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Dataset Development on Soil Nutrient in Yucheng City, Shandong Province (2007–2020)

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Abstract: This study was conducted in the wheat-maize rotation area of Yucheng City, Shandong Province, China, using annual soil surveys conducted from October 2007 to October 2020. Soil samples from the 0–20 cm plow layer were collected and analyzed for key indicators, included soil pH (determined via water-to-soil extraction at a 5:1 ratio), total nitrogen (TN, determined by the Kjeldahl method), available phosphorus (Avail-P, determined by sodium bicarbonate extraction with molybdenum-antimony colorimetry), and available potassium (Avail-K, determined by ammonium acetate extraction with flame photometry). The resulting dataset, *In situ* soil nutrient dataset in Yucheng City, Shandong Province of China (2007–2020), includes annual soil sampling coordinates (longitude and latitude), pH, TN, Avail-P, Avail-K, soil type, and subtype data. The dataset is archived in .gdb and .xlsx data formats, and consists of 94 data files with data size of 2.26 MB (Compressed into one file with 1.17 MB).

Keywords: Yucheng City; intensive agricultural zone; wheat-maize rotation; soil fertility

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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.2025.03.06.V1.

1 Introduction

Intensive agricultural production, as opposed to conventional agricultural management, is essential to meet the nutritional demands of a rapidly growing population and increase crop yields per unit area of soil[1]. Yucheng City (116°36′E, 36°57′N), located in the central North

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China Plain, is a typical intensive agricultural zone. As one of the first counties in China to achieve and sustain ton-grain field construction, Yucheng City provides critical insights into soil nutrient dynamics. Monitoring the changes in soil nutrients in Yucheng City supports climate change resilience and informs future intensive agricultural management strategies for the North China Plain.

Soil properties regulate carbon and nitrogen turnover efficiencies, thereby influencing crop growth and determining the contributions of tillage, fertilization, and crop residues to soil fertility. Soil type, a fundamental property of soil, governs the rate of nutrient accumulation. Soil pH restricts soil carbon input and alters substrate decomposition pathways. Nitrogen, phosphorus, and potassium, as essential competitive nutrients for crop growth and directly affect crop development. For instance, available phosphorus, a limiting factor for root growth, restricts the accumulation of belowground biomass[2].

Continuous soil monitoring enables the precise assessment of temporal trends in soil-related factors, minimizing the biases associated with long-interval observations. This dataset was compiled through long-term fixed-point field surveys conducted from October 2007 to October 2020, and soil nutrient data were systematically analyzed and compiled.

2 Metadata of the Dataset

The metadata of *In situ* soil nutrient dataset in Yucheng City, Shandong Province of China (2007–2020)[3] 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, and data sharing policy, etc.

Table 1 Metadata summary of the *In situ* soil nutrient dataset in Yucheng City, Shandong Province of China (2007–2020)

Items	Description
Dataset full name	*In situ* soil nutrient dataset in Yucheng City, Shandong Province of China (2007–2020)
Dataset short name	YuchengSoilNutrient2007–2020
Authors	Xu, S.S., Shihezi University, 20222110063@stu.shzu.edu.cn Gong, H. R., Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, hrgong@igsnrr.ac.cn Li, J., Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, jingli@igsnrr.ac.cn Liu, H. G., Shihezi University, liuhongguang-521@163.com
Geographical region	Yucheng City, Shandong Province
Year	2007–2020
Data format	.xlsx, .gdb
Data size	2.26 MB (compressed to 1.17 MB)
Data files	Geo-location of the samples, pH, TN, Avail-P, Avail-K, soil type, and subtype
Foundation	National Natural Science Foundation of China (42271278)
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 principal" 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[4]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS, GEOSS, PubScholar, CKRSC

3 Methods

Yucheng City (116°36′E, 36°57′N), located in the central North China Plain (Figure 1), is a typical intensive agricultural zone spanning 988.6 km^2 located at an elevation of 23 m. It has wheat-maize rotation as the primary cropping system, where the soil parent material is derived from the Yellow River alluvium, predominantly comprising fluvo-aquic and salinized fluvo-aquic soil. The region has a warm temperate semi-humid monsoon climate, and an average annual temperature of 13.1 ℃. The mean annual precipitation is 538 mm, with 68% of the precipitation occurring from June to August. It receives a total annual solar radiation of 5,215.6 MJ/m^2, with 1,920 h of sunshine. The accumulated temperature above 0 ℃ is 4,951 ℃, with frost-free period of 200 days.

