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Groundwater quality evaluation and source analysis in typical karst areas

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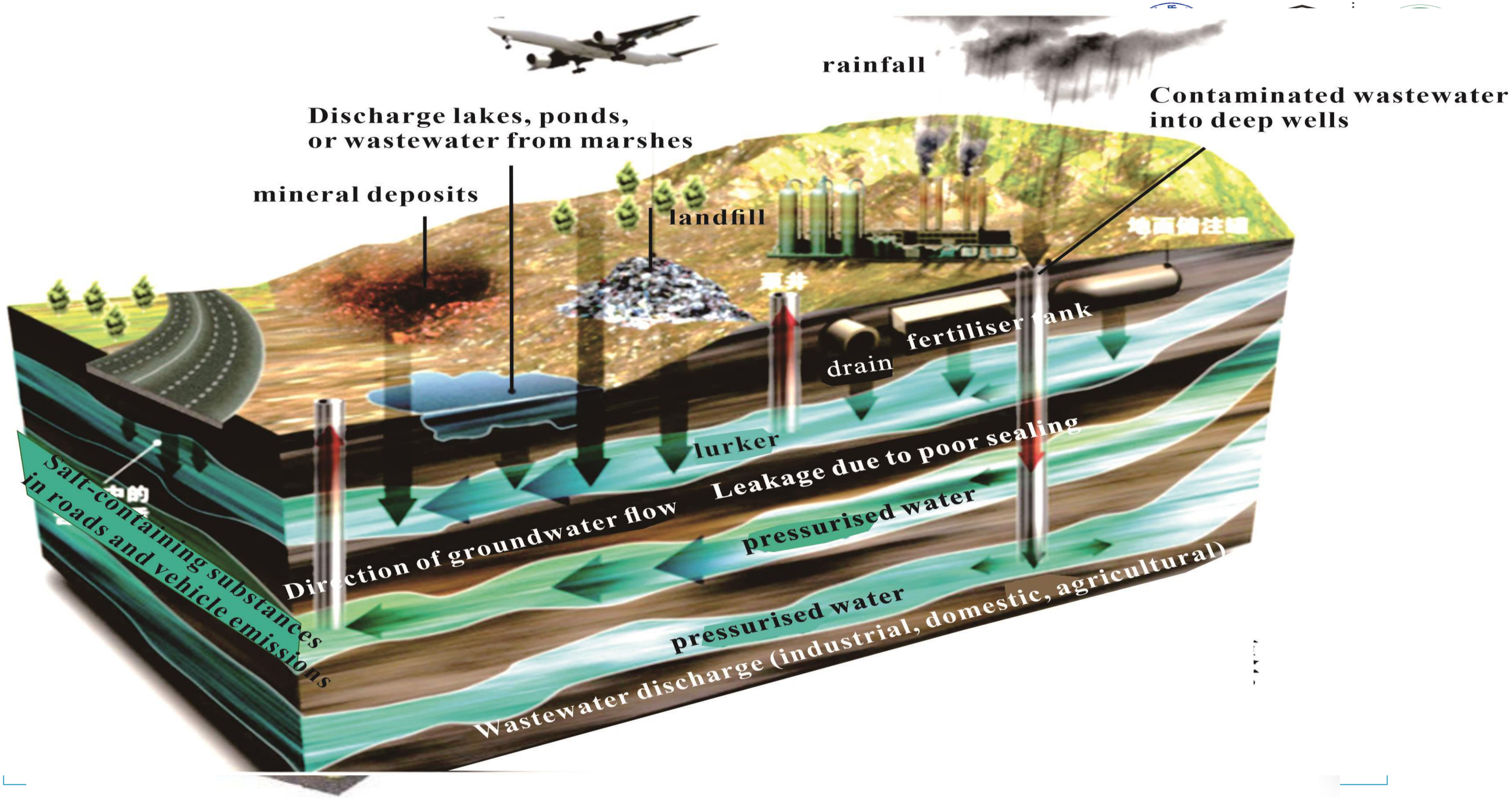
Outline

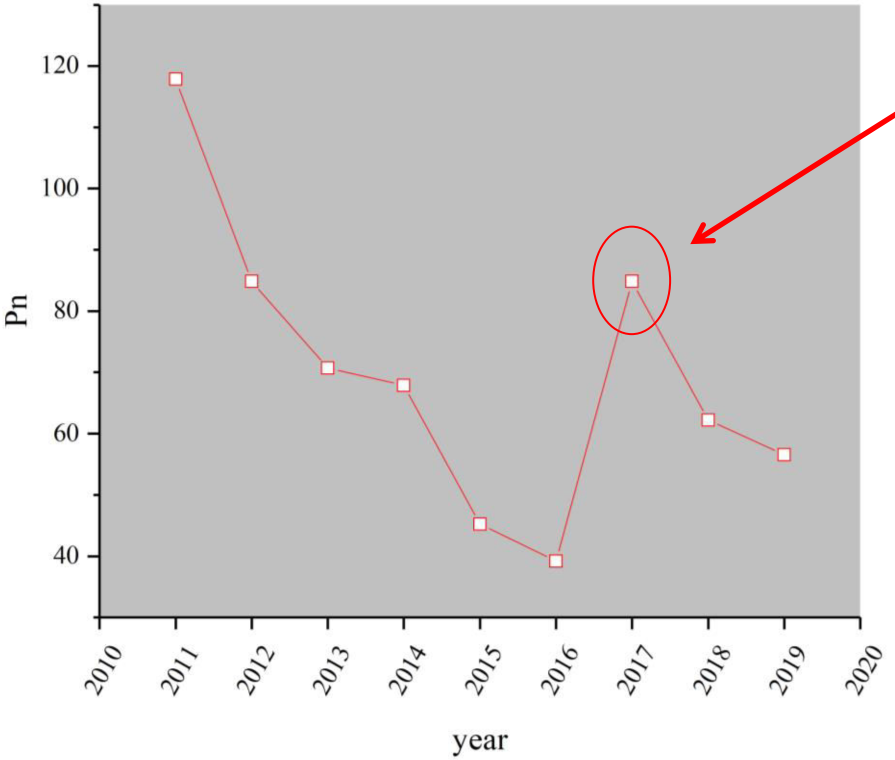
1. Introduction
2. Research highlights
3. Site description and Methods
4. Discussion
5. Summary


rainfall
Discharge lakes, ponds,
or wastewater from marshes
Contaminated wastewater
into deep wells
mineral deposits
landfill
fertiliser tank
drain
lurker
Leakage due to poor sealing
pressurised water
Direction of groundwater flow
Salt-containing substances
in roads and vehicle emissions
pressurised water
Wastewater discharge (industrial, domestic, agricultural)

2. Research highlights

Study area map of Lingui District, Guilin

- Important industrial base and transport hub of Guilin City
- Area 2190.27 km^2



Water quality shifts in 2017

- Therefore, the specific pollution sources and main pollution factors of its water quality from 2017 -2019 were selected for analysis.

3. Site Description and Methods

Water chemical parameters

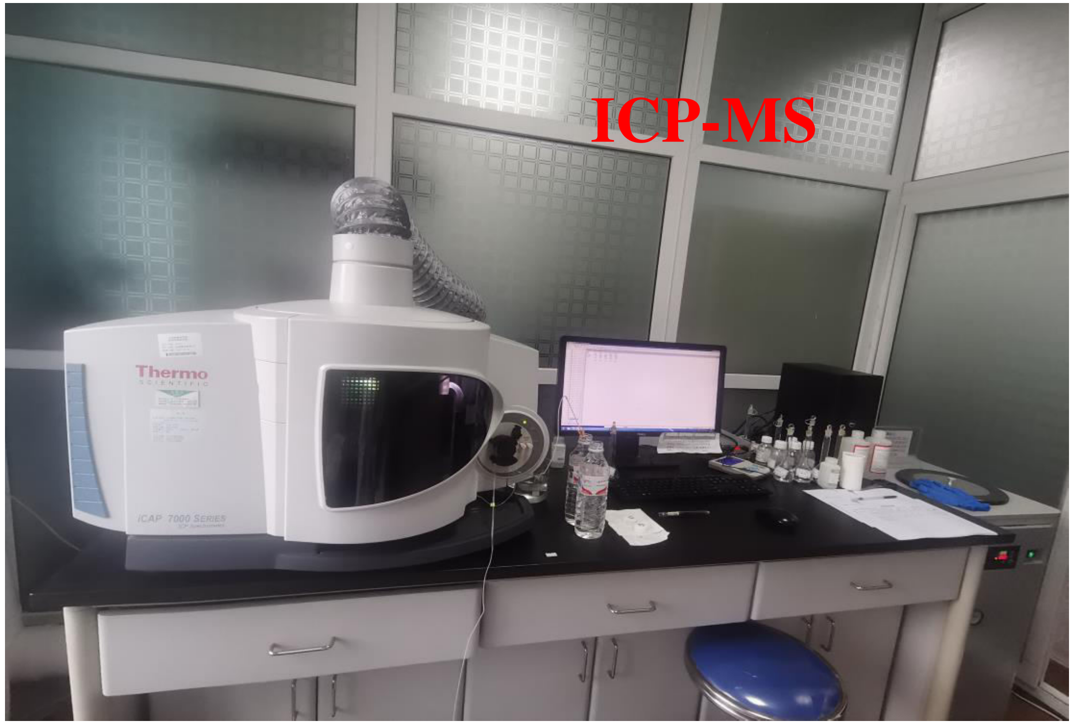
Field indexes
- pH
- TDS
- HCO_3^-
- Ca^{2+}

