# Final Report

on

Research on the Distribution of Soil Chemistry and Fe Dynamics in Sanjian Plain for 2006

by

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# 1. Main contents and accomplishment of our work in these three years

In 2005, soil sampling was made for marshy soil with different reclamation histories and different land use, which addresses seven regions with duplicate samplings per each region in Sanjiang plain. The total number of sampling sites was 14, 7 regions times 2 sites.

The samples were collected vertically from surface to a depth of 1.2 meters with soil coring kit for soil chemical analysis. The soil profile was divided into 6 layers, i.e., 10-20 cm, 20-40 cm, 40-60 cm, 60-90 cm, and 90-120 cm. The total number of soil samples is 84, 14 sampling sites times 6 layers.

In 2006, soil samples were collected from marsh soil and albic soil at several locations between Naoli River and Nonjiang River, including four land covers, *i.e.*, natural wetland, paddy field, upland field, and forest. The sampling was carried out in duplicate per each location with soil coring kit, and the total number of sampling sites was 32.

Soil samples were collected vertically from surface to a depth of 1.2 meters. The soil profile was divided into 7 layers, *i.e.*, 0-10cm, 10-20 cm, 20-30 cm, 30-40 cm, 40-60 cm, 60-90 cm and 90-120 cm, and the total number of soil samples was 224.

In this year, some items such as $Fe_s$ (alumino-silicate iron), $Fe_c$ (crystal iron oxide), $Fe_o$ (amorphous iron oxides), the ratio $Fe_d/Fe_t$ (often termed the 'weathering ratio'), the ratio $Fe_o/Fe_d$ (often termed the 'active ratio'), $Fe_p/Fe_d$ (often termed the 'chelate ratio'), the ratio $SiO_2/Al_2O_3$ (often termed the 'Sa or Ki value') of soil samples both in 2005 and 2006 were determined. In addition, some items such as $Fe_t$ (total iron), $Fe_d$ (free iron oxide iron), $Fe_p$ (chelate iron), OC *et al*. were analyzed renewedly.

In this report, effects of land use change on the distribution, mobility and activation of soil iron in Sanjiang Plain were discussed.

# 2. Analytical items and methods

## 2.1 Analytical items and methods, and soil treatments

The soils from each core were loosely disaggregated, air-dried at room temperature, and passed through 2 mm mesh sieve and through 0.25 mm mesh respectively.

**Table1: Analytical items and pretreatment, and determination**

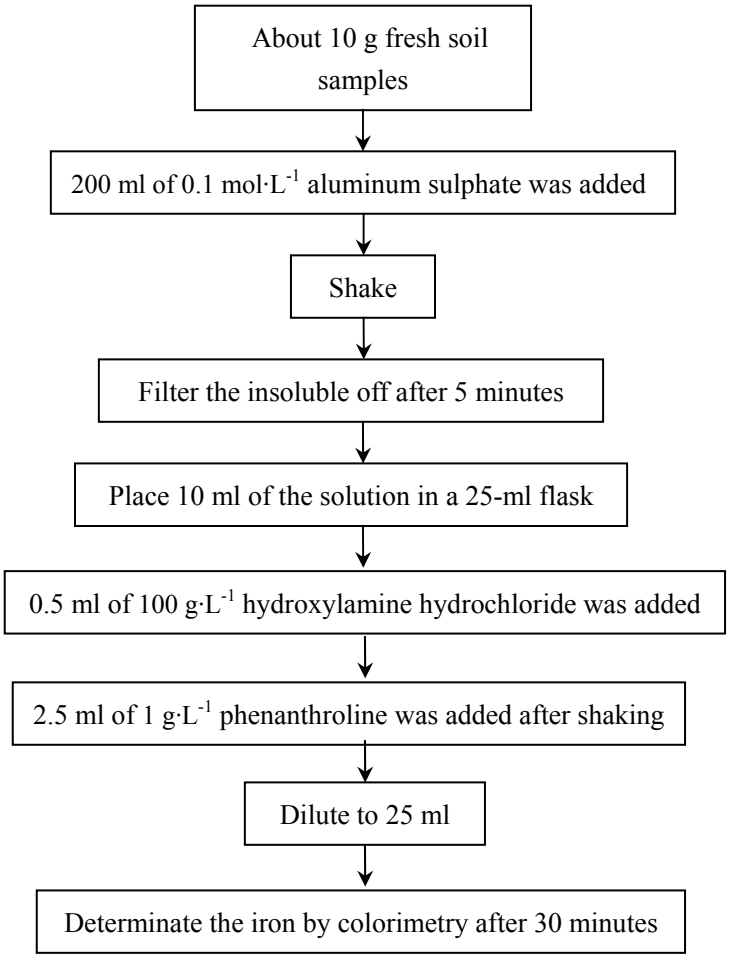
| No. | Analytical items | pretreatment | determination |
|---|---|---|---|
| 1 | Total iron | Drying, sieving, Sodium carbonate fusion | Flame atomic absorption spectrophotometry |
| 2 | Free iron oxides | Drying, sieving, Sodium hydrosulfite – Sodium citrate – Sodium bicarbonate extraction method (DCB) | Determinate the iron by colorimetry |
| 3 | Amorphous iron oxides | Drying, sieving, Acid ammonium oxalate extraction method (AAO) | Determinate the iron by colorimetry |
| 4 | Chelate iron | Drying, sieving Sodium pyrophosphate extraction method | Determinate the iron by colorimetry |
| 5 | Fe (II) | Fresh | Phenanthroline colorimetry |
| 6 | $SO_4^{2-}$ | Air-dry, sieving | EDTA indirect titrimetric method |
| 7 | Mn | Drying, sieving Sodium carbonate fusion | Flame atomic absorption spectrophotometry |
| 8 | Al | Drying, sieving Sodium carbonate fusion －Potassium fluoride substitution | EDTA volumetric method |
| 9 | Si | Drying, sieving Sodium carbonate fusion | Mass metrical method |
| 10 | OC (Organic carbon) | Drying, sieving | Determined directly on the TOC autoanalyzer |
| 11 | pH ($H_2O$) | Air-dry, sieving | Potentiometric method |
| 12 | Moisture content （%） | Drying, sieving | Mass metrical method |

