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Determination of Nitrogen, Phosphorus and Potassium in Soil and Plant Due to Husbandry Farming in Parit Rasipan Drainage System

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Abstract: Nutrient flow into waterways and soils has rapidly causing eutrophication, which causes ecological instability, dissolved oxygen (DO) depletion, extinction of aquatic species, and perhaps public health risks. Therefore, this study focuses on the determination of nitrogen, phosphorus, and potassium (NPK) in soil and plants in the Parit Rasipan drainage system due to the livestock farming area. The water quality of the drainage system is being monitored. Soil and plant at the study area have been collected by grid sampling method at 4 sampling points on wet and dry seasons for N determination using APHA 4500 NORG-B and PK using US EPA 6010B (ICP OES) methods, respectively. In addition, water quality has been monitored in situ for pH, DO, and temperature by a HI 98192 HANNA multiparameter instrument, while water samples were collected and analyzed for selected parameters including total nitrogen (TN), total phosphorus (TP) using the HACH DR6000 Spectrophotometer and potassium (K) by atomic absorption spectroscopy (AAS). The results of this study show that the concentrations of TN (3380–6290 mg/kg), TP (450-820 mg / kg) and K (381–931 mg/kg) in the soil are classified as moderate to very high. Due to the high concentration, TN (5270–6870 mg/kg), TP (262-769 mg / kg) and K (10200–16200 mg/kg) concentrations in plants are also high. For water quality monitoring, the data shows (pH 6.1-6.4), (DO 0.8–1.1 mg/L), and (temperature 26.6-29.2˚C) both in wet and dry seasons. The concentrations of TN, TP and K (average ± s.d) concentrations in water during the wet season are (TN 43 ± 1mg/L), (TP 0.4 ± 1mg/L) and (K 3.9 ± 0.2mg/L) while during the dry season are (TN 49 ± 1mg/L), (TP 0.7 ± 1mg/L) and (K 4.2 ± 0.2mg/L). In conclusion, from the analysis of the results, the Parit Rasipan drainage system has a high level of NPK in both the wet and dry seasons due to the livestock activities in the area.

Keywords: Livestock waste, soil nutrients, plant nutrients, eutrophication

1. Introduction

Husbandry industry in Malaysia is an essential and crucial sector in the country's agricultural growth. Food availability, a rise in the population, resource shortages, the energy issue, environmental concerns, and pollution have put enormous strains on the livestock farming sector. Because of the environmental impact, waste management from animal farms is required. Massive and unmanaged livestock waste discharge has significant consequences for environmental stability and human health. In addition to being very perishable and odorous, livestock waste is also rich

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in nutrients and pathogens that may contaminate soil, surface water, and groundwater (Cheng *et al.*, 2021). Even though its importance has been underrated, soil has been important to the production of food, water, and air since the beginning of civilization. The global biosphere's evolution depends on the soil's condition. Tan *et al.*, (2022), stated that soil quality relates directly to the capacity of an ecosystem to sustain productivity, guarantee the quality of the environment, and encourage healthy wildlife and anthropogenic behaviour. Changes in land use and climate are likely to have an effect on ecological soil characteristics and therefore function (Xiao & Tan, 2020).

Eutrophication is among the most common problems that freshwater systems encounter across the world. As a consequence of human activity, numerous cases of algal growth have now become common events, influencing the environment. According to Zhang *et al.*, (2021), the issue of eutrophication garners a lot of concern since it could lead to major environmental disturbances such as low levels of dissolved oxygen, the extinction of aquatic species, and even threats to human health. Excess nutrients in the presence of livestock waste are subjected to farmland in soils, and then rain or snowmelt happens, the nutrients wash into bodies of water, causing ecological disturbances like excessive algal growth. Inadequate treatment or recovery at wastewater treatment plants may lead to large amounts of nutrients being released into the environment, which can lead to eutrophication. Livestock activity has the greatest impact on worldwide nitrogen and phosphorus cycles.

