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Dataset Development on Litter Decomposition and $\delta^{13}C/\delta^{15}N$ Contents for Three Dominant Plant Species in Poyang Lake Wetland

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Abstract: Based on an in situ decomposition experiment conducted from 2017 to 2018 in Baisha Lake, within the Nanjishan National Nature Reserve, Poyang Lake, this study constructed a high-temporal-resolution dataset tracking dry matter, lignin, cellulose, total carbon, total nitrogen, total phosphorus, and stable isotopes ($\delta^{13}C$ and $\delta^{15}N$) during the decomposition of litter from 3 dominant wetland plants: *Phragmites australis*, *Triarrhena lutarioriparia*, and *Carex cinerascens*. The dataset covers a decomposition time series spanning 15, 30, 60, 90, 120, and 150 days, systematically recording the dynamic changes of each variable. Results showed significant species-specific differences in decomposition rates and nutrient release patterns among the three litter types. The instantaneous loss coefficients of dry matter, lignin, and cellulose all showed a pattern of first increasing then decreasing, peaking at day 15, with *Phragmites australis* consistently exhibiting the highest decomposition rate and *Triarrhena lutarioriparia* the lowest. The relative return indices of carbon, nitrogen, and phosphorus all followed the order: *Phragmites australis* > *Carex cinerascens* > *Triarrhena lutarioriparia*. $\delta^{13}C$ showed an overall decreasing trend, while $\delta^{15}N$ fluctuated significantly during the early decomposition stage. This dataset provides critical data support for understanding the driving mechanisms of wetland litter decomposition, quantifying carbon, nitrogen, and phosphorus cycling processes, and for model development, and is of great significance for evaluating wetland carbon sink functions and ecological management. The dataset is archived in .shp and .xlsx formats, and consists of 9 data files with data size of 73.8 KB (Compressed into one single file with 64.2 KB).

Keywords: dry matter; lignin; cellulose; carbon and nitrogen isotopes; phosphorus

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Dataset Availability Statement:

The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2025.10.06.V1.

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[2] Zhang, Q. J., Duan, H. L., Wu, D. L., *et al*. Litter decomposition and C-N of three dominant plants dataset in Poyang Lake Wetland [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2025. https://doi.org/10.3974/geodb.2025.10.06.V1.

1 Introduction

Litter decomposition of wetland plants is a key process driving the biogeochemical cycles of essential elements such as carbon and nitrogen. Its dynamics directly affect the carbon sink function of wetlands and the global carbon budget balance[1]. Due to alternating flooding-drying conditions and anoxic environments that significantly inhibit decomposition rates, wetland systems accumulate large amounts of organic matter, thereby becoming important inert carbon pools. Litter decomposition rates are highly sensitive to environmental changes, and even minor fluctuations can significantly affect carbon fluxes at various scales[2–4]. The decomposition process is primarily regulated by substrate quality; lignin, cellulose, and nitrogen, and phosphorus contents along with their stoichiometric ratios (C/N, N/P, Lignin/N), as well as different carbon fractions, significantly affect decomposition rates and pathways[5,6]. Currently, developing a unified predictive indicator applicable to different species and decomposition stages remains a challenge. This study developed a dataset on the chemical composition and $\delta^{13}C$, $\delta^{15}N$ contents during the decomposition of litter from 3 dominant plants (*Phragmites australis*, *Triarrhena lutarioriparia*, and *Carex cinerascens*) in Poyang Lake wetland, aiming to provide key data support for quantifying wetland carbon cycling processes and response mechanisms, and to offer a structured and reusable data foundation for constructing multi-factor driven models and identifying stage-specific indicators.

The fractionation effects of stable isotopes $\delta^{13}C$ and $\delta^{15}N$ play a tracing role in elucidating organic matter transformation pathways and microbial metabolic processes[7,8]. Fractionation intensity is jointly affected by substrate chemical properties, exogenous nitrogen input, and microbial community activities[9,10], but the quantitative relationships among these factors remain understudied. The high-temporal-resolution isotope variation data provided in this study can be used to identify the main controlling factors of fractionation, evaluate the effects of environmental disturbances, and provide a basis for validating model parameterization.