# 2. Analytical items and methods

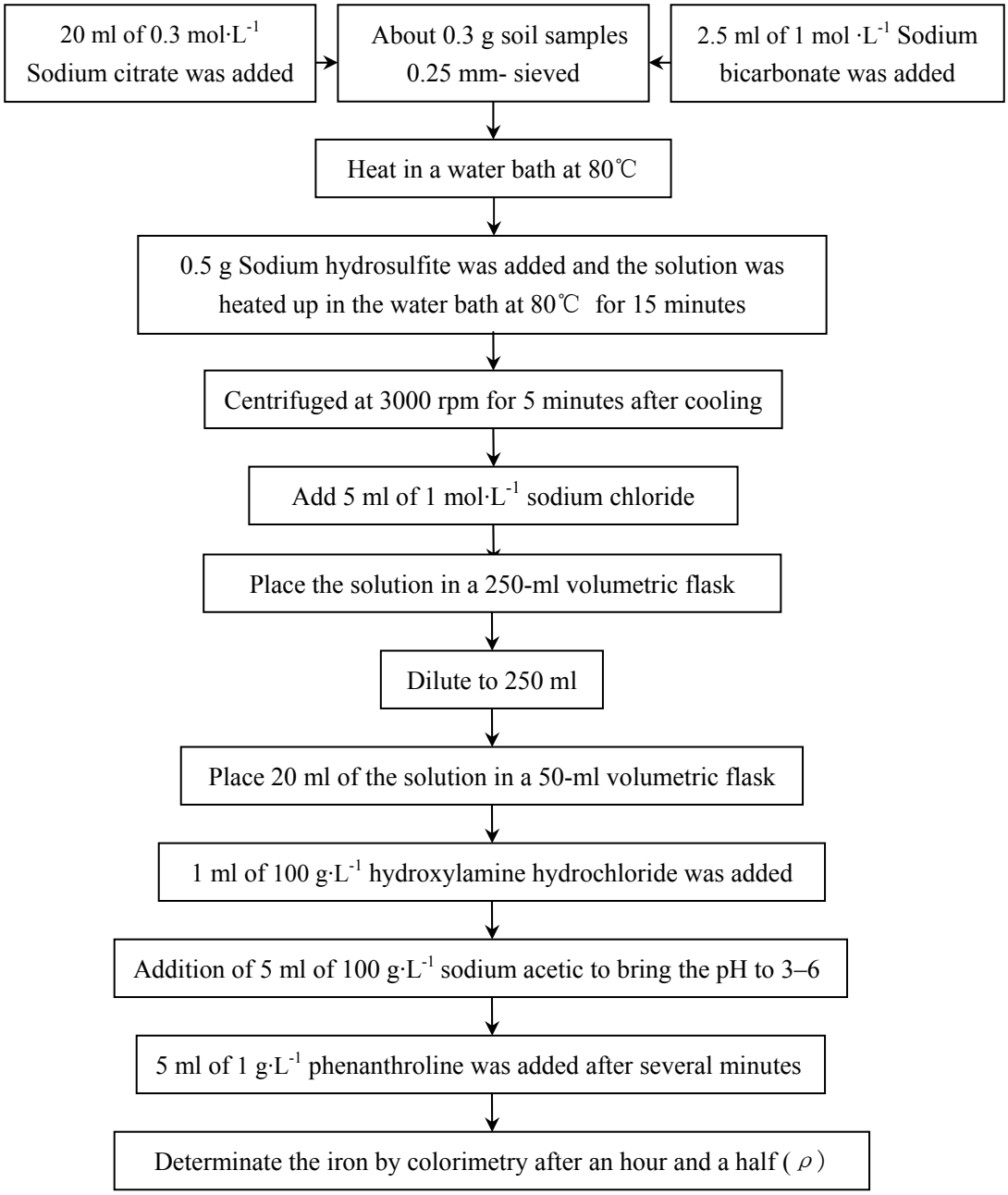
## 2.1 Analytical methods for each item in detail