Aim of this research is to determine the concentration of nitrogen, phosphorus, and potassium (NPK) in soil and plants at the Parit Rasipan drainage system in the livestock farming area. This study was also conducted to monitor the water quality of selected parameters at the Parit Rasipan drainage system, such as pH, dissolved oxygen (DO), temperature, total nitrogen (TN), total phosphorus (TP), and potassium (K)

2. Methodology of The Study

2.1 Study Area

The study was conducted at Parit Rasipan, Batu Pahat, Johor. The source point was focused on the drainage that located around the livestock farming area which is cow, goat and chicken. Figure 1 shows the sample location from a satellite view (01˚48’45.6” N, 103˚06’35.1” E).

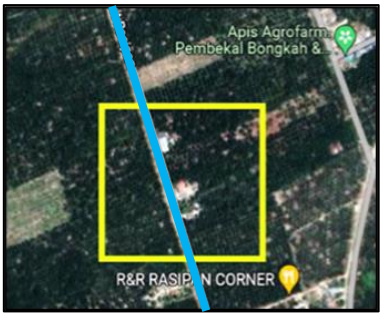

Fig. 1 - Sampling location from the Google Image

2.2 Soil and Plant Sampling

Soil and plant samples were collected during the wet and dry seasons. The sampling area was divided into four grids. Composite soil sampling was conducted to reduce the impacts of soil variability by averaging the soil properties across wider areas by integrating many subsamples together into a single composite sample. 20-30 cm of soils collected after soil surface cleared. Plant samples were taken from the root to the leaves of each plant located within the grid line. The soil and plant samples were stored in labelled plastic bags and brought to the laboratory for further analysis.

2.3 Soil and Plant Sampling

Concentration of Total Nitrogen (TN) in the soil and plant samples was determined using APHA 4500 NORG-B, while the concentrations of the Total Phosphorus (TP) and Potassium (K) were tested using US EPA 6010B (ICP OES). The concentration range for soil nutrients is classified according to the Department of Agriculture Malaysia (DOA), as stated in Table 1.

Table 1 - Soil classification of nutrient content, N, P, K

Nutrients	N(mg/kg)	P(mg/kg)	K (mg/kg)
Very high	>10000	>45	>546
High	6000-10000	25-45	312-546
Moderate	3000-6000	1-25	175.5-312
Low	1000-3000	3-10	54.6-175.5
Very low	<1000	<3	<54.6

2.4 Water Quality Monitoring

Water samples were taken from the study location in the Parit Rasipan drainage system during wet and dry seasons for lab testing. The water pH, DO, and temperature were measured in-situ by using Hanna Instrument HI98196 Multiparameter meter. Samples were collected and analysed for TN, TP and K at the Micropollutant Research Centre (MPRC) laboratory at UTHM by using DR6000 Spectrophotometer following Persulfate Digestion Method (Method 10072) and Reactive High Range Phosphorus Molybdovanadate Method (Method 8114) HACH method.

3. Results and Discussion

3.1 Soil Nutrients

3.1.1 Total Nitrogen (TN)

TN concentrations in samples at points 1, 2, 3, and 4 for a sample in the dry season are 3400 mg/kg, 6290 mg/kg, 4080 mg/kg, and 3820 mg/kg, respectively. For a wet season sample, point 1 is 3380 mg/kg, point 2 is 6090 mg/kg, point 3 is 4080 mg/kg, and point 4 is 3820 mg/kg. According to Table 1, the DOA's soil classification of nutrient content table, the concentration of TN in soil samples can range between high and moderate.

Figure 2 illustrates the concentration of TN in four-point soil samples, revealing that the content of TN varies for each point during the wet and dry seasons. Dry season samples have a higher concentration of TN than wet season samples. Compared with both the dry and wet season samples at points 2 and 3, this sample has a higher concentration of TN because it is located closer to the livestock waste discharge, which affects the TN value of the soil. Samples at points 1 and 4 are positioned farther away from the livestock waste discharges. The effluent in livestock farms is high in nitrogen due to the wastes and urine of the livestock (Giordano *et al.*, 2021). It could be shown that there is no substantial difference in the concentration of TN between the wet and dry seasons. High and moderate concentrations of TN in the soil result in the eutrophication of water bodies.