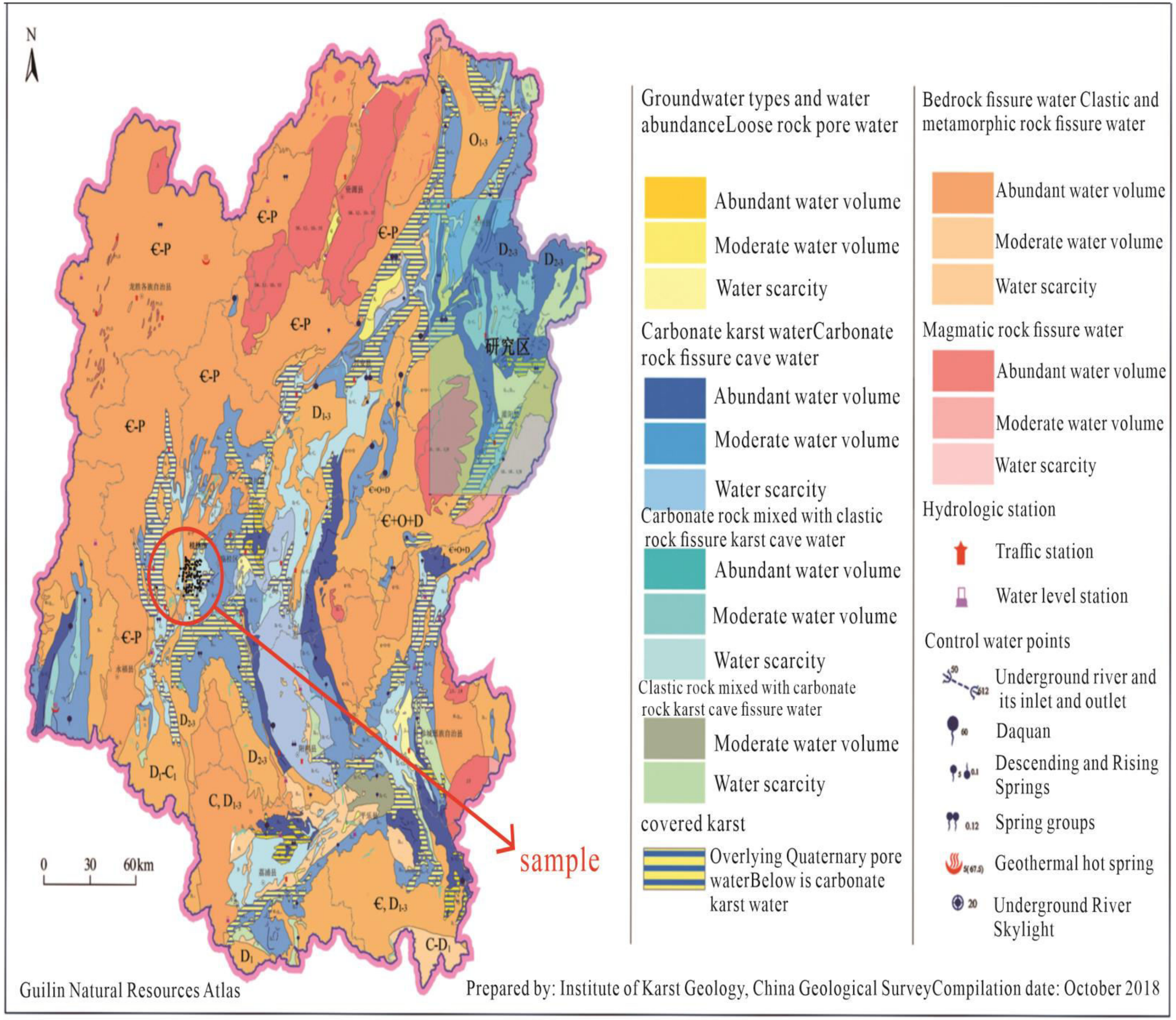
Laboratory analysis

- **Main factors**

K^+、Na^+、Ca^{2+}、Mg^{2+}、$SO4^{2-}$、NO_3^-、HCO_3^-、Cl^-、F^-

Pb、As、Hg、Zn、Mn、Fe





- **Location**

Guilin city, SW China

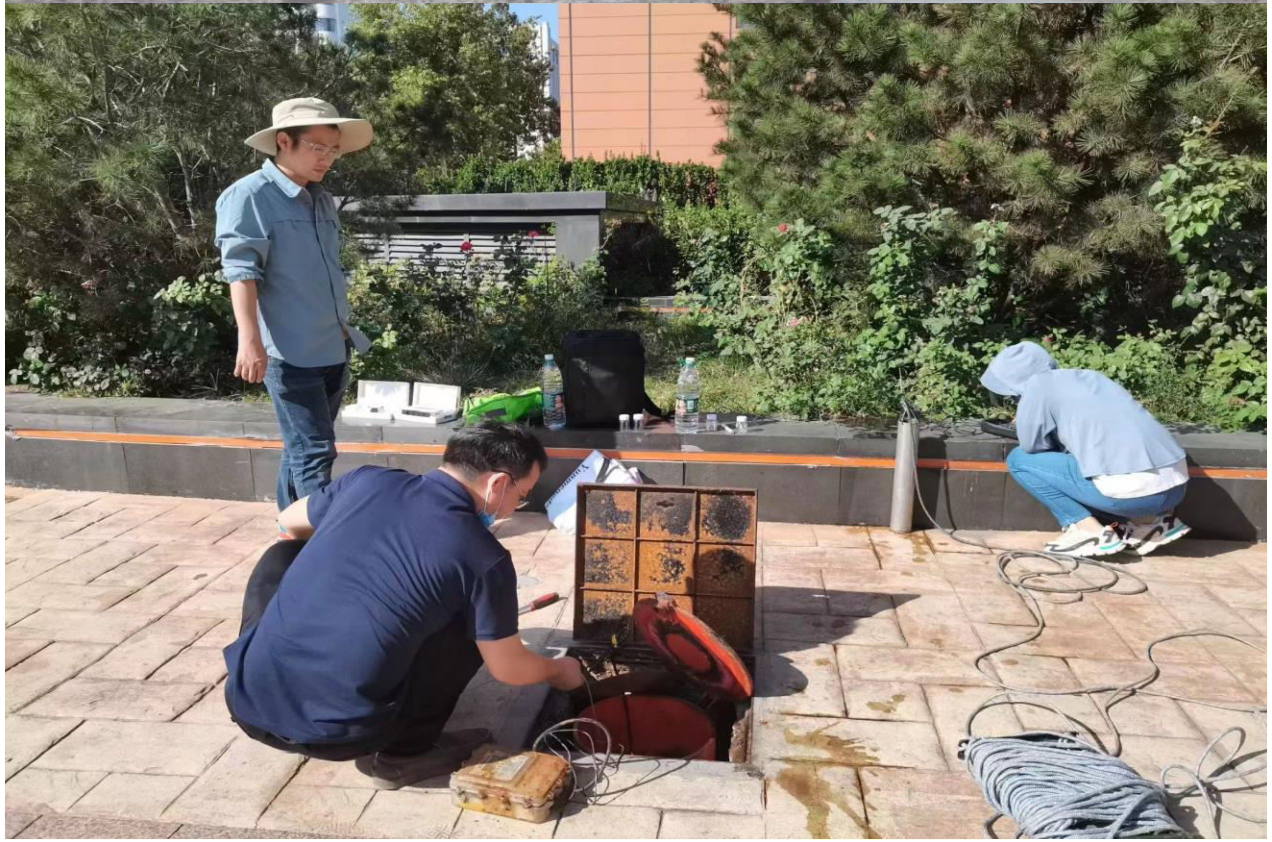
- **lithology**

Carbonate rocks

- **area**

2190km^2

Period
July, 2017
July, 2018
July, 2019



Calculation

(1) Single-Factor pollution Index (P_i)

$$P_i = \frac{C_i}{B_i}$$

C_i: Measured concentrations of factor i

B_i: factor i corresponding environmental standard values

(2) Nemerow Multi-Factor pollution Index (P_n)

$$P_n = \sqrt{\frac{\max(P_i)^2 + \text{ave}(P_i)^2}{2}}$$

max (P_i) : Maximum value of single-factor pollution index for factors

ave (P_i) : Mean values of single-factor pollution indices for each factor

Calculation

The evaluation criteria for the single-factor pollution index Pi and the multi-factor composite pollution index Pn are shown in Table 1.