### 1. Analytical methods for Fe (II) (Lu, 1998)

**Analytical methods for (II)**



## 2. Analytical methods for free iron oxides (Mehra and Jackson, 1960)

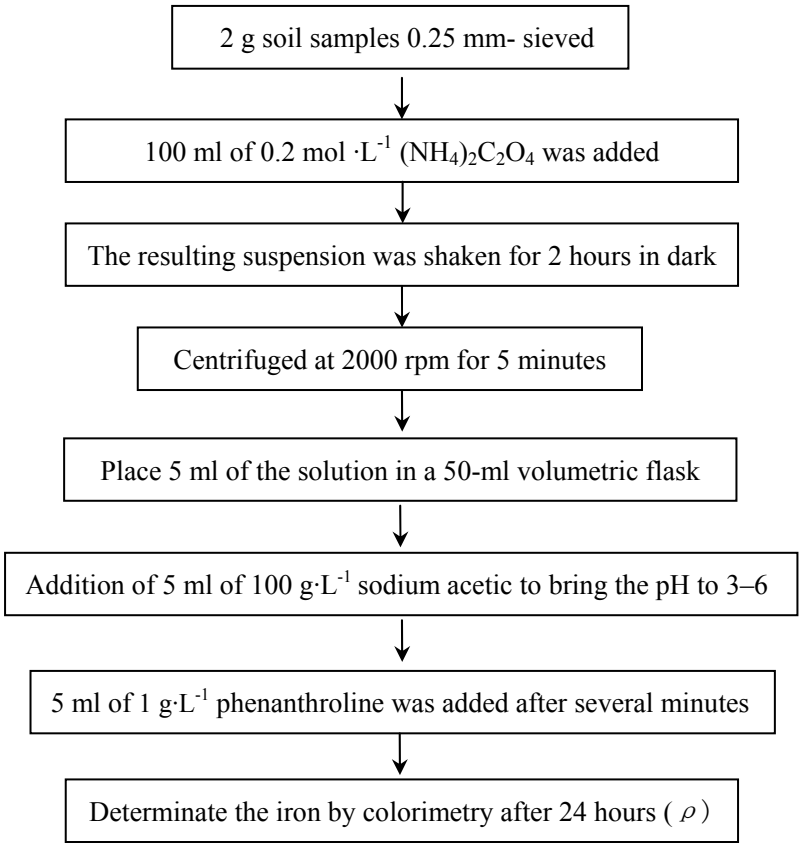



$$\omega(Fe_2O_3)=\frac{\rho \times 50 \times 12.5 \times 1.43}{m}$$

Thereinto: $\omega(Fe_2O_3)$: Content of $Fe_2O_3$ in soil, mg $kg^{-1}$;

$m$: Mass of air-drying soil, g.