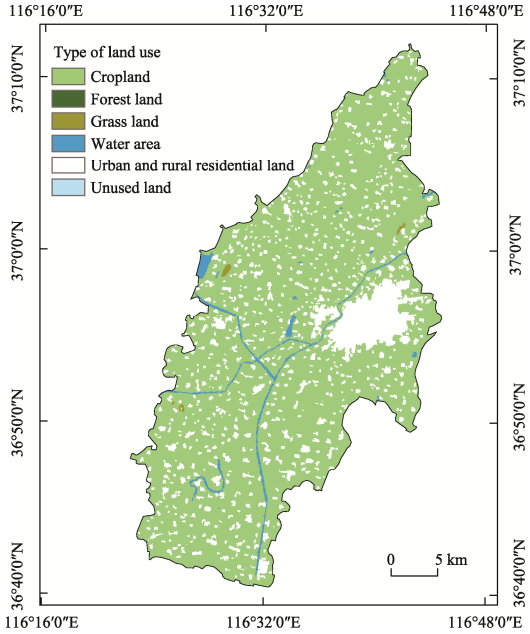

Figure 1 Land use map of Yucheng City, Shandong Province

Soil sampling was conducted annually from 2007 to 2020 during the maize harvest season (in October) within the wheat-maize rotation zone (Figure 1). Sampling points were randomly distributed across the farmland (Table 2). At each point, composite samples (0–20 cm depth) were collected from the 3 subareas for analysis. Geo-location data of the samples and soil morphological characteristics (color, texture, and structure) were recorded. The key indicators were analyzed using standardized methods at the Yucheng Experimental Station of the Chinese Academy of Sciences.

Table 2 Number of sampling points

Time	Land use type	Number	Time	Land use type	Number
200710	Cropland	2,306	201410	Cropland	508
200810	Cropland	1,362	201510	Cropland	632
200910	Cropland	597	201610	Cropland	443
201010	Cropland	574	201810	Cropland	146
201110	Cropland	427	201910	Cropland	155
201210	Cropland	414	202010	Cropland	171
201310	Cropland	419			

Note: 2014 TN and 2017 complete data are unavailable because of soil sample measurement problems.

Soil pH was determined after extraction at a water-to-soil ratio of 5:1. Total nitrogen (TN) was analyzed using the Kjeldahl method. Available phosphorus (Avail-P) was measured by sodium bicarbonate extraction with molybdenum-antimony colorimetry. Available potassium (Avail-K) was determined by ammonium acetate extraction with flame photometry. Soil type and subtype classifications were determined based on laboratory measurements of soil physicochemical properties (pH, electrical conductivity, particle composition, and mineral analysis), morphological observations, systematic retrieval, and comprehensive judgment according to the Chinese Soil Taxonomy.

4 Data Results

4.1 Dataset Composition

The dataset includes 94 files in .gdb, .xlsx formats, containing information on soil pH, TN, Avail-P, Avail-K, soil type, and subtype for the 0–20 cm plow layer from 2007 to 2020 (see Table 3 for abbreviations). Spatial map naming follows the "year+month" format (e.g., 200710 for October 2007).

Table 3 Dataset abbreviation descriptions.

Full Name	Abbreviation	Unit
Total nitrogen	TN	g/kg
Available phosphorus	Avail-P	mg/kg
Available potassium	Avail-K	mg/kg

4.2 Data Results

From 2007–2020, Yucheng City's soils were predominantly fluvo-aquic, with typical fluvo-aquic soil being the dominant subtype, followed by salinized fluvo-aquic soil (Figure 2). Long-term interactions between natural processes and human activities have driven soil subtype transitions. Systematic improvements in saline-alkali land since the 1960s have significantly reduced soil salinity[5]. Additionally, the proportion of saline-alkali soil declined with sustained cultivation. High fertilizer input and straw incorporation in the wheat-maize rotation system accelerated soil organic matter accumulation and structural improvement, promoting typical fluvo-aquic soil development.

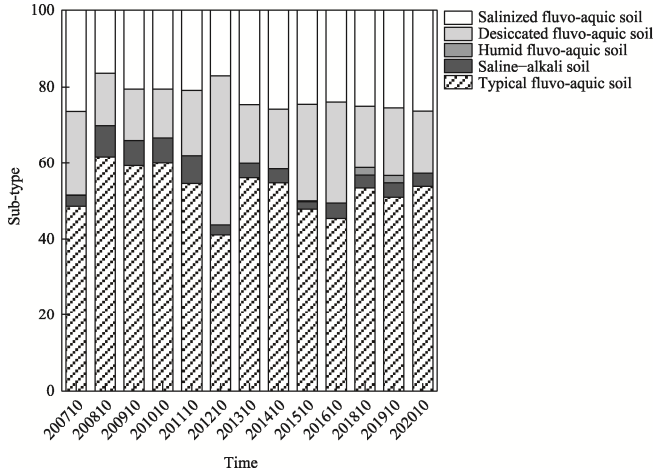

Figure 2 Changes in soil subtypes in Yucheng City (2007–2020)