Table1 Evaluation criteria of single factor pollution index P_i and multi-factor comprehensive pollution index P_n

P_i	P_n	pollution assessment
$P_i \leqslant 1$	$P_n \leqslant 0.7$	No Pollution
$1 < P_i \leqslant 2$	$0.7 < P_n \leqslant 1$	Low pollution
$2 < P_i \leqslant 3$	$1 < P_n \leqslant 2$	Moderate polluted
$P_i > 3$	$P_n > 2$	Strong polluted

4. Discussion

4.1 Groundwater quality assessment

4.2 Screening of groundwater quality for major pollutants

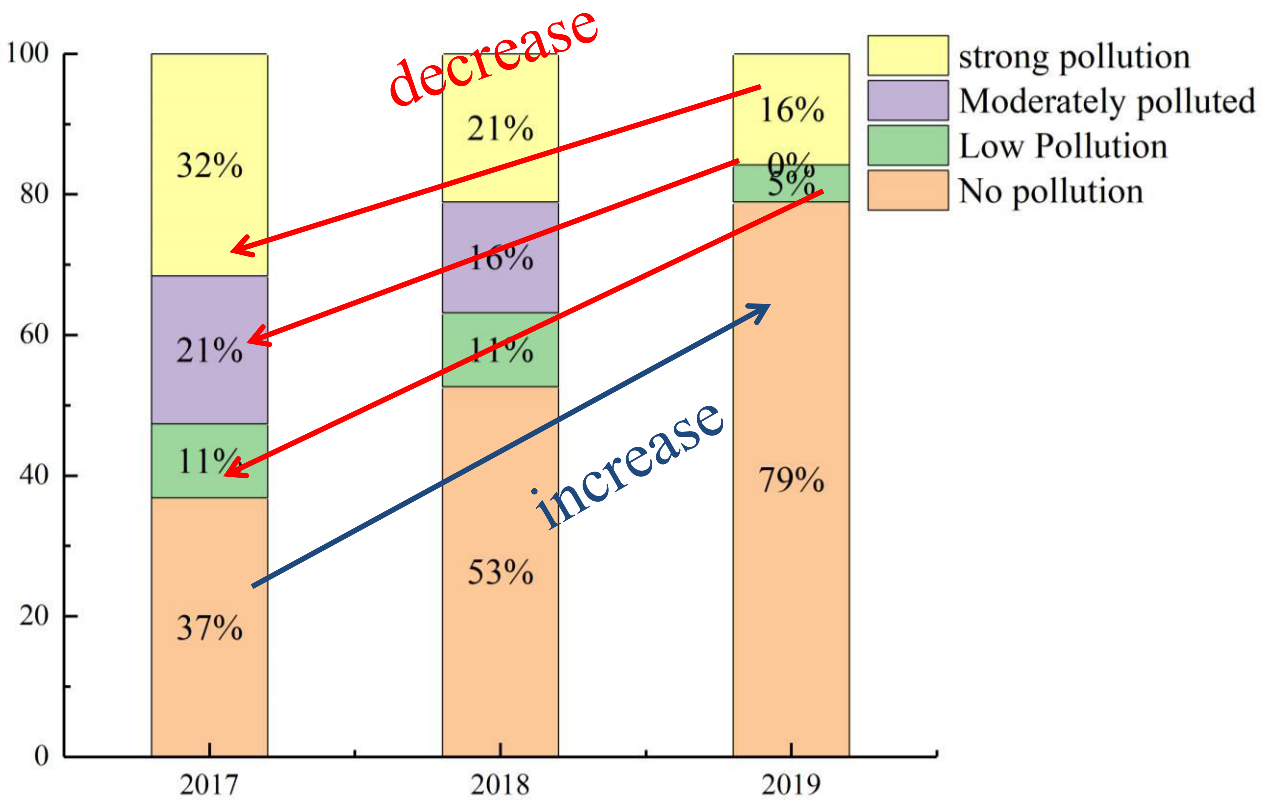
4.3 Spatial and temporal distribution of the main pollutants of groundwater quality

4.4 Source analyses of groundwater quality

4.1Groundwater quality assessment

Year	Nemerow Multi-Factor pollution Index (P_n)	Degree of contamination
2017	84.85	Strong polluted
2018	62.23	Strong polluted
2019	56.57	Strong polluted

decrease

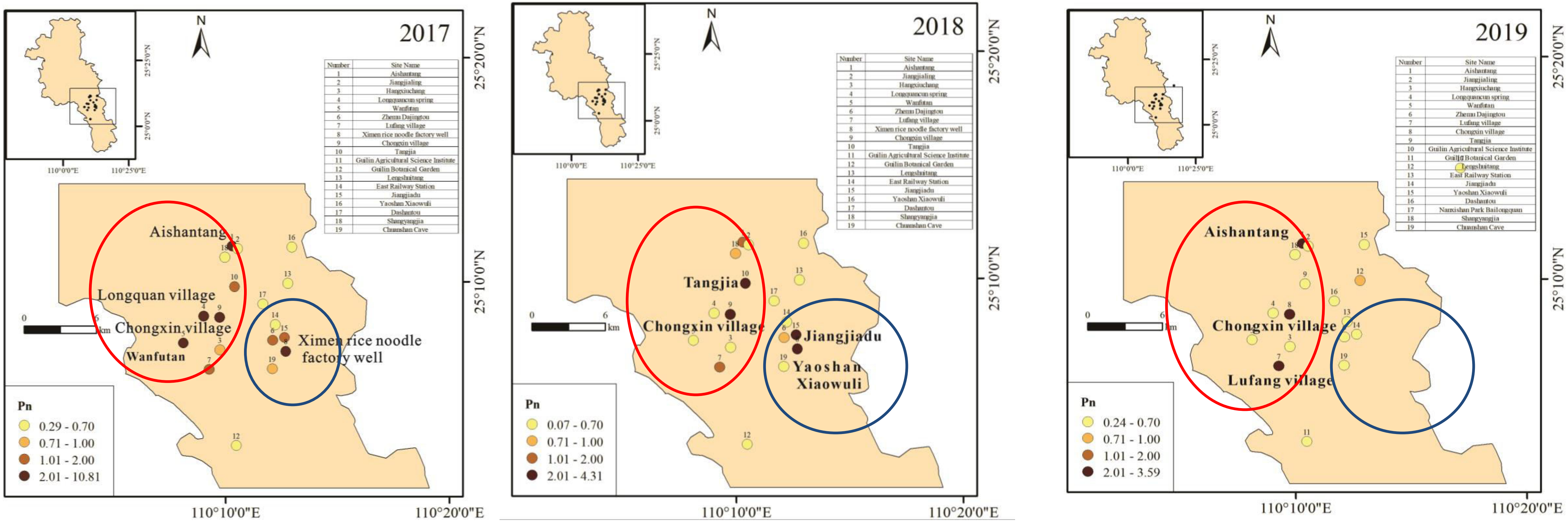


Groundwater Quality Percentage Map for the Study Area

Guilin groundwater quality in terms of time distribution, 2017-2019 with time changes in water quality generally improved. This may be related to the Notice of the General Office of the People's Government of the Guangxi Zhuang Autonomous Region on the "Issuance of Measures for the Management of Groundwater in Guangxi".

4.1 Groundwater quality assessment

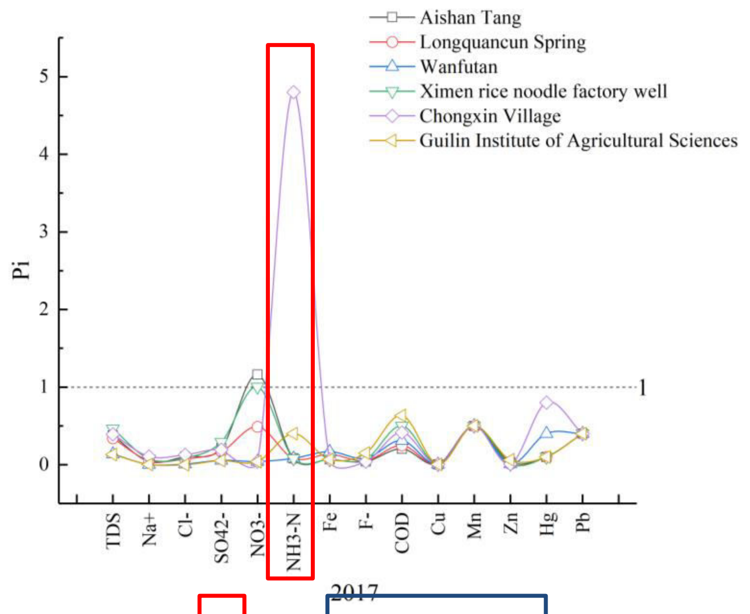
Spatial distribution of pollutant: west is worse than in the east.