## 3. Analytical methods for amorphous iron oxides (Schwertmann, 1973)

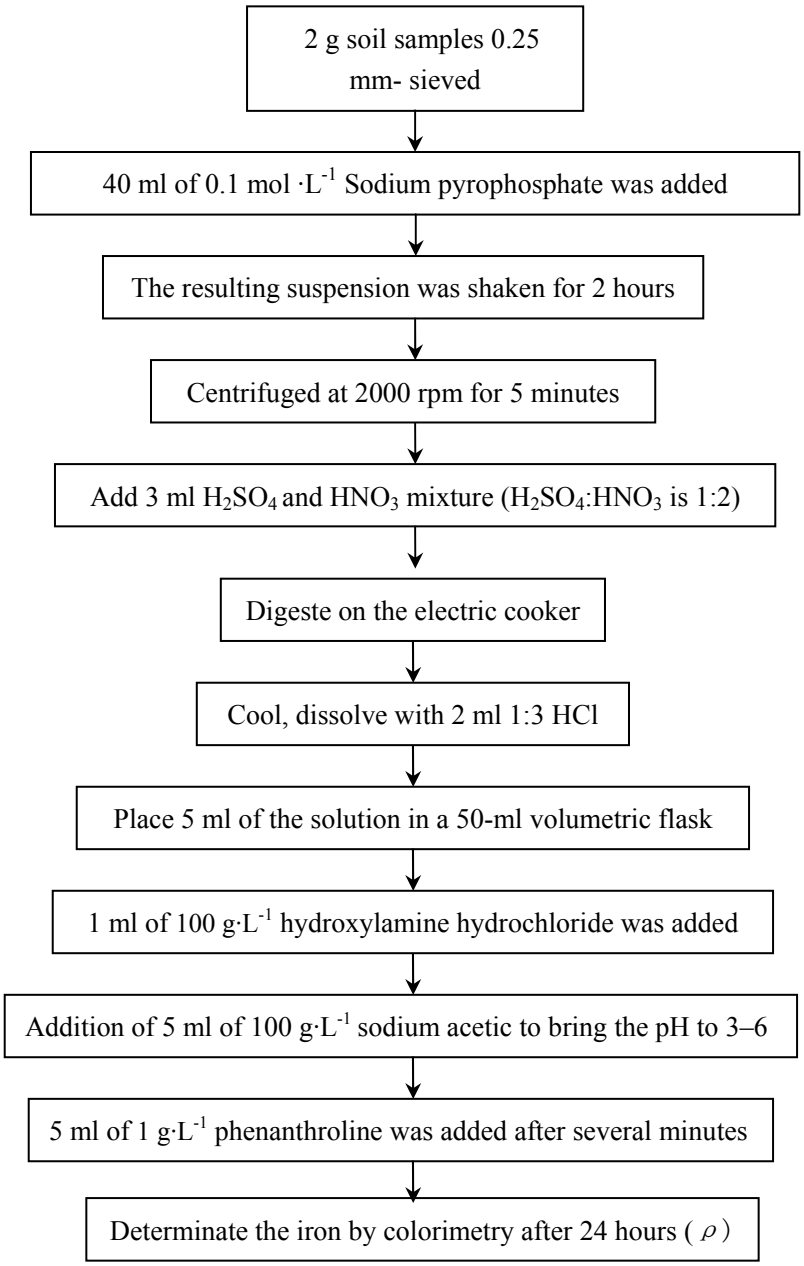



$$\omega(\mathrm{Fe})=\frac{\rho \times 50 \times 10}{m}$$

Thereinto: $\omega$(Fe): Content of amorphous iron oxides in soil, mg $kg^{-1}$;

$m$: Mass of air-drying soil, g.