Poyang Lake, as a typical seasonal flood-pulse wetland, experiences dramatic water level fluctuations that create large-area beach habitats, supporting a high-biomass vegetation community dominated by *Phragmites australis*, *Triarrhena lutarioriparia*, and *Carex cinerascens*[11–14]. The litter decomposition process in this area directly regulates nutrient cycling and carbon sequestration potential. However, systematic in situ observational data are still relatively scarce, which constrains in-depth research on the relevant mechanisms. Based on long-term dynamic data obtained from in situ decomposition experiments, this study aims to quantify: (1) dynamic differences in decomposition rates and chemical composition of litter from three dominant species; (2) species-specific patterns of carbon, nitrogen, and phosphorus release; and (3) fractionation patterns of stable isotopes during decomposition. The dataset can serve regional carbon-nitrogen cycling simulations, eco-hydrological effect assessments, and wetland management strategy optimization, and has significant scientific research and application value.

2 Metadata of the Dataset

The metadata of the Litter decomposition and C-N of three dominant plants dataset in Poyang Lake Wetland[15] is summarized in Table 1. It includes the dataset full name, short name, authors, year of the dataset, data format, data size, data files, data publisher, etc.

3 Methods

3.1 Data Collection Area

The data collection area was defined as Baisha Lake, a representative dish-shaped sub-lake

Table 1 Metadata summary of the Litter decomposition and C-N of three dominant plants dataset in Poyang Lake Wetland

Item	Description
Dataset full name	Litter decomposition and C-N of three dominant plants dataset in Poyang Lake Wetland
Dataset short name	LitterDEC_PLW
Authors	Zhang, Q. J., Meteorological Observation Centre, China Meteorological Administration, zhangqj@cma.gov.cn Duan, H. L., Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, duanhl@igsnrr.ac.cn Wu, D. L., Meteorological Observation Centre, China Meteorological Administration, wudongli666@126.com Xia, S. X., Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, xiasx@igsnrr.ac.cn Yu, X. B., Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, yuxb@igsnrr.ac.cn
Geographical region	Poyang Lake
Year	2017–2018
Data format	.xlsx, .shp
Data size	73.8 KB
Data files	Plot geographic location, dry matter decomposition rate, lignin decomposition data, cellulose decomposition data, relative return index of total carbon, relative return index of total nitrogen, relative return index of total phosphorus, $\delta^{13}C$ content, $\delta^{15}N$ content
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	(1) *Data* are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use *Data* subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute *Data* subject to written permission from the GCdataPR Editorial Office and the issuance of a *Data* redistribution license; and (4) If *Data* are used to compile new datasets, the "ten percent principle" should be followed such that *Data* records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[16]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS, GEOSS, PubScholar, CKRSC, OARL

located within the Nanjishan National Nature Reserve of Poyang Lake (Figure 1). The reserve is situated at the southern delta front of Poyang Lake, where the main branches of the Ganjiang River enter the lake. The region experiences a subtropical humid monsoon climate with abundant annual precipitation and significant seasonal variations, characterized by hot, rainy summers and mild, dry winters. The water level is jointly influenced by the inflow of 5 rivers (Ganjiang, Xiushui, Xinjiang, Raohe, Fuhe) and the backwater effect of the Yangtze River, resulting in a highly regular hydrological rhythm: from April to September each year, the wet season causes lake water levels to rise, inundating most beaches; from October to March of the following year, the dry season sees lake water receding, exposing extensive grassy flats, mudflats, and marsh wetlands. These periodic hydrological dynamic shapes the unique and typical structure of the wetland ecosystem in the region[11–14].

Baisha Lake was selected as the experimental site primarily due to its highly representative dish-shaped lake morphology and the complete alternation of aquatic-terrestrial processes. This type of lake and its surrounding beach wetlands are key sites for material cycling and energy flow within the reserve. Especially during the water recession period, exposed areas with fertile soil and favorable hydrothermal conditions are highly suitable for the development of hygrophilous and aquatic plant communities. Among them, *Carex cinerascens*, *Triarrhena lutarioriparia*, and *Phragmites australis* are the three most representative dominant plants in the reserve, widely distributed along the beach gradient from lakeshore to lake center, with clear community structures and large biomass, constituting the main vegetation and primary carbon-nitrogen carriers of the Poyang Lake

wetland. *Carex cinerascens* exhibits a unique phenology with alternating autumn and spring growth, while *Triarrhena lutarioriparia* and *Phragmites australis* show pronounced seasonal biomass accumulation and litter input. Together, these three species dominate litter production and decomposition processes in the region[4,6]. Given the well-preserved native vegetation, minimal human disturbance, and concentrated distribution of dominant species in the beach wetlands of Baisha Lake, the area provides an ideal site for wetland plant litter decomposition experiments.