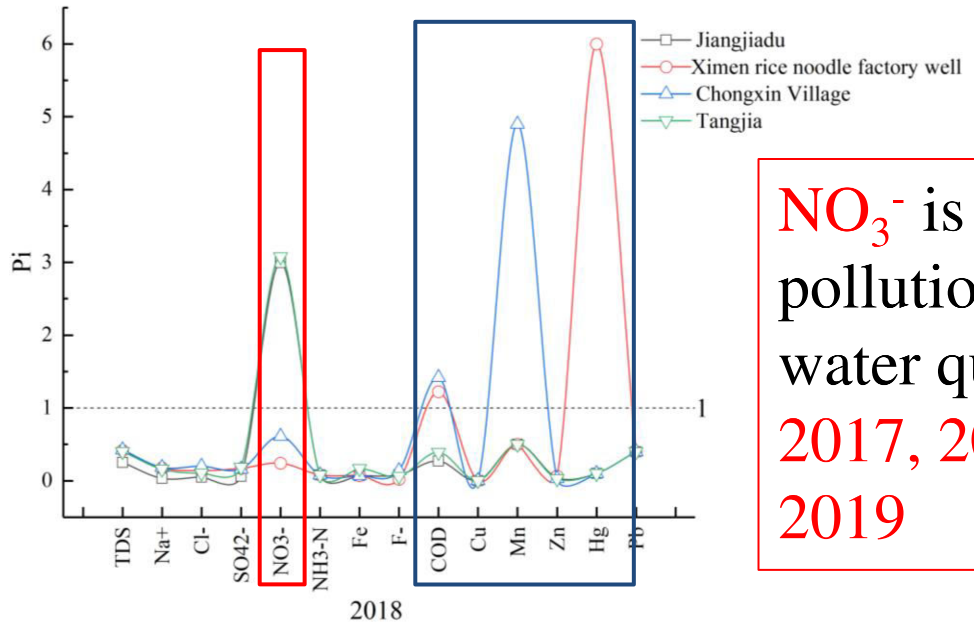


- Anthropogenic: due to measures such as centralised disposal of pollutants and enhanced industrial wastewater management since the implementation of the policy in 2017, the water quality of the industrial area in the East District has shown significant improvement.

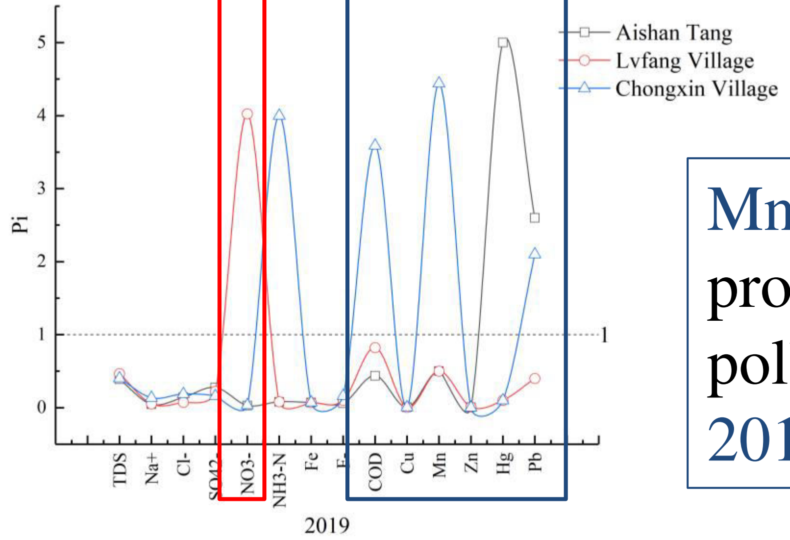
- Natural: the groundwater in the East District has a high degree of karst development, good hydraulic conductivity, strong dilution and self-purification ability, and pollutants are not easy to be enriched in the groundwater (Jia Yannan, 2004), so the water quality is better.

4.2 Screening of groundwater quality for major pollutants





NO_3^- is a common pollution factor for water quality in 2017, 2018 and 2019



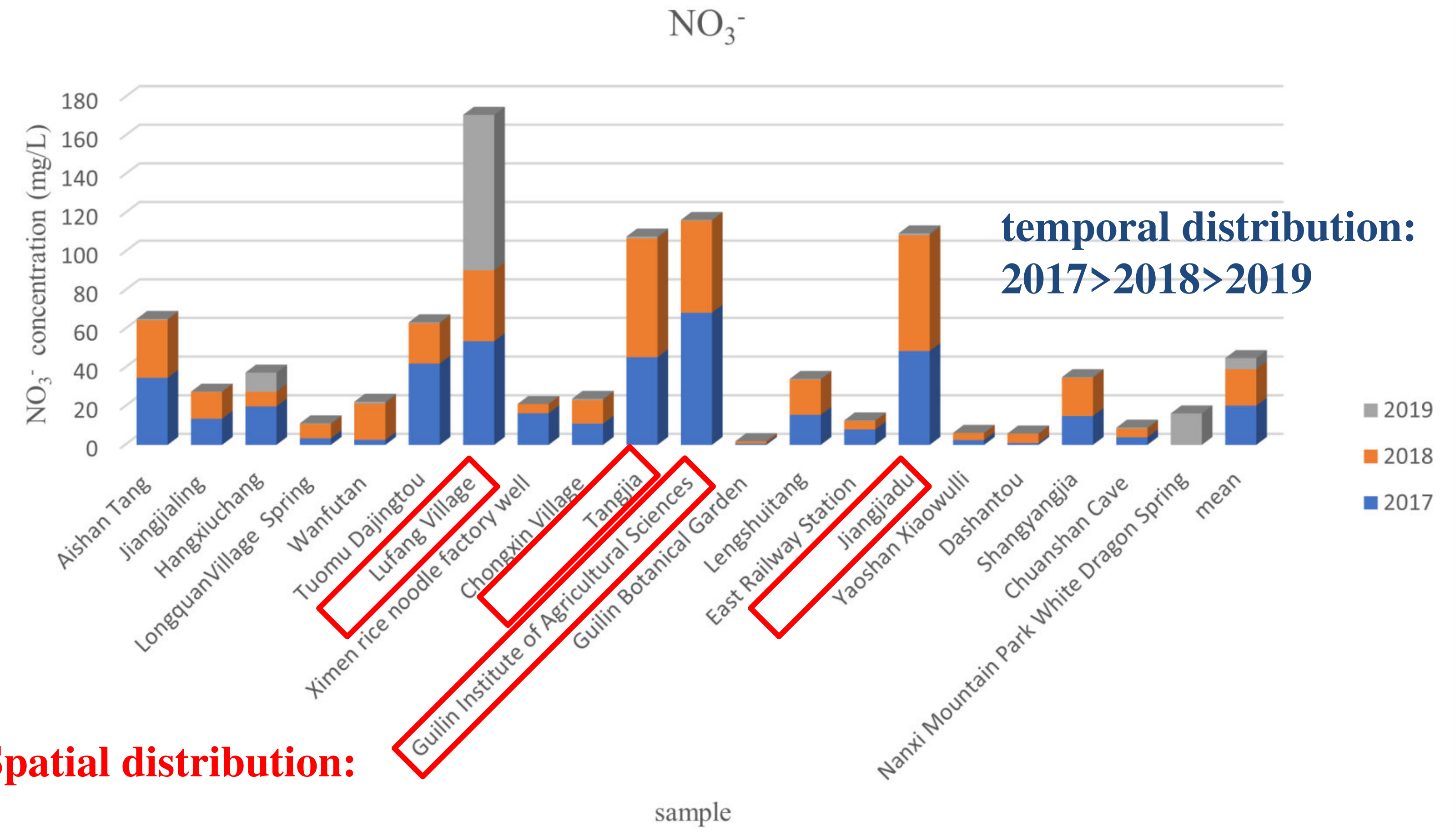
Mn, Hg, Pb more prominent factors of pollution in 2018 and 2019

The trend in the evolution of water quality from 2017-2019 is a gradual decrease in pollution, but an increase in the diversity of pollutants.

4.3 Spatial and temporal distribution of the main pollutants of groundwater quality

The spatial and temporal distributions of NO_3^-, Mn ,Pb, which were screened as the more polluting factors, were analysed in order to analyse the specific causes of pollution.