## 4. Analytical methods for chelate iron (Alexandrova, 1960)

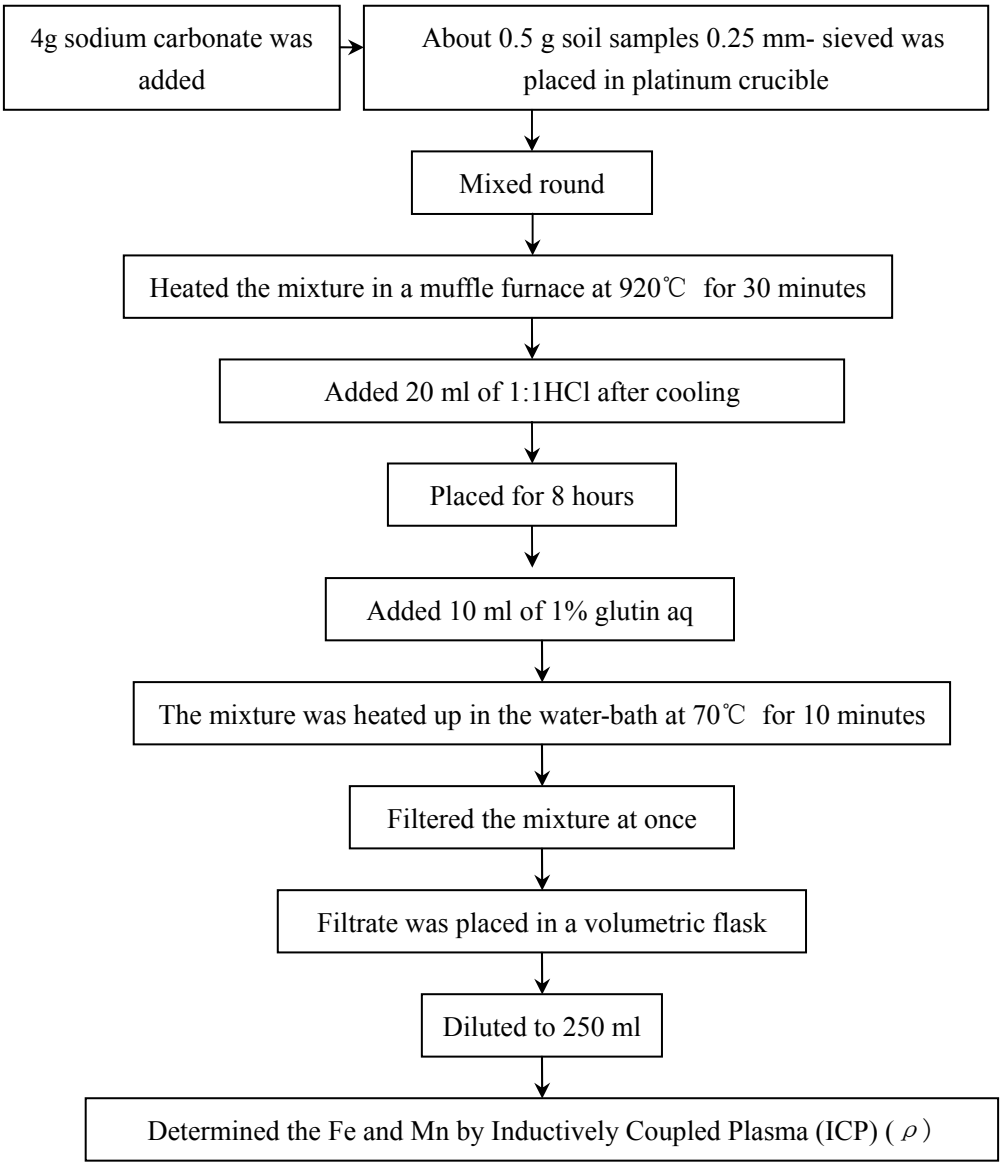



$$\omega(\mathrm{Fe})=\frac{\rho\times 50\times 8}{m}$$

Thereinto: $\omega$(Fe): Content of ferric chelate in soil, mg $kg^{-1}$;

$m$: Mass of air-drying soil, g.

## 5. Analytical methods for Total iron and Mn (Lu, 1998)

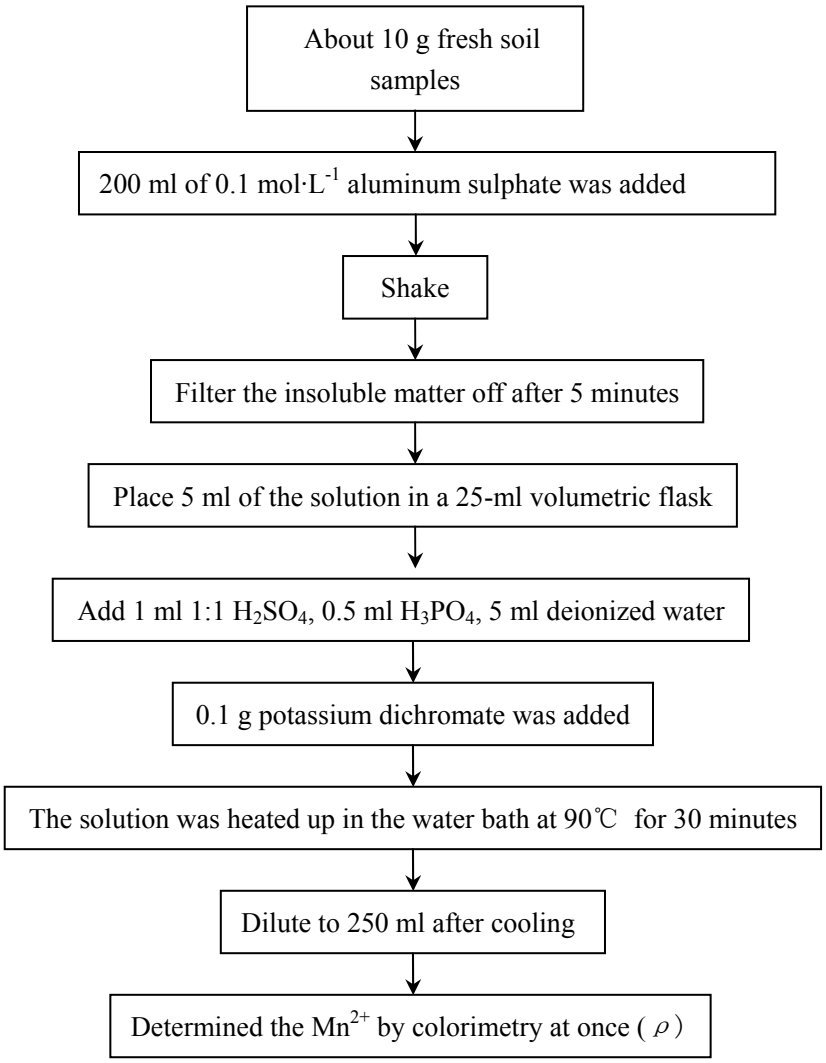



$$\omega(Fe^{2+})=\frac{\rho \times 25 \times 20}{m}$$

Thereinto: $\omega(Fe^{2+})$: Content of $Fe^{2+}$ in soil, mg $kg^{-1}$;

$m$: Mass of oven-drying soil, g.