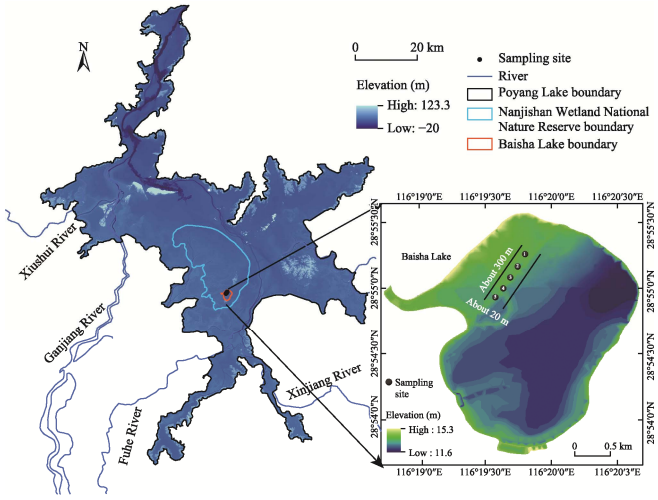


Figure 1 Location map of sampling sites in Poyang Lake Wetland

3.2 Field Experimental Design

3.2.1 Plot Establishment

The in situ decomposition experiment was initiated on November 15, 2017, coinciding with the onset of the dry season in Poyang Lake Wetland. The experimental site was selected in a typical grassy beach in Baisha Lake, located approximately 500 m away from the lake center. A rectangular area (approximately 300 m long × 20 m wide) was delineated within this area, and 5 permanent plots (each about 4 m^2) were evenly arranged as replicates for the decomposition experiment, with plot spacing of about 50 m. This area remains exposed during the dry season and experiences a short inundation period during the wet season. The vegetation is dominated by the three dominant species (*Phragmites australis*, *Triarrhena lutarioriparia*, and *Carex cinerascens*), with healthy growth conditions and uniform distribution, providing ideal conditions for decomposition experiments.

3.2.2 Sample Preparation

Senescent leaves of *Phragmites australis*, *Triarrhena lutarioriparia*, and *Carex cinerascens* were collected near the sampling plots, washed with deionized water, cut into 10 cm segments, and mixed to eliminate size effects. Samples were oven-killed at 120 ℃ for 1 h, then dried at 60 ℃ to constant weight. Samples were placed into litter bags according to 3 treatments: *Phragmites australis* (5 g), *Triarrhena lutarioriparia* (5 g), and *Carex cinerascens* (5 g). The litter bags were 100-mesh (0.15 mm pore size), 15 cm × 20 cm white nylon mesh bags, which prevent sample loss while allowing microbial activity.

3.2.3 Field Deployment and Sampling

The prepared litter bags were fixed at the preset sampling points. PVC tubes were used to secure the bags close to the ground surface, avoiding mutual compression and disturbance of the native litter layer. Litter bags were randomly placed in the 5 plots, ensuring that for each

sampling time point and each species, the specified number of replicates was assigned. Samples were retrieved on days 15, 30, 60, 90, 120, and 150 after deployment. At each retrieval, 3 replicates of *Phragmites australis*, 3 replicates of *Triarrhena lutarioriparia*, and 5 replicates of *Carex cinerascens* were collected. The final sampling (day 150) was completed on April 15, 2018, after which the site was flooded and the experiment was terminated.

3.3 Laboratory Analysis

After each retrieval, litter bags were first cleaned of attached sediment, algae, and other foreign matter. The samples were then transferred to kraft paper envelopes and dried in a 60 ℃ constant-temperature oven until constant weight was achieved. After drying, samples were accurately weighed for dry mass, ground into fine powder, and stored in labeled polyethylene sample bags sealed for subsequent analysis. Each replicate sample powder was analyzed individually for all chemical and isotopic indicators, and the mean and standard deviation were subsequently calculated.