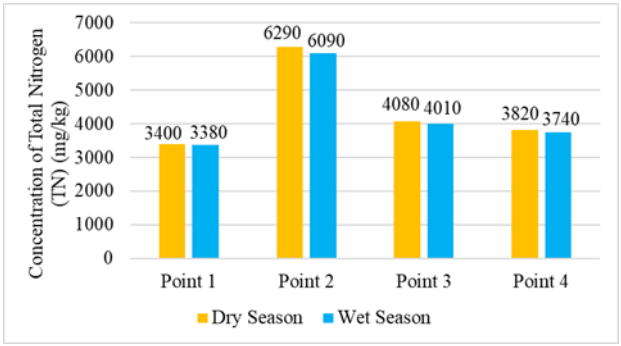

Fig. 2 - Nitrogen concentration in soil on wet and dry seasons

3.1.2 Total Phosphorus (TP)

TP concentrations in samples at points 1, 2, 3, and 4 for a sample in the dry season are 490 mg/kg, 820 mg/kg, 690 mg/kg, and 530 mg/kg, respectively. For a sample in the wet season, point 1 is 450 mg/kg, point 2 is 790 mg/kg, point 3 is 660 mg/kg, and point 4 is 520 mg/kg. Based on Table 1, which is the soil classification of nutrient content by DOA, the concentration of TP in the soil samples can be classified as very high. It could be shown that there is no significant difference in the concentration of TP between the wet and dry seasons.

Figure 3 illustrates the concentration of TP in four-point samples, revealing that the content of TP varies for each point both in the dry and wet seasons. Due to its proximity to livestock waste discharge, which influences the soil's TP value, the samples taken during the dry and wet seasons at points 2 and 3 have higher concentrations of TP. The samples at locations 1 and 4 are further removed from the discharges of livestock waste. The fast expansion and development of livestock activity has resulted in P imbalances in waterbodies. Tan *et al.*, (2022) stated that high levels of P are often found in the soils of farms as well as other locations with a significant number of livestock. Excessive concentrations of phosphorus build up in the topsoil; however, as the soil P concentration rises, so does the likelihood of P leach to the subsurface and surface bodies of water due to surface runoff and degradation (Tan *et al.*, 2022).

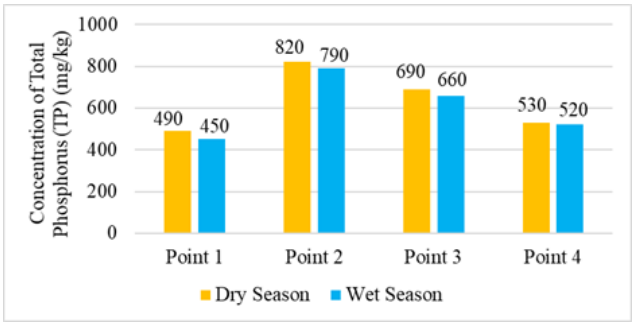

Fig. 3 - Phosphorus concentration in soil on wet and dry seasons

3.1.3 Potassium (K)

K concentrations in samples at points 1, 2, 3, and 4 for a sample in the dry season are 386 mg/kg, 931 mg/kg, 661 mg/kg, and 394 mg/kg, respectively. For a wet season sample, point 1 is 381 mg/kg, point 2 is 921 mg/kg, point 3 is 656 mg/kg, and point 4 is 390 mg/kg. Based on the table 1 which is soil classification of nutrient content table by DOA, the concentration of the K in the soil samples can be classified as in range high to very high. It could be shown that there is no huge difference in the concentration of K between the wet and dry seasons.

Concentration of K in four-point samples is shown in Figure 4, which demonstrates how the concentration of K differs for each point both during wet and dry seasons. K concentrations are higher in dry season samples than in wet season samples. When compared to both of the dry and wet season samples at points 2 and 3, has a higher concentration of K because it is closer to the livestock waste outflow, which impacts the soil's K value. The concentration of K in this soil sample is sufficient to support plant growth in the drainage system.