## 6. Analytical methods for total $Mn^{2+}$ (Lu, 1998)

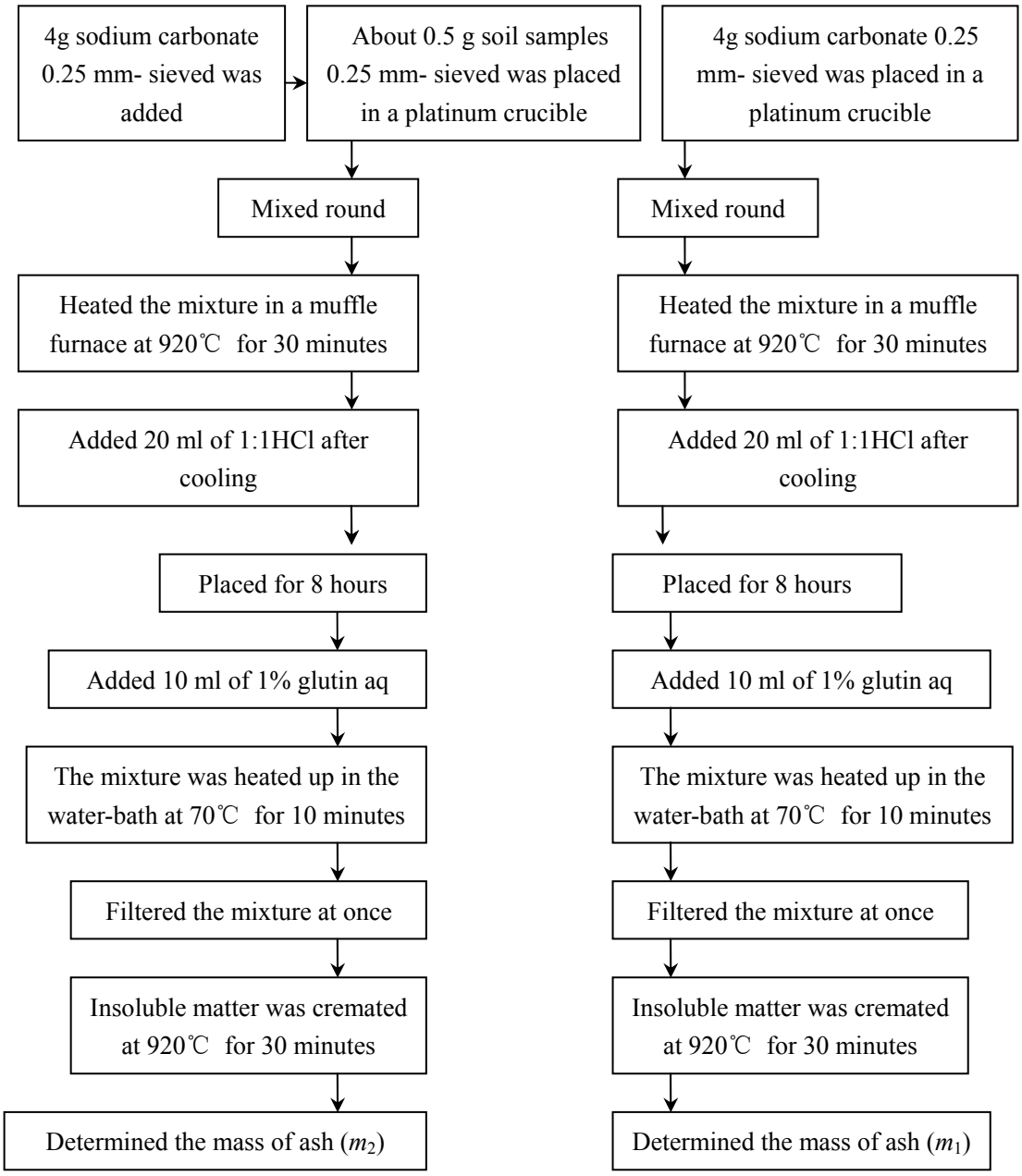



$$\omega(Mn^{2+})=\frac{\rho \times 25 \times 40}{m}$$

Thereinto: $\omega(Mn^{2+})$: Content of $Mn^{2+}$ in soil, mg $kg^{-1}$;

$m$: Mass of oven-drying soil, g.