The determination methods and instruments for various chemical indicators in this study were as follows: cellulose and lignin contents were determined by the acid-detergent fiber method[17,18]; total carbon and total nitrogen contents were determined using a Vario Max CN elemental analyzer (Elementar, Germany); total phosphorus content was determined using an Optima 5300DV inductively coupled plasma optical emission spectrometer (Perkin-Elmer, America)[6]; stable isotopes $\delta^{13}C$ and $\delta^{15}N$ were determined using a Thermo elemental analyzer coupled with a Delta Plus Finnigan MAT 253 mass spectrometer[6], with the calculation Equations as follows:

$$\delta^{13}C=\frac{^{13}C/^{12}C_{sample}}{^{13}C/^{12}C_{standard}}-1 \tag{1}$$

$$\delta^{15}N=\frac{^{15}N/^{14}N_{sample}}{^{15}N/^{14}N_{standard}}-1 \tag{2}$$

Pee Dee Belemnite (PDB) was used as the reference standard for carbon stable isotopes, and atmospheric nitrogen was used as the reference standard for nitrogen stable isotopes[6]. During instrumental analysis, the standard errors for replicate samples were: $\delta^{13}C \leq 0.1‰$, $\delta^{15}N \leq 0.4‰$.

3.4 Decomposition Models and Parameter Estimation

The remaining rate (R_t, %) was calculated as follows[6]:

$$R_t=\frac{M_t}{M_0}\times 100\% \tag{3}$$

where, R_t is the remaining rate at time t (%), M_t and M_0 are the dry mass (g) of litter at time t and initial time, respectively, and t represents decomposition time (d).

The instantaneous loss coefficient (k) was estimated using the Olson negative exponential decay model[18]:

$$M_t=M_0e^{-kt} \tag{4}$$

where, k represents the instantaneous loss coefficient at time t, with larger values indicating faster decomposition. M_t and M_0 are the dry mass (g) of litter at time t and initial time, and t is the decomposition time (d).

The relative return index (*RRI*) was calculated as follows:

$$RRI_t=\frac{M_0\times C_0-M_t\times C_t}{M_0\times C_0}\times 100\% \tag{5}$$

where C_t and C_0 are the concentrations (%) of an element at initial time and time t,

respectively. In this study, *CRRI*, *NRRI*, and *PRRI* represent the relative return indices of total carbon, total nitrogen, and total phosphorus, respectively.

4 Data Results

4.1 Dataset Composition

The data include plot geographic location and litter decomposition-related data, archived in .shp and .xlsx formats, respectively. The Excel file of litter decomposition-related data contains 8 sheets, namely dynamic monitoring data of dry matter, lignin, cellulose, total carbon, total nitrogen, total phosphorus, $\delta^{13}C$, and $\delta^{15}N$ at decomposition days 15, 30, 60, 90, 120, and 150, including measured values, means, and standard deviations. Detailed data for each indicator are shown in Table 2.

Table 2 Measured indicators and their statistics

Indicator	Calculated statistics (units)			
Dry matter	Initial mass (g)	Residual mass (g)	k	R_t (%)
Lignin	Percentage of residual dry matter (%)	Residual mass (g)	k	R_t (%)
Cellulose	Percentage of residual dry matter (%)	Residual mass (g)	k	R_t (%)
Total carbon	Percentage of residual dry matter (%)	Residual mass (g)	*RRI* (%)	
Total nitrogen	Percentage of residual dry matter (%)	Residual mass (g)	*RRI* (%)	
Total phosphorus	Proportion of residual dry matter (mg/kg)	Residual mass (g)	*RRI* (%)	
$\delta^{15}N$	Permille of residual dry matter (‰)			
$\delta^{13}C$	Permille of residual dry matter (‰)			

4.2 Data Results Analysis

The results showed that the instantaneous loss coefficients of dry matter, lignin, and cellulose for the three plant species (*Phragmites australis*, *Carex cinerascens*, and *Triarrhena lutarioriparia*) all exhibited a pattern of rapid initial increase, followed by a decrease and eventual stabilization. All three reached their maximum values at day 15 of decomposition and remained relatively stable after day 90. At each measurement time point, the instantaneous loss coefficients of dry matter, lignin, and cellulose were highest for *Phragmites australis*, followed by *Carex cinerascens*, and lowest for *Triarrhena lutarioriparia* (Figures 2a, 2b, 2c).

