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# Modelling of redox conditions in the shallow groundwater: A case study of agricultural areas in the Poyang Lake basin, China

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**Abstract**

Various natural and anthropogenic factors affect the formation of the groundwater chemical composition and geochemical conditions in agricultural areas. However, it is often difficult to evaluate the role of individual factors in these processes. The article is focused on the research of the alteration of redox conditions in the shallow groundwater of the Poyang Lake basin under the influence of agricultural activity with help of thermodynamic modelling. The thermodynamic modelling and field observations demonstrate that the reducing conditions result from joint effects of anthropogenic factors, organic or $NH_4$–fertiliser usage, and proper natural conditions, such as low-level topography, which, in its turn, leads to the decrease in water exchange rate. The modelling also denotes that fertiliser usage may result in the clay minerals formation at lower concentrations of main clay-forming components in aqueous solution than the ones under natural conditions.



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*Keywords:* reducing conditions; ammonium pollution; atmosphere–water–rock–fertiliser interaction; $(NH_2)_2CO$; Jiangxi Province.

## 1. Introduction

The Poyang Lake basin is a typical agricultural region located in Jiangxi Province, south-eastern China. The shallow groundwater in the study area is characterised primarily by oxidizing conditions with Eh>100 mV. However, locally redox potential diminishes below 100 mV sometimes taking negative values. The crucial consequence of the decrease of redox potential is a shift in a balance of nitrogen species in the shallow groundwater of the study area, specifically the accumulation of more toxic reduced form, ammonium ion[1]. Nature of alteration in redox conditions in the groundwater of the study area is obscure because the formation of groundwater chemical

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composition and geochemical conditions in such agricultural areas is determined by complex influence of natural and anthropogenic factors[2]. The most probable cause of the redox potential changing in the Poyang Lake basin is the use of fertiliser.

The variety of affecting factors often makes it difficult to evaluate contribution of individual factors to the formation of geochemical conditions. One of the effective tools for this purpose is thermodynamic modelling. The current article is focused on the research of the alteration of redox conditions under influence of fertiliser usage with help of the thermodynamic modelling of atmosphere–water–rock–fertiliser interaction.

## 2. Environmental settings

The shallow groundwater with low Eh values (below 100 mV) occurs mainly in lower reaches of the Ganjiang River which feeds Poyang Lake (Fig. 1). This area is characterised by widespread of alluvial plains and the lowest absolute altitudes within Poyang Lake basin, which determine periodical flooding and may result in the decrease of water exchange rate. Table 1 presents the chemical composition of the shallow groundwater with the lowest Eh values, where geochemical conditions become reducing. This groundwater is primarily neutral; the average TDS value is 200 mg/L. The decrease of redox potential results in the accumulation of reduced species in the groundwater. The mean content of $NH_4^+$ in this specific groundwater, 1.16 mg/L, exceeds background level for the groundwater of the Poyang Lake basin, which amounts 0.1 mg/L.

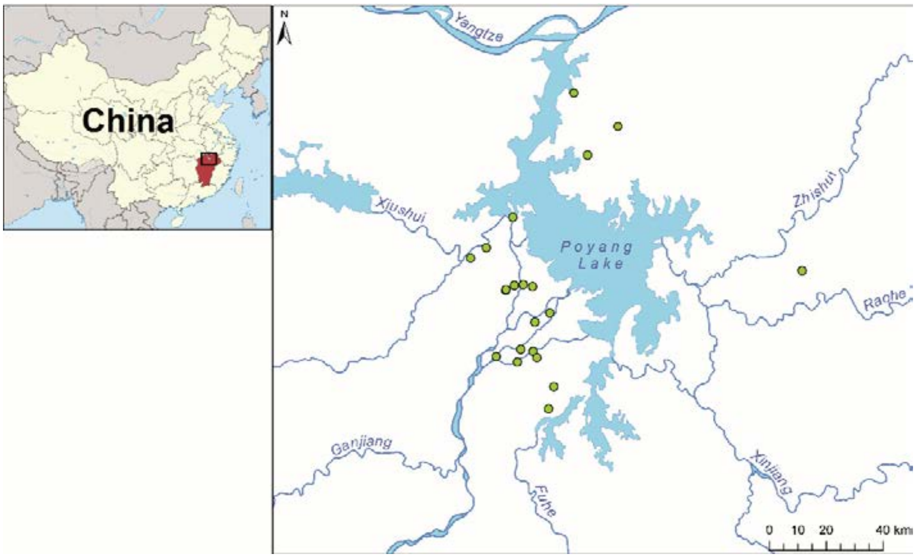


Fig. 1. Location of the sampling points of the groundwater with Eh<100 mV in the Poyang Lake basin

Table 1. Chemical composition of the shallow groundwater with reducing conditions, mg/L, Eh – mV

| Component | Sampling point | | | | Component | Sampling point | | | |
|---|---|---|---|---|---|---|---|---|---|
| | P2 | P14 | P15 | P16 | | P2 | P14 | P15 | P16 |
| pH | 6.3 | 6.4 | 6.5 | 7.05 | $Ca^{2+}$ | 15.2 | 26.2 | 10.3 | 21.8 |
| Eh | -73 | -68 | -78 | -91 | $Mg^{2+}$ | 5.09 | 4.95 | 2.86 | 7.58 |
| $HCO_3^-$ | 100 | 165 | 54.9 | 146 | $Na^+$ | 8.75 | 8.36 | 10.7 | 8.3 |
| $SO_4^{2-}$ | 0.67 | 0.75 | 6.1 | 0.94 | $K^+$ | 1.54 | 1.32 | 4.43 | 1.65 |
| $Cl^-$ | 17.3 | 1.67 | 16.6 | 3.7 | $NH_4^+$ | 2.9 | 3.4 | 1.95 | 6.4 |
| $NO_2^-$ | <0.02 | <0.02 | <0.02 | <0.02 | $SiO_2$ | 41.2 | 24.2 | 37.2 | 22.6 |
| $NO_3^-$ | 0.22 | 0.22 | 0.2 | 0.24 | TDS | 190 | 232 | 143 | 213 |