## 7. Analytical methods for Si (Lu, 1998)

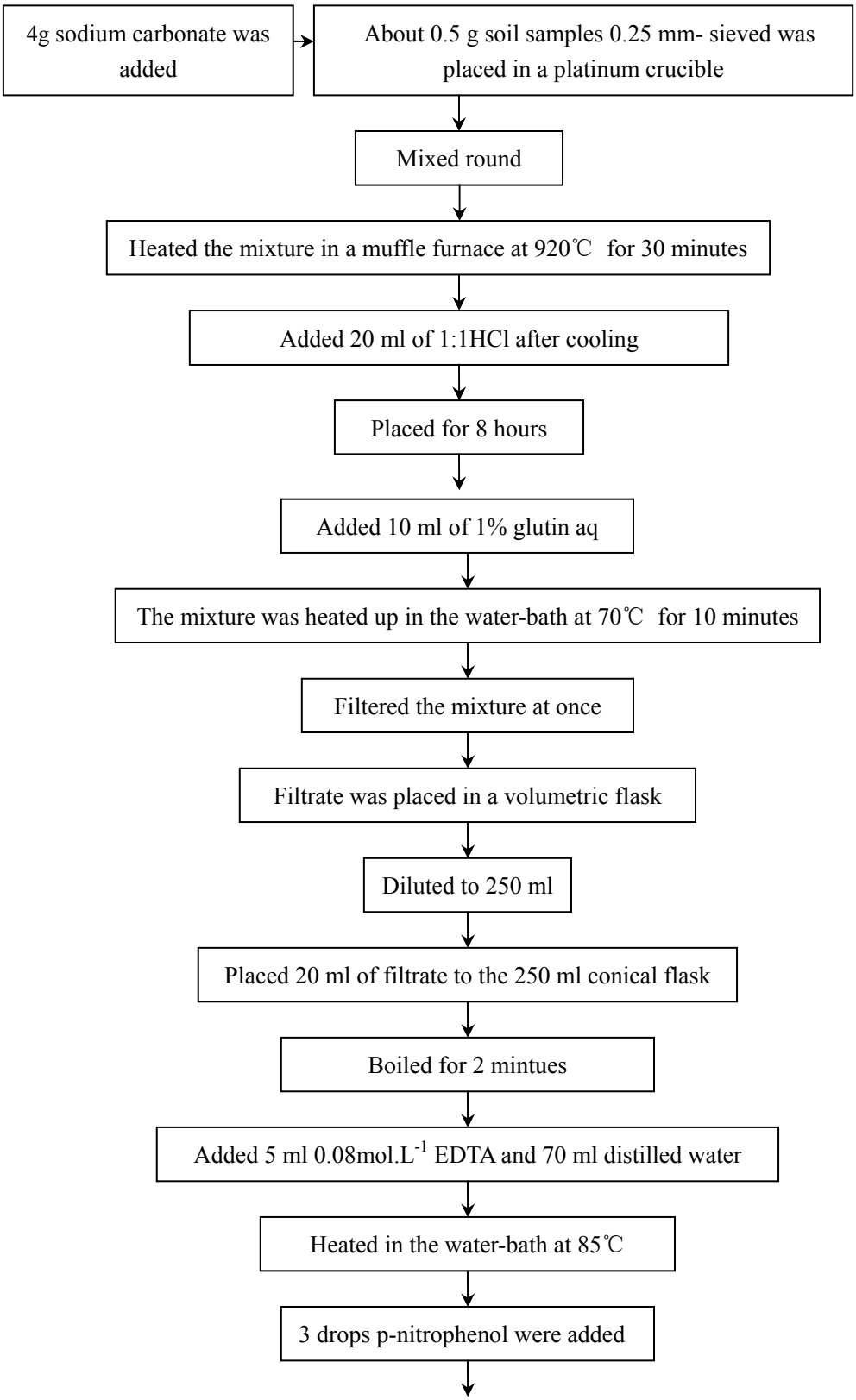


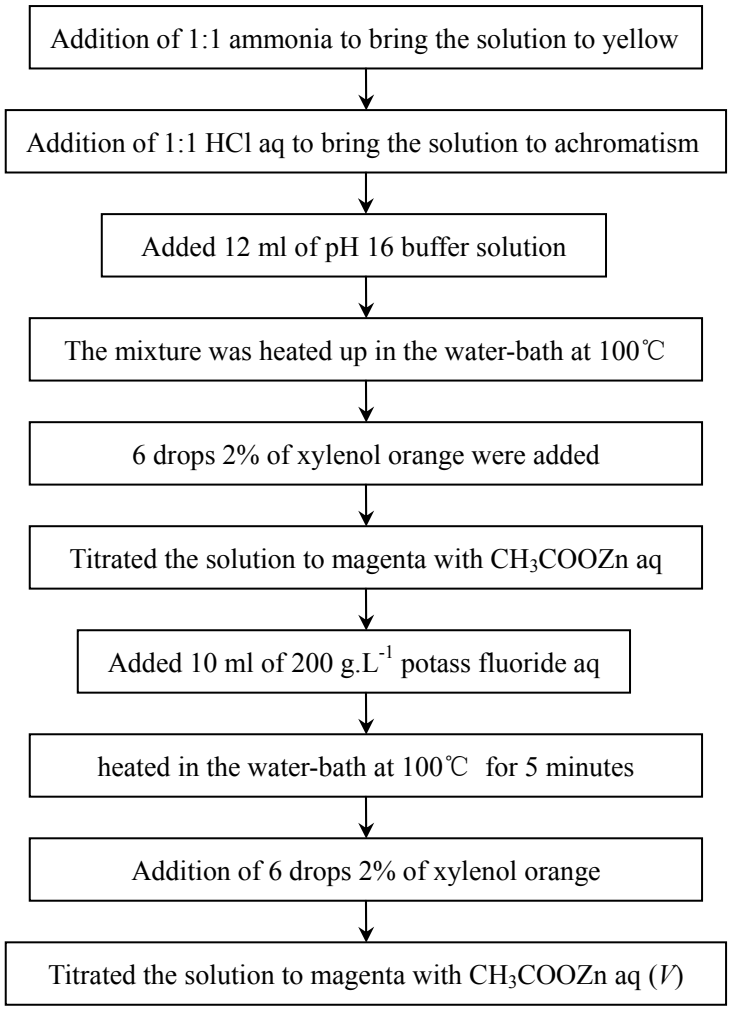

$$\omega(SiO_2)=\frac{m_2-m_1}{m}\times 10$$

Thereinto:$\omega(SiO_2)$: Content of $SiO_2$ in soil, g $kg^{-1}$