- Spatial and temporal distribution of NO_3^-



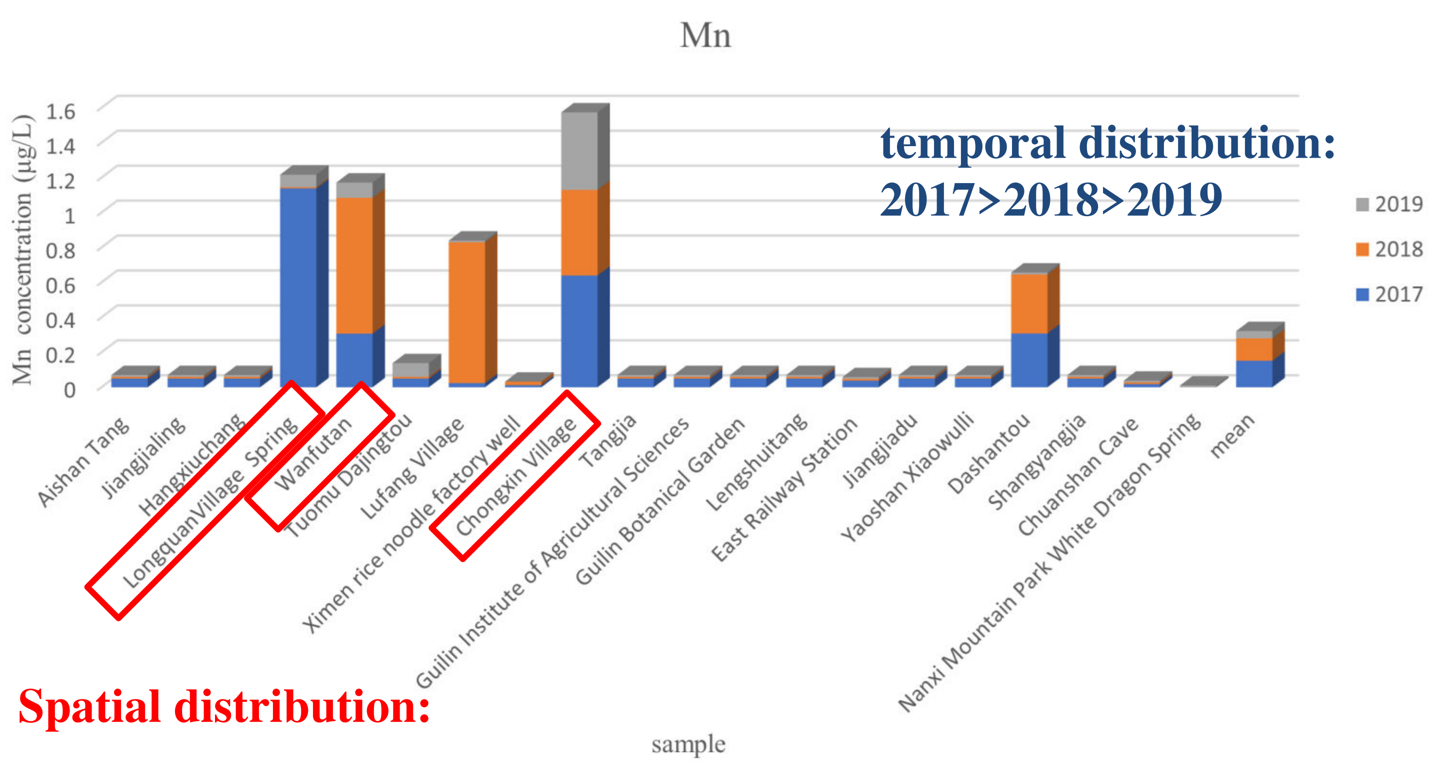
temporal distribution: 2017>2018>2019

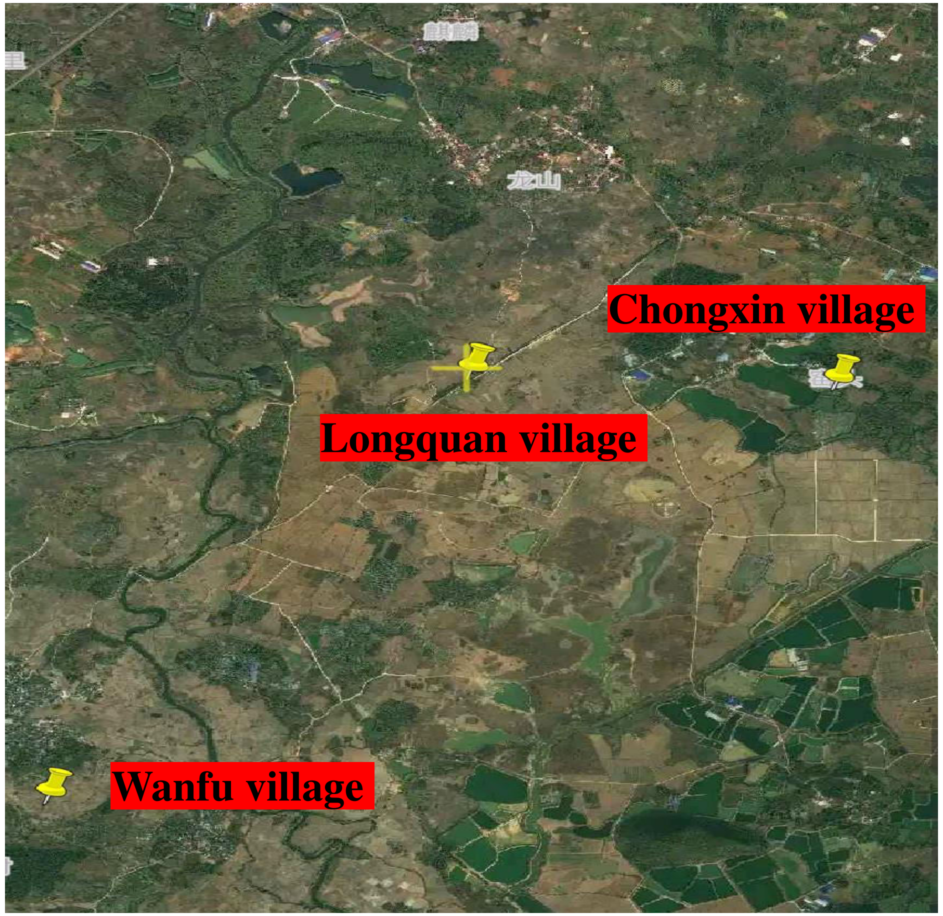
Spatial distribution:

Higher spatial NO_3^- concentrations in agricultural and residential areas may be related to the use of agricultural nitrogen fertilisers and the infiltration of domestic sewage.