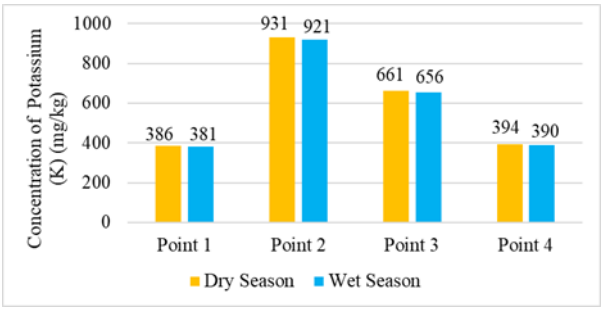

Fig. 4 - Potassium concentration in soil on wet and dry seasons

3.2 Plant Nutrients

3.2.1 Total Nitrogen

TN concentrations in samples at points 1, 2, 3, and 4 for a sample in the dry season are 5400 mg/kg, 6870 mg/kg, 6540 mg/kg, and 6000 mg/kg, respectively. For a wet season sample, point 1 is 5270 mg/kg, point 2 is 6700 mg/kg, point 3 is 6503 mg/kg, and point 4 is 5910 mg/kg. Figure 5 illustrates the concentration of TN in four-point plant samples, revealing that the content of TN in plants varies for each point during the wet and dry seasons. Dry season samples have a higher concentration of TN than wet season samples. Compared with both the dry and wet season samples at points 2 and 3, this sample has a higher concentration of TN because it is located closer to the livestock waste discharge, which affects the TN in the plant. The concentration of TN in plant results clearly proved that the analysed soil sample has a moderate to high concentration of TN. It can be shown that there is no substantial difference in the concentration of TN between the wet and dry seasons. According to Jiao *et al.*, (2022), N is an essential mineral nutrient needed by plants as well as an element in chlorophyll synthesis. Plants employ chlorophyll and solar energy to produce carbohydrates using water and carbon dioxide. N also helps stimulate root development, improve root volumes, area, thickness, whole and primary root lengths, dry mass, and absorption of nutrients, as well as balancing (Anas *et al.*, 2020).

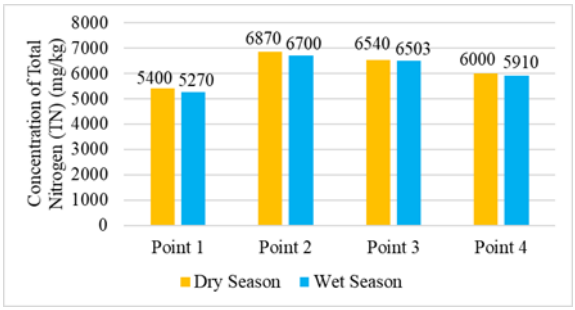

Fig. 5 - Nitrogen concentration in plant during wet and dry seasons

3.2.2 Total Phosphorus (TP)

TP concentrations in samples at points 1, 2, 3, and 4 for a sample in the dry season are 265 mg/kg, 779 mg/kg, 572 mg/kg, and 543 mg/kg, respectively. For a wet season sample, point 1 is 262 mg/kg, point 2 is 769 mg/kg, point 3 is 569 mg/kg, and point 4 is 535 mg/kg. Figure 6 shows that sample 1 has a higher concentration of TP than samples 2, 3, and 4. P is a vital macronutrient for optimal plant development. The plant absorbs TP from the soil, and the presence of very high concentrations of TP in plant samples proved that the concentration of TP in soil is very high. It could be shown that there is no significant difference in the concentration of TP between the wet and dry seasons.