Soil TN and Avail-K exhibited significant increasing trends from 2007 to 2020, while Avail-P showed minimal change (Figure 3). TN increased from 0.82 g/kg to 0.97 g/kg, peaking in 2018. Avail-P increased from 22.81 mg/kg to 25.19 mg/kg (mean annual increase: 0.17 mg/kg). Avail-K rose from 122.06 mg/kg to 269.23 mg/kg (mean: 163 mg/kg), with a significant increase observed from 2016 to 2020. These trends are attributed to long-term soil testing, formula fertilization, and straw incorporation, which enhance nutrient accumulation, boost crop yields, and improve soil fertility. Fertilizers promote root and litter organic carbon inputs, further increasing TN[6]. Avail-P changes were limited due to the alkaline soil pH in Yucheng, where phosphorus forms insoluble compounds with calcium and magnesium ions[7], coupled with low phosphorus fertilizer efficiency[8]. In contrast, Avail-K increased significantly following potassium fertilizer application and straw incorporation, addressing long-term potassium deficits in North China Plain farmlands.

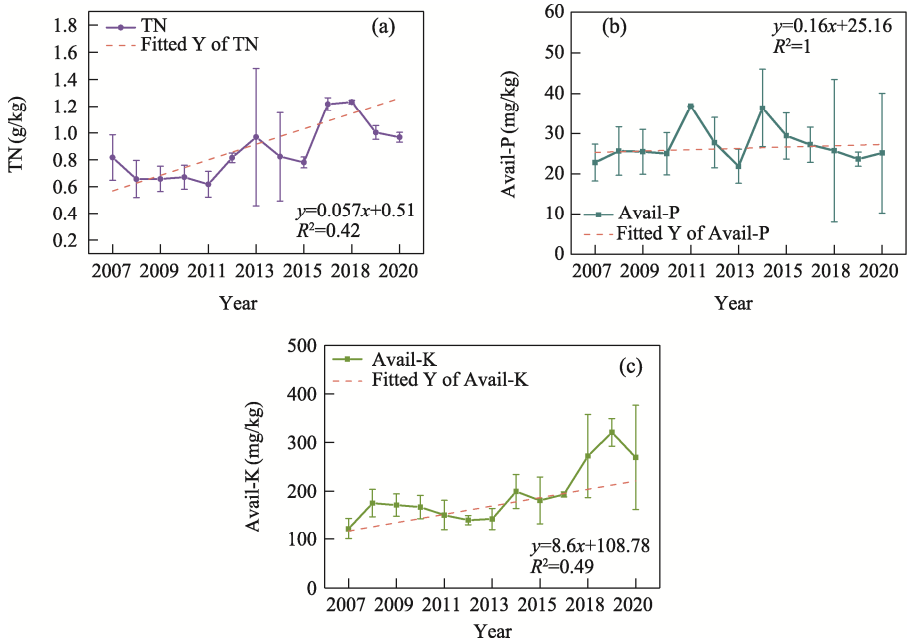

Figure 3 Temporal variations in soil TN, Avail-P, and Avail-K contents (2017–2020)

5 Discussion and Conclusion

Kriging interpolation of the 2007–2020 soil data revealed spatial variations in the TN across Yucheng (Figure 4). Nutrient increases were spatially heterogeneous. Specifically, TN decreased in the southwestern and northeastern regions (minimum reduction of 20.30%) and increased in the southeastern region (maximum increase of 84.85%). Notably, data applicability is limited to farmland soils because sampling points are concentrated in croplands, which reduces the reliability of the interpolated results near urban areas.

This dataset, based on soil sampling data collected from Yucheng City, Shandong Province, between 2007 and 2020, enhanced data coherence and analytical reliability through continuous monitoring. Results indicate increasing trends in TN, Avail-P, and Avail-K across Yucheng City. The spatial analysis revealed heterogeneous nutrient dynamics,

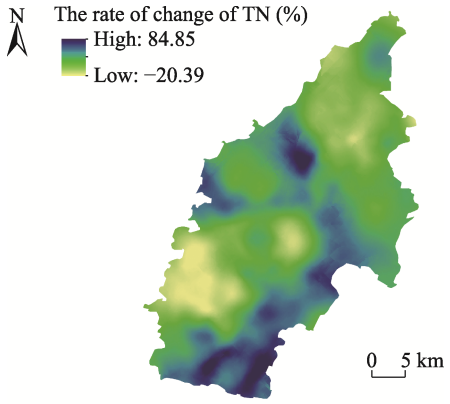

Figure 4 Map of the change rate of total nitrogen (TN) content in soils from 2007 to 2020

emphasizing the need for site-specific agricultural management. This dataset supports research on soil quality assessments, carbon emission predictions, and agricultural management. This study provides critical indicators and data for evaluating the dynamic impacts of long-term intensive agriculture on soil fertility, and supports evidence-based, real-time agricultural management strategies under climate change.

Author Contributions

Xu, S. S., Gong, H. R., Li, J., Liu, H. G. designed the algorithms of dataset. Xu, S. S., Gong, H. R., Li, J. contributed to the data processing and analysis. Xu, S. S. wrote the data paper.

Conflicts of Interest

The authors declare no conflicts of interest.

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