4.3 Spatial and temporal distribution of the main pollutants of groundwater quality

- Spatial and temporal distribution of Mn

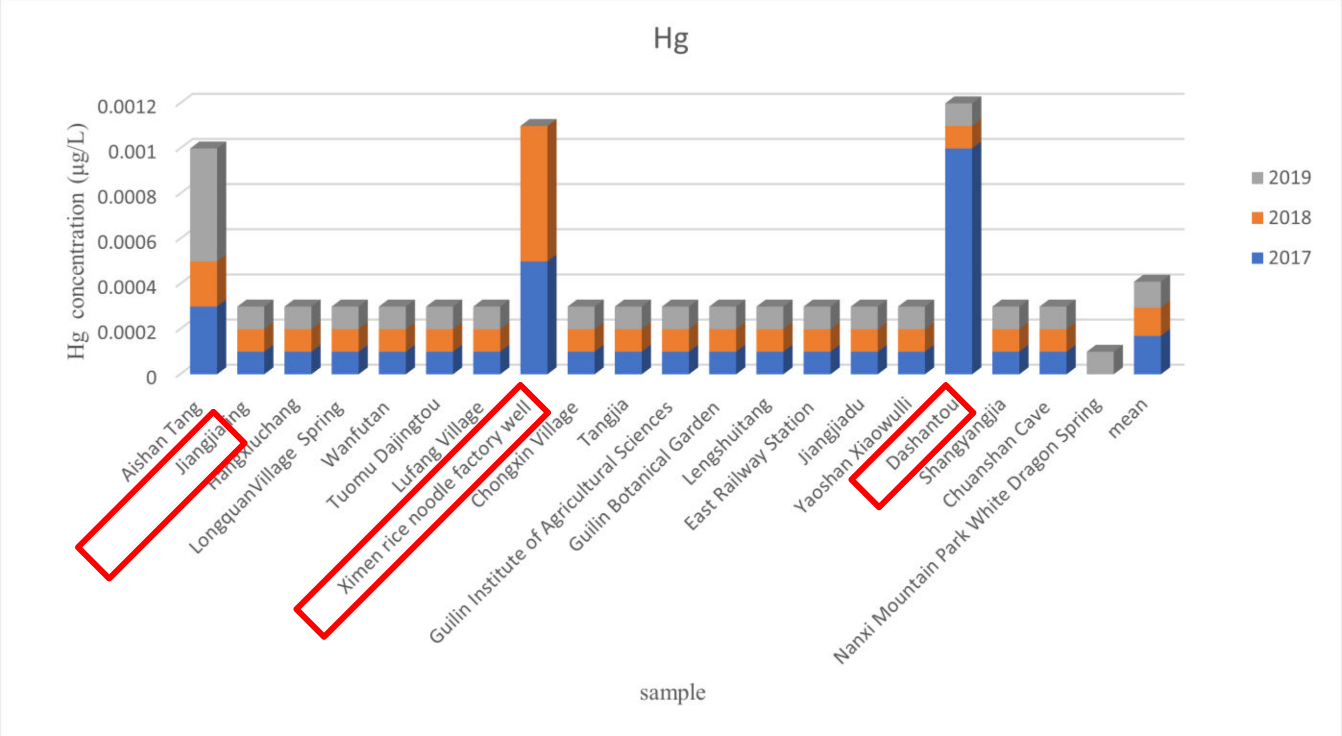


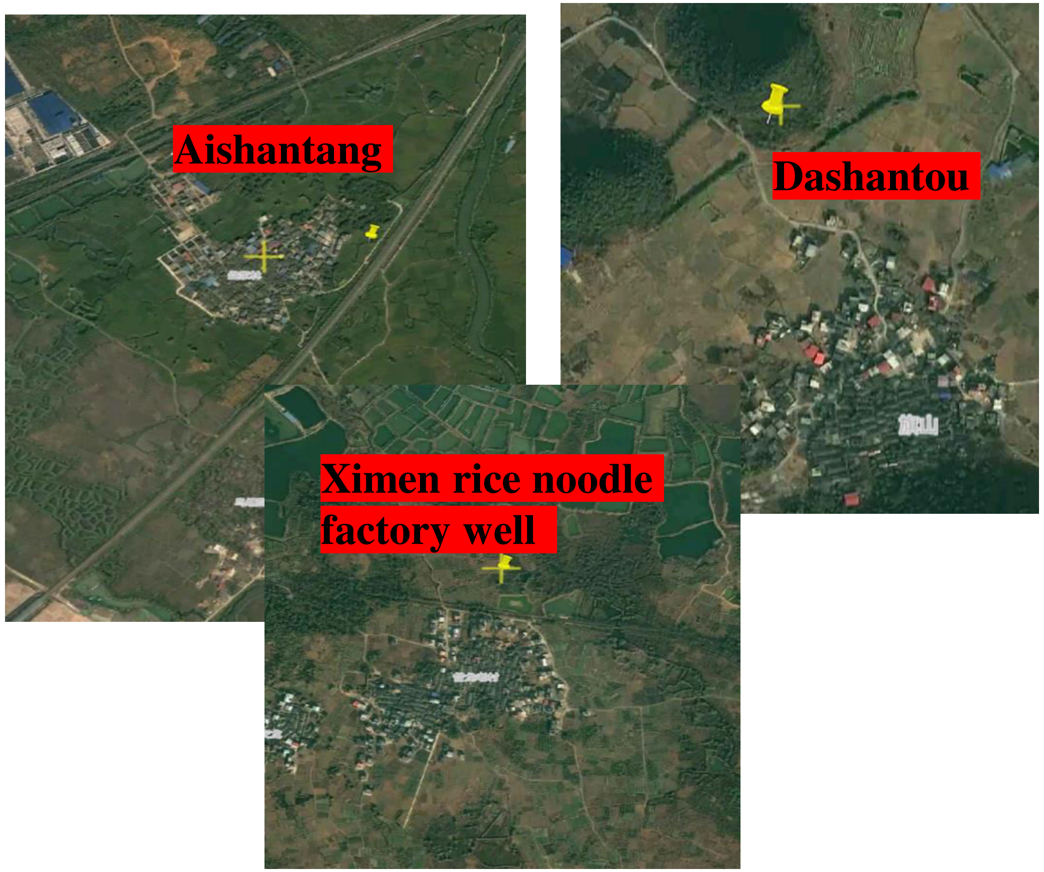


The sampling sites with high concentrations Mn were all near water systems and may have been caused by the discharge of effluents that allowed manganese to enter the groundwater system.

4.3 Spatial and temporal distribution of the main pollutants of groundwater quality

- Spatial and temporal distribution of Hg

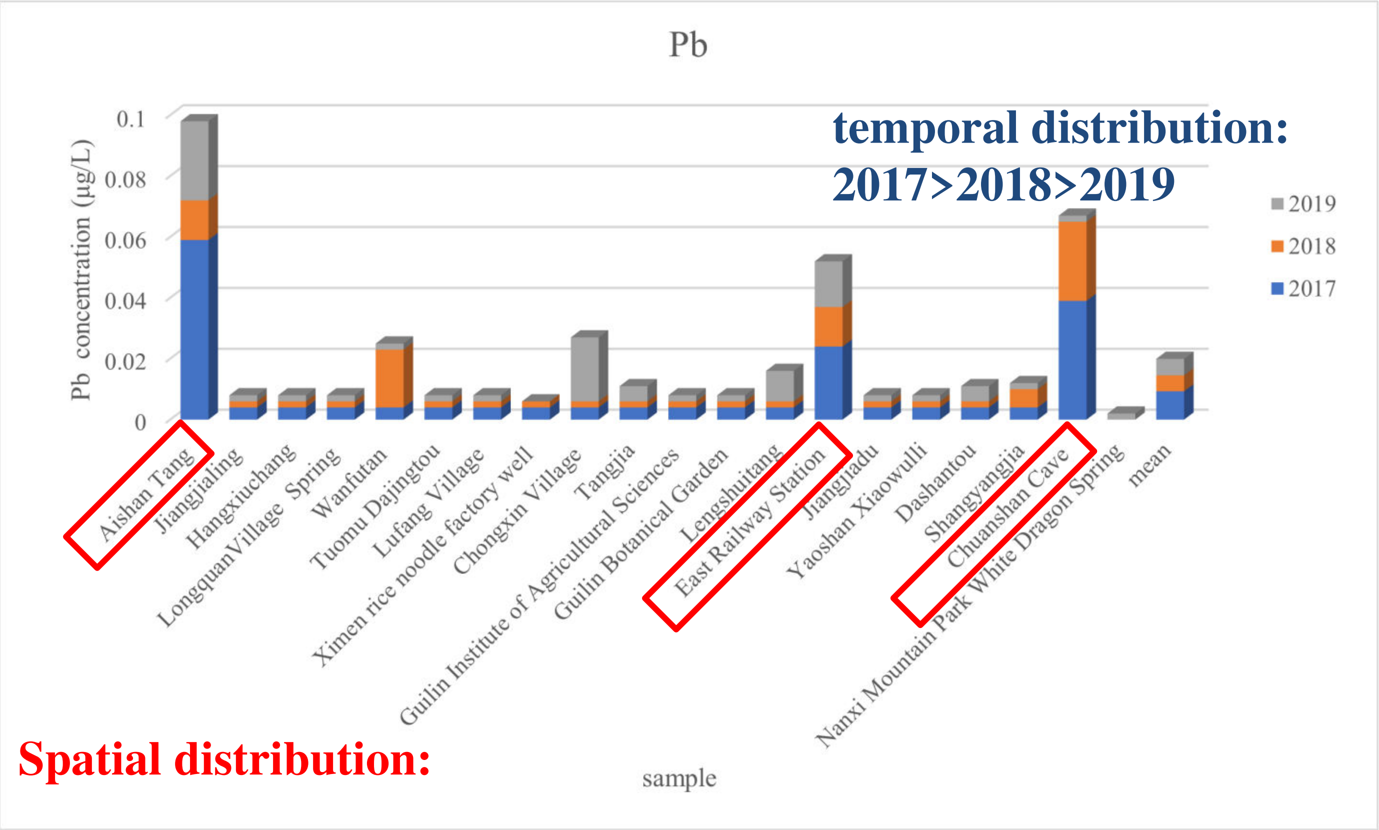


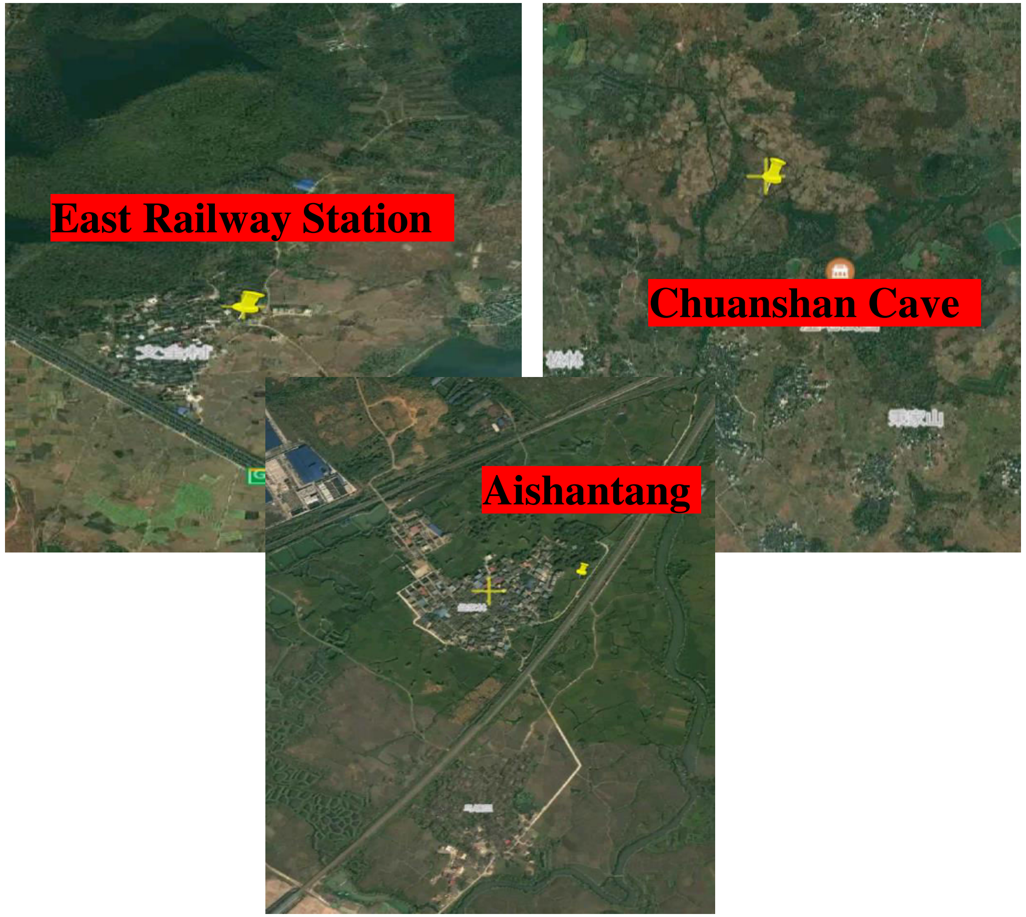


The spatial distribution of Hg is dominated in agricultural land near villages and factories.
The temporal distribution of Hg is more evenly distributed.