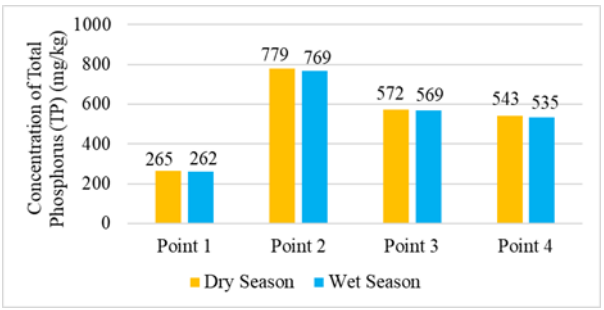

Fig. 6 - Phosphorus concentration in plant during wet and dry seasons

3.2.3 Potassium (K)

K concentrations in samples at points 1, 2, 3, and 4 for a sample in the dry season are 10600 mg/kg, 16200 mg/kg, 15400 mg/kg, and 12400 mg/kg, respectively. For a sample in the wet season, point 1 is 10200 mg/kg, point 2 is 14600 mg/kg, point 3 is 13400 mg/kg, and point 4 is 12100 mg/kg. It could be shown that there is no huge difference in the concentration of K between the wet and dry seasons. Figure 7 illustrates the concentration of K in four-point samples, indicating how the concentration of K varies at each point both during the wet and dry seasons. Dry-season samples had higher K concentrations than wet-season samples. When compared to the dry and wet season samples at points 2 and 3, the latter has a larger concentration of K because it is closer to the livestock waste discharge, which affects the K value of the plant. Potassium is required for plants to be able to withstand environmental stresses such as drought, pests, and disease. So, the plants in this sample can endure all of the challenges, thrive, and reproduce in large numbers because of K's presence. This factor contributed to eutrophication in the drainage.

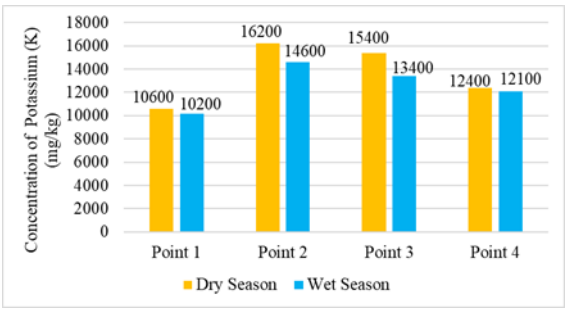

Fig. 7 - Potassium (K) concentration (mg/kg) in plant during wet and dry seasons

3.3 Water Quality Monitoring

In this study, the pH, dissolved oxygen (DO), and temperature of the water are all measured. Table 2 shows the water parameters measured for each sample collected during the wet and wet seasons. The DO for the sample collected in the wet and dry seasons was less than 5 mg/L. DO in water is a critical physical parameter. A sufficient amount of dissolved oxygen is essential for the quality of the water. Aquatic organisms require oxygen to thrive in water. Currently, a lot of comprehensive study is focused on DO and associated dropdown issues. It is seen as a critical water quality parameter, a necessary component of aquatic environments, as well as a participant in all metabolic functions (Abouelsaad *et al.*, 2022). DO concentrations in water were less than 5 mg/L in both wet and dry seasons, which is not insufficient for aquatic life's survival. This circumstance occurred as a result of the DO in the water being consumed by the plant, which reduced the DO level in the water.

pH is a measurement of the acidity or alkalinity of water, defined in terms of the concentration of hydrogen ions. When the pH of a body of water falls below 6.5, it is classified as acidic due to rising emissions of carbon dioxide (CO2) and hydrogen ions (H+) in the water, which are mostly the result of human activity (Jung Liew *et al.*, 2022). The researcher also stated acidification has been shown to degrade the quality of the ecosystem and interfere with the natural food chain, reducing plant and animal species. According to Table 2, pH is lower than 6.5-8 based on the US EPA. pH in the wet and dry seasons do not really differ significantly, but pH in the dry season is lower than pH in the wet season for aquatic life survival. The temperature of the water in both the wet and dry seasons was higher than the optimal temperature for aquatic life, which is 5˚C to 25˚C according to the USGS.

Table 2 - Soil classification of nutrient content, N, P, K

Season	Parameter		
	Dissolved oxygen, DO (mg/L)	pH	Temperature (˚C)
Dry	0.80	6.1	29.2
Wet	1.1	6.4	26.4

3.3.1 Total Nitrogen (TN), Total Phosphorus (TP) and Potassium (K)

The result for concentration of nitrogen (TN) was in the range of 43 to 49 mg/L, and total phosphorus (TP) was in the range of 0.4 to 0.7 mg/L while total potassium (TK) was in the range of 3.9 to 4.2 mg/L.