Regarding the relative return indices of carbon, nitrogen, and phosphorus, a consistent pattern was observed at all sampling time points: highest for *Phragmites australis*, followed by *Carex cinerascens*, and smallest for *Triarrhena lutarioriparia* (Figures 2d, 2e, 2f). During decomposition, the carbon relative return index of all three litters remained positive and increased continuously. The nitrogen relative return index varied by species: *Phragmites australis* remained positive and increased continuously; *Triarrhena lutarioriparia* was consistently negative, showing a pattern of initial decrease followed by increase. The phosphorus relative return index was positive for all species, showing an overall pattern of rapid initial increase followed by stabilization, reaching a steady state approximately 30 days after decomposition initiation.

Although the $\delta^{13}C$ values of the three litters fluctuated throughout the decomposition period, their rank order remained constant: lowest for *Phragmites australis*, intermediate for *Carex cinerascens*, and highest for *Triarrhena lutarioriparia* (Figure 3a). In terms of trends, $\delta^{13}C$ of *Phragmites australis* decreased significantly overall, with only occasional high values at days 30 and 90; $\delta^{13}C$ of *Triarrhena lutarioriparia* decreased significantly after 15 d

of decomposition. In contrast, although $\delta^{13}C$ of *Carex cinerascens* showed high values at days 90 and 150, it also exhibited a significant decreasing trend during the remaining periods.

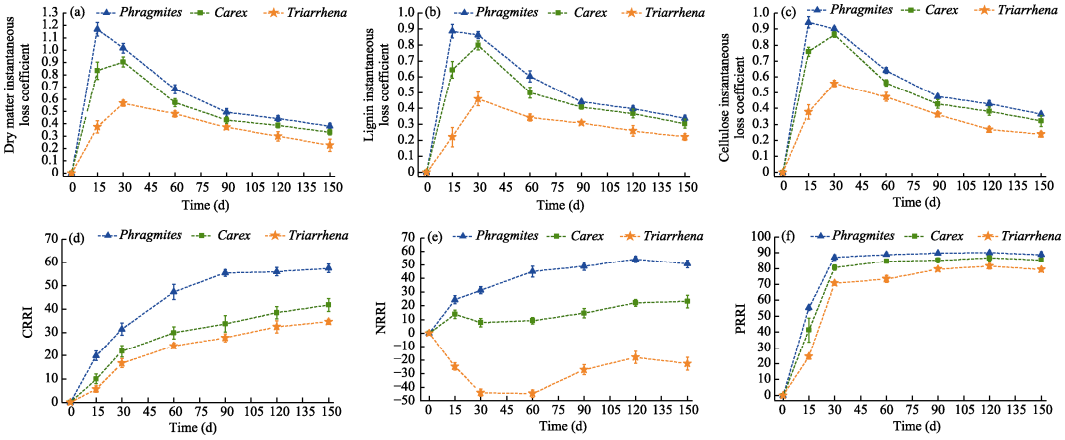


Figure 2 Temporal variation characteristics of litter components during decomposition

For the nitrogen isotope $\delta^{15}N$, all three litters showed the most pronounced changes during the early decomposition stage (first 15 d), followed by fluctuating states (Figure 3b). Regarding $\delta^{15}N$ dynamics, all three litters exhibited the most significant changes in the early stage (0–15 d), followed by fluctuating trends. Throughout the decomposition process, the $\delta^{15}N$ values at each time point consistently followed the order: *Phragmites australis* > *Carex cinerascens* > *Triarrhena lutarioriparia*. Overall, $\delta^{15}N$ of all litters showed a slight increase during decomposition; by day 90, $\delta^{15}N$ of *Carex cinerascens* and *Triarrhena lutarioriparia* was significantly higher than initial values, and the fluctuation amplitude of $\delta^{15}N$ in *Triarrhena lutarioriparia* was the most moderate among the three species throughout decomposition.

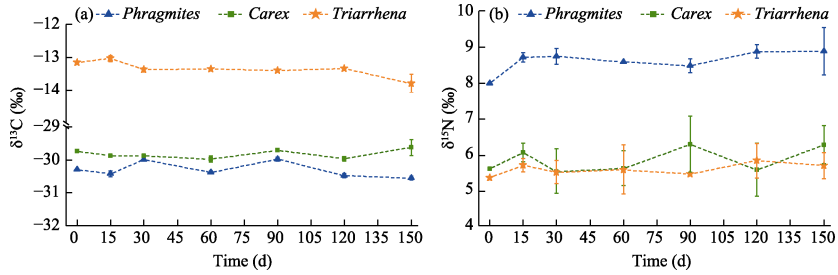


Figure 3 Temporal variation characteristics of $\delta^{13}C$ and $\delta^{15}N$ contents during litter decomposition