4.3 Spatial and temporal distribution of the main pollutants of groundwater quality

- Spatial and temporal distribution of Pb

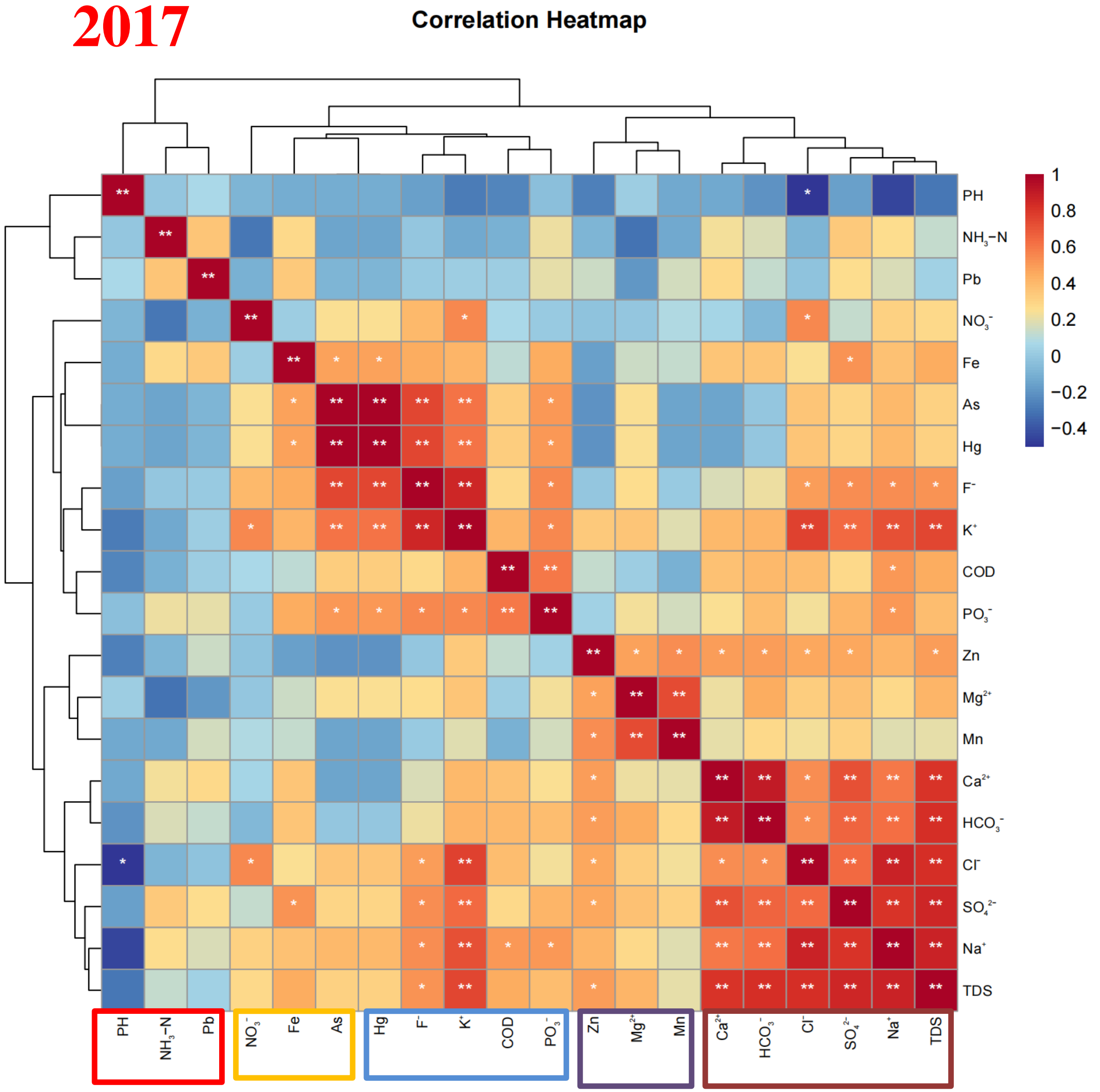




The Pb element is mainly distributed in the population gathering area.

4.3 Spatial and temporal distribution of the main pollutants of groundwater quality

2017



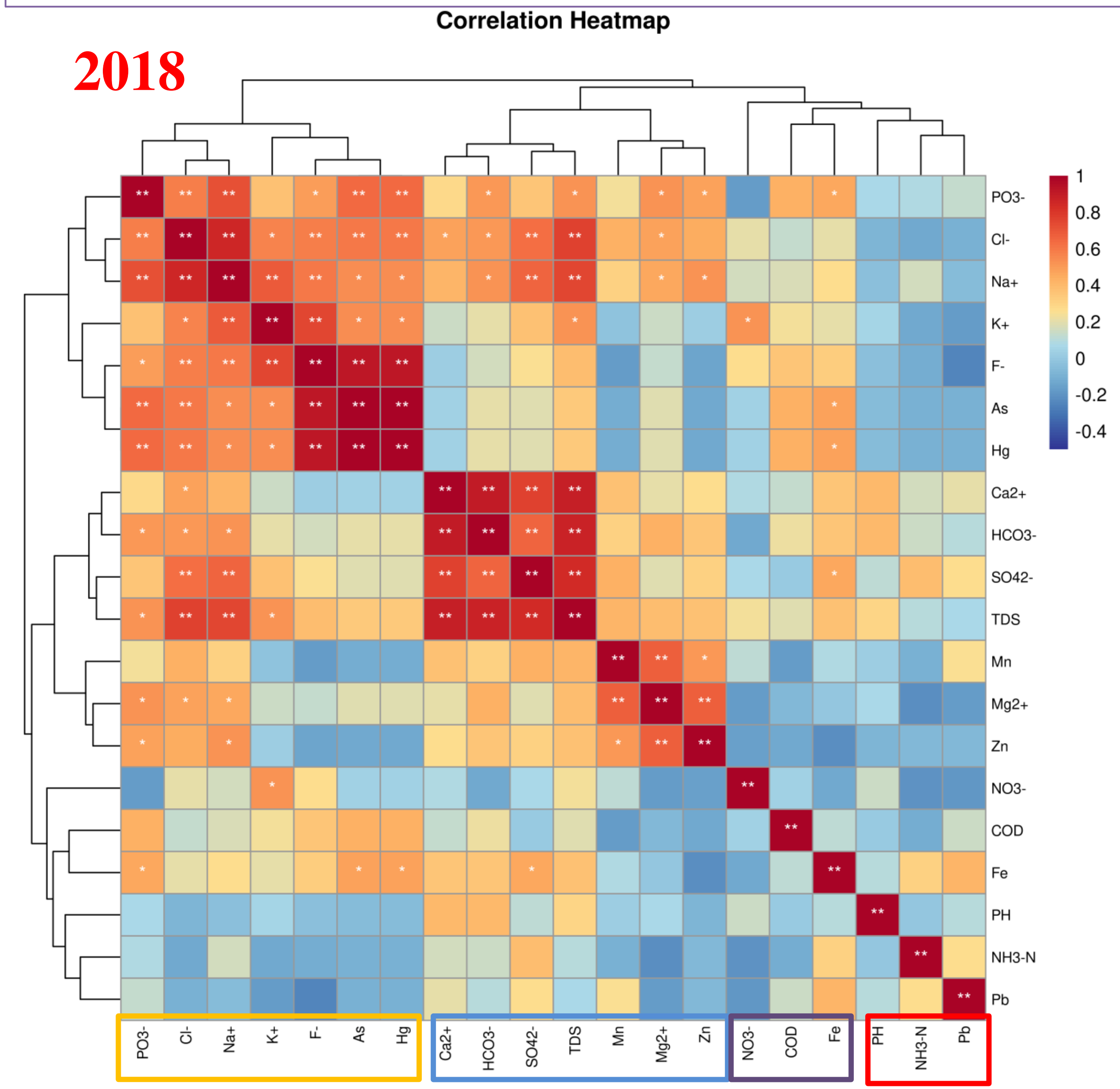
- **Pb** and NH_3-N re located in traffic areas such as railway stations, and studies have shown that automobile exhaust contains Pb, **the source of Pb may be related to dry and wet deposition of automobile exhaust emissions** (Sun, 2014).