The nutrients' concentration (mg/L) in water samples is shown in Table 3. Total Nitrogen (TN) concentrations in the dry season is 49 mg/L, while TN in the wet season is 43 mg/L. Table 3 shows that the samples from the dry season contain higher TN concentrations than the samples from the wet season. Zhao *et al.*, (2021), mentioned that TN in water consists of inorganic chemicals such as nitrate (NO3-), nitrite (NO2-), and ammonia (NH4+), as well as organic components like urea, nucleic acids, peptides, proteins, and perhaps a variety of synthetic organic compounds. Eutrophication occurs when there is an excess of nitrogen in the water. Zhao *et al.*, (2021), excess N can easily transfer into water bodies, posing serious concerns about water quality and human health. For example, it might cause an algae bloom, a condition that uses a significant level of oxygen and thus reduces the possibilities of aquatic species surviving, causing a significant detrimental effect on the environment as well as the economy.

TP concentrations in the dry season sample are 0.7 mg/L, while the concentrations of TP in water during the wet season are 0.4 mg/L. Table 3 shows the concentration of Total Phosphorus (mg/L) in a water sample for the dry and wet seasons. The graph demonstrates that the dry season sample had a higher concentration of TP than the wet season sample. This might happen because the TP concentration in the dry season is saturated in water, while the TP in the wet season is diluted by the rainwater. Numerous studies have been conducted, mostly on the behaviour of phosphorus in water bodies, because its high concentration can promote algae growth and eutrophication, which would disrupt the human food chain (Abdul Ghani *et al.*, 2019). Anas *et al.*, (2020), P concentrations in waterbodies are progressively rising, and farming sources of P have been acknowledged as a major factor in eutrophication. When the properties of various aquatic plants begin to alter, the balance of the environment is disturbed.

K concentrations in the dry season are 4.2 mg/L, whereas the concentrations in the wet season are 3.9 mg/L. Table 3 shows that the sample from the dry season has a higher concentration of K than the sample from the wet season. The amount of K in the water is higher in the dry season than in the wet season because rainwater dilutes the K concentration in the water during the wet season. Weather and surface runoff may influence the concentration of K in each sample on various days. K is the most prevalent inorganic cation, and optimum plant development requires its presence (Xu *et al.*, 2020). K from decaying flora and fauna waste is frequently linked to clay minerals in soils before it dissolves in water. K is highly transportable in plants and serves an important role as an osmotic pressure controller and cation and anion balancer (Xu *et al.*, 2020). The presence of K in water promotes algal bloom and aquatic plant development, which contributes to eutrophication conditions.

Table 3 - Concentration of nutrient in water (mg/L)

Season	Nutrient		
	Total Nitrogen (TN) (mg/L)	Total Phosphorus (TP) (mg/L)	Potassium (K) (mg/L)
Dry	49	0.7	4.2
Wet	43	0.4	3.9

4. Conclusion

Result shows that livestock activity is influencing the level of eutrophication in the Parit Rasipan drainage system, which contributes to high level of NPK in soil, plants, and water. According to the results of the soil analysis, the amount of TN in the soil is 3400 mg/kg, 6290 mg/kg, 4080 mg/kg, and 3820 mg/kg during the dry season, and 3380 mg/kg, 6090 mg/kg, 4010 mg/kg, and 3740 mg/kg during the wet season. These values indicate that the TN level is moderate to high in comparison with the guidelines stated by the Department of Agriculture Malaysia (DOA). The levels of TP concentration in soil are 490 mg/kg, 820 mg/kg, 690 mg/kg, and 530 mg/kg during the dry season, and 450 mg/kg, 790 mg/kg, 660 mg/kg, and 520 mg/kg during the wet season. These values can be classified as very high, whereas the levels of K concentration are 386 mg/kg, 931 mg/kg, 661 mg/kg, and 394 mg/kg during the dry season, and 381 mg/kg, 921 mg/kg, 656 mg/kg, and 390 mg/kg during the wet season, which can be classified as being in the range of high to very high according to guidelines stated in the Department of Agricultural Malaysia (DOA). The analysis of plant samples proved that the concentration of TN, TP, and K in the study area is high. The higher the degree of eutrophication, the higher the concentration of TN, TP, and K discharged into the drainage system. In conclusion, the livestock farming activities contributed to the high levels of TN, TP, and K in Parit Rasipan's drainage system.

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