5 Discussion and Conclusion

This study employed a 150-d in situ decomposition experiment to systematically track the litter decomposition process of 3 dominant Poyang Lake plants (*Phragmites australis*, *Triarrhena lutarioriparia*, and *Carex cinerascens*). Multiple indicators including dry matter, lignin, cellulose, total carbon, total nitrogen, total phosphorus, and stable isotopes $\delta^{13}C$ and $\delta^{15}N$ were monitored, resulting in a high-temporal-resolution dataset. The results showed significant species-specific differences in decomposition rates, nutrient release, and isotope fractionation behaviors, reflecting species-specific chemical properties and complex biogeochemical processes.

In terms of decomposition rates, dry matter, lignin, and cellulose of the three plant litters

all showed a trend of initial increase, then decrease, and eventual stabilization, peaking at day 15 and stabilizing after day 90. The rapid initial decomposition was primarily attributed to the loss of labile components and rapid microbial colonization, while the later slowdown was due to the increased proportion of recalcitrant compounds. *Phragmites australis* consistently had the highest instantaneous loss coefficient, *Triarrhena lutarioriparia* the lowest, and *Carex cinerascens* intermediate. This difference may be related to their initial substrate quality[19]. The lower C/N ratio and higher nitrogen content of *Phragmites australis* are favorable for microbial utilization, which may explain its fastest decomposition rate. The higher fiber content (cellulose/lignin) and secondary metabolite content of *Triarrhena lutarioriparia* may inhibit decomposition.

Regarding nutrient return dynamics, the relative return indices (RRI) of carbon, nitrogen, and phosphorus all followed the order: *Phragmites australis*>*Carex cinerascens*> *Triarrhena lutarioriparia*, indicating that *Phragmites australis* has the highest nutrient release efficiency and contributes most significantly to wetland nutrient cycling. Carbon RRI remained positive and increasing, indicating continuous carbon release. Nitrogen RRI showed species specificity: *Phragmites australis* showed continuous release, while *Triarrhena lutarioriparia* was consistently negative, indicating net nitrogen immobilization, possibly related to microbial immobilization or litter chemical structure. Phosphorus RRI was positive for all species and stabilized after about 30 days, suggesting that phosphorus release reaches equilibrium earlier, possibly due to adsorption-desorption reactions in the wetland environment[20].

The changes in stable isotopes $\delta^{13}C$ and $\delta^{15}N$ provide important clues for revealing decomposition mechanisms[21,22]. The overall decrease in $\delta^{13}C$ may be related to preferential microbial utilization of ^{13}C-depleted compounds, leading to relative enrichment of ^{13}C in the residual material. $\delta^{15}N$ showed the greatest fluctuations in the early decomposition stage, indicating that early microbial activity significantly affects nitrogen cycling. The higher $\delta^{15}N$ value of *Phragmites australis* may reflect its intense nitrogen transformation processes, while the lower and less variable $\delta^{15}N$ of *Triarrhena lutarioriparia* suggests a relatively conservative nitrogen cycle.

The limitations of this study include the lack of simultaneous monitoring of microbial community structure, extracellular enzyme activities, and environmental factor dynamics, all of which are key variables regulating decomposition. Future research should integrate multi-omics and multi-source scientific data with in situ environmental monitoring to deeply reveal the microbial ecological processes and hydro-chemical coupling mechanisms of litter decomposition.

In summary, through high-resolution multi-indicator observations, this study revealed the material changes and isotope tracing patterns during litter decomposition in Poyang Lake wetland, emphasizing the differences in decomposition strategies among species and their impacts on material cycling. The resulting dataset can provide scientific basis for parameter optimization of regional carbon-nitrogen models, wetland management policy formulation, and carbon sink function assessment under global change scenarios.

Author Contributions

Zhang, Q. J. designed and implemented the field experiment, and was responsible for sample collection, laboratory analysis, data processing, and data paper writing; Xia, S. X. and Duan, H. L. guided and assisted in field experiment design and sample collection; Wu, D. L. guided data quality control and data paper writing; Yu, X. B. conceived the overall design for dataset development, and guided and supervised experiment implementation.

Conflicts of Interest

The authors declare no conflicts of interest.

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