- **NO_3^-, Hg,** Fe, As, K^+, and F^- in groundwater are mainly distributed in villages with intensive agricultural activities, and their higher concentrations, **NO_3^- and Hg may originate from agricultural activities** (Zhang, 2015).

- Sampling sites with higher Zn, Mg^{2+}, **Mn** are mostly located near Ximen Rice Noodle Industrial Zone, **Mn is mainly derived from industrial production wastewater** (Zhang et al., 2015).

4.3 Spatial and temporal distribution of the main pollutants of groundwater quality

2018



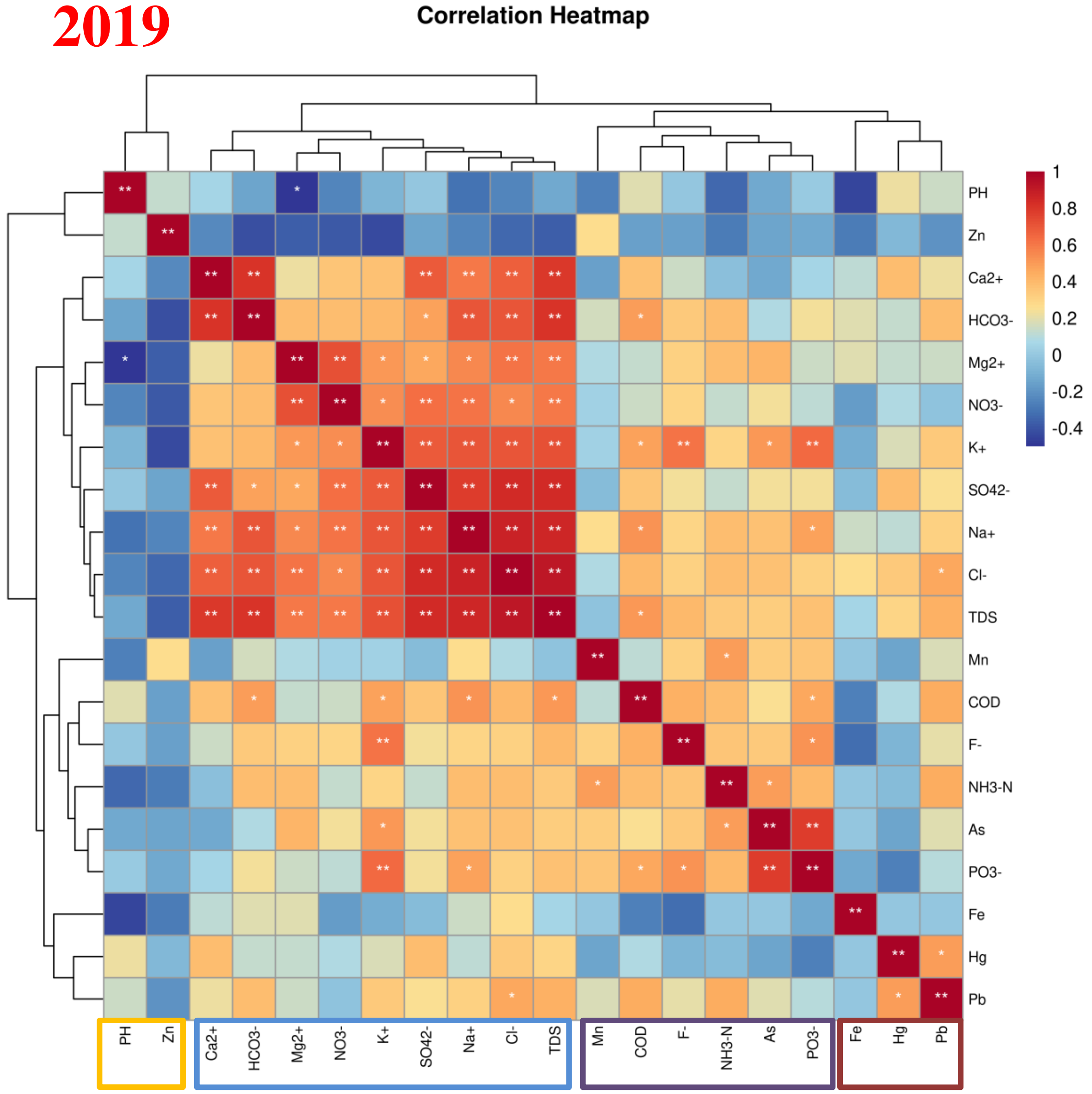
- The correlation between pH, NH_3-N, **Pb** is strong, Pb is a signature element of traffic activities (Cai Limei et al., 2004), mainly from car exhaust, etc., by NH_3-N, Pb is mainly distributed in the areas of high urban traffic, **which may be mainly related to car exhaust and municipal domestic waste.**

- The high correlation between **NO_3^-** , **Hg** and K^+ can be seen in the correlation heat map, then it may be related to the application of potash fertilisers (Zhang et al., 2023), **thus NO_3^- and Hg is mainly of agricultural origin.**

- Groundwater Zn and **Mn** contents are mainly controlled by natural factors, **Mn may be of geological origin (Liao et al., 2004).**

4.3 Spatial and temporal distribution of the main pollutants of groundwater quality

2019



- Compound fertiliser (KNO_3) is a common source of K^+ and **NO_3^-**, suggesting that K^+, Cl^- and KNO_3 are most likely derived from the application of fertilisers from **agricultural activities (Meng, 2020)**.
- The high correlation between **Pb**, **Hg**, Fe and mainly present in villages, could then be related to the landfill of domestic waste such as lead batteries and the application of lead-containing fertilisers (Wang et al., 2022; Zhang et al., 2018), and thus **Pb and Hg could originate from both domestic and agricultural activities.**
- **Mn,** NH_3-N, As, PO_3^- have the highest concentrations near industry, and industrial wastewater may contain Mn and As (Mo, 2010), **Mn mainly originate from industrial.**

5. Summary

Water quality assessment

- The temporal order of pollution is from greatest to least: 2017>2018>2019, with cleaner water quality in 2019.

- Spatially the degree of pollution in the West Zone is worse than the East Zone, this is mainly related to the implementation of the **Environmental protection policy** and the **natural geographical advantages** of the Eastern District.

5. Summary

Identification of major pollutants

By comparing the single factor pollution indices of strongly polluted sampling sites in 2017, 2018 and 2019, the more polluted factors were screened as:

NO_3^-, Mn, Hg, Pb.

Where NO_3^- is the common pollution factor in 2017, 2018 and 2019;

Mn, Hg, Pb are more prominent pollution factors in 2018 and 2019.

5. Summary

Source analysis

Combined with the results of the source analysis of each factor in 2017-2019, there are diverse sources of each factor in the water body.

- NO_3^- and Hg is mainly from agricultural sources.

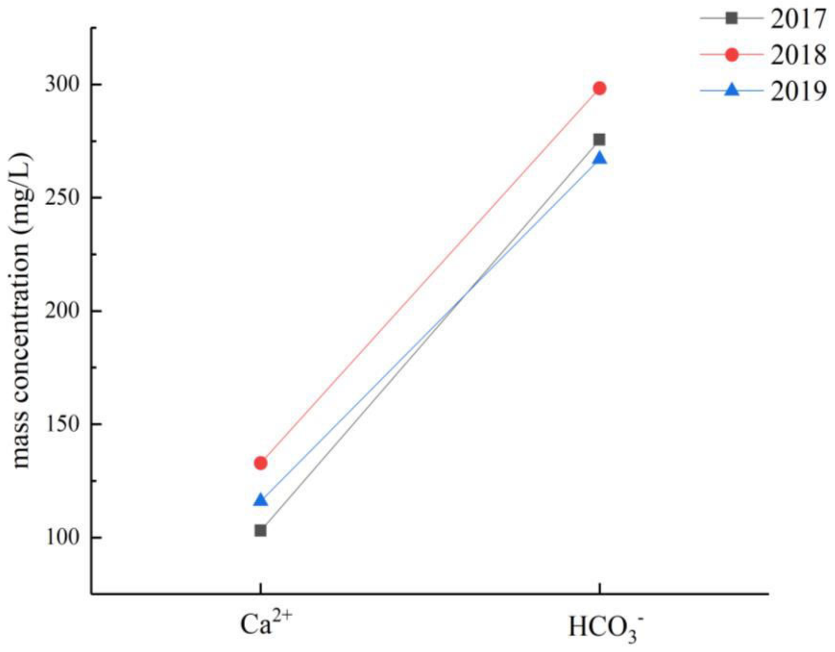
- Pb is mainly from vehicle exhaust, domestic waste and agricultural sources.

5. Summary

Source analysis

- Sources of Mn include geological and anthropogenic sources (industrial wastewater).
- 2018： geological source
- 2017 and 2019： anthropogenic sourcess

The reason for this discrepancy may be due to enhanced weathering of Mn-bearing rocks due to higher rainfall during the 2018 and the dilution effect on industrial and agricultural wastewater making the geological source of Mn dominant.



Stronger water-rock action in 2018

Thanks!