., Minardi, S., Komariah, K., Chandra, T. O., Elmahdi, M. A., & Senge, M. (2020). Predicting peatland groundwater table and soil moisture dynamics affected by drainage level. *Sains Tanah - Journal of Soil Science and Agroclimatology, 17*(1), 42. http://dx.doi.org/10.20961/stjssa.v17i1.38459
43. Yuliana, E. D. (2012). Types of clay minerals and changes in soil chemical properties due to reduction and oxidation processes in acid sulfate soil environments. *Bumi Lestari Journal of Environment, 12*(2).
44. Zhang, B., Zeng, F., Gao, X., Shareef, M., Zhang, Z., Yu, Q., Gao, Y., Li, C., Yin, H., Lu, Y., Huang, C., & Tang, G. (2022). Groundwater depth alters soil nutrient concentrations in different environments in an arid desert. *Frontiers in Environmental Science, 10*. DOI: 10.3389/fenvs.2022.939382
45. Zhang, H., Gallego-Sala, A. V., Amesbury, M. J., Charman, D. J., Piilo, S. R., & Väliranta, M. M. (2018). Inconsistent response of Arctic permafrost peatland carbon accumulation to warm climate phases. *Global Biogeochemical Cycles, 32*, 605–620. https://doi.org/10.1029/2018GB005980

1._Nutrient_dynamics_in_peat,_FIX.pdf

ORIGINALITY REPORT

10%	%	10%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

MATCH ALL SOURCES (ONLY SELECTED SOURCE PRINTED)

Exclude quotes	Off	Exclude matches	< 1%
Exclude bibliography	Off		

1._Nutrient_dynamics_in_peat,_FIX.pdf

GRADEMARK REPORT

FINAL GRADE

/100

GENERAL COMMENTS

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8