$m$: Mass of air-drying soil, g

**8. Analytical methods for the sum of Al and Ti (Lu, 1998)**





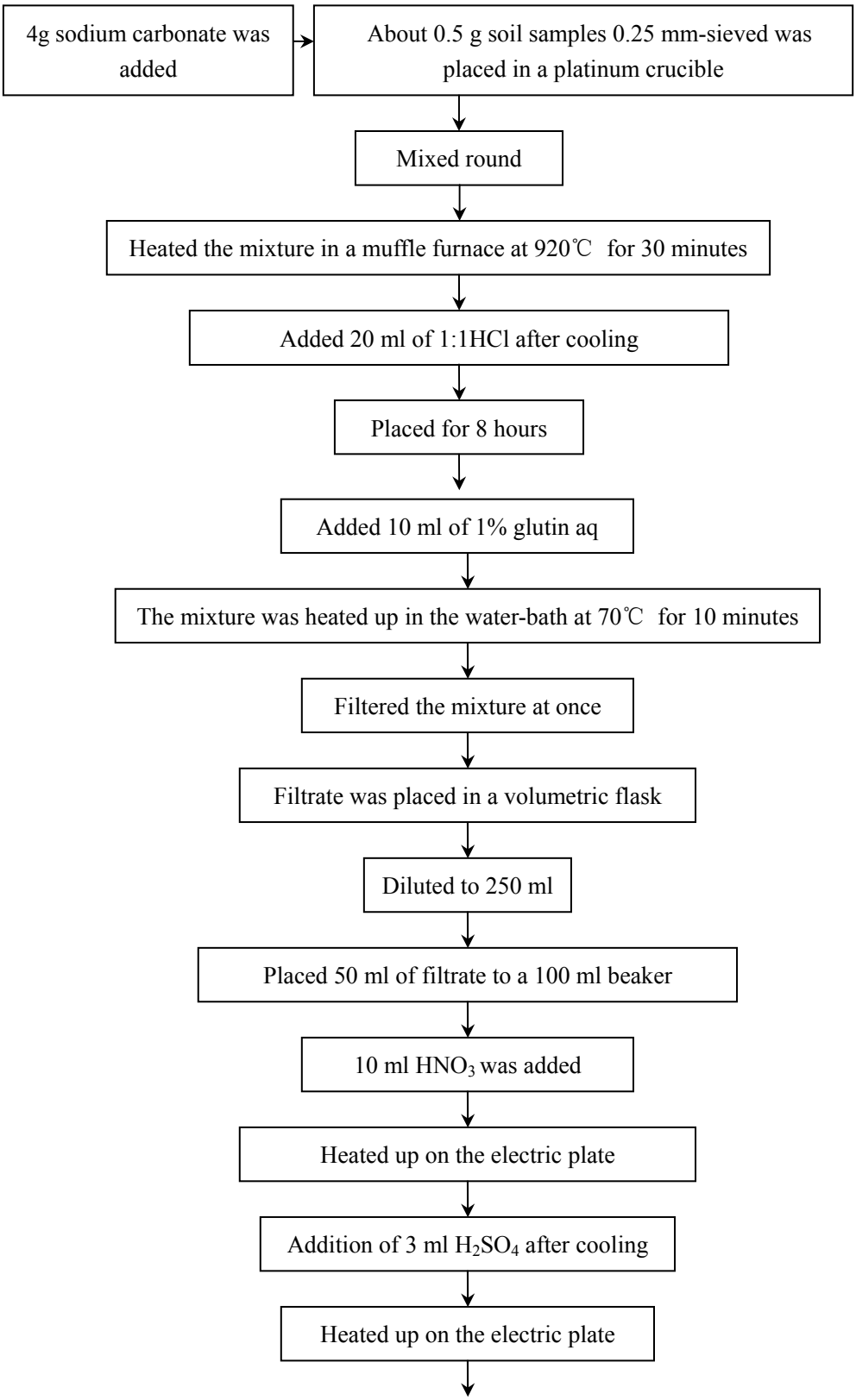

$$\omega(Al_2O_3)=\frac{0.015\times V\times 50.98\times 10^3\times 12.5}{m}\times 100-\omega(TiO_2)\times 0.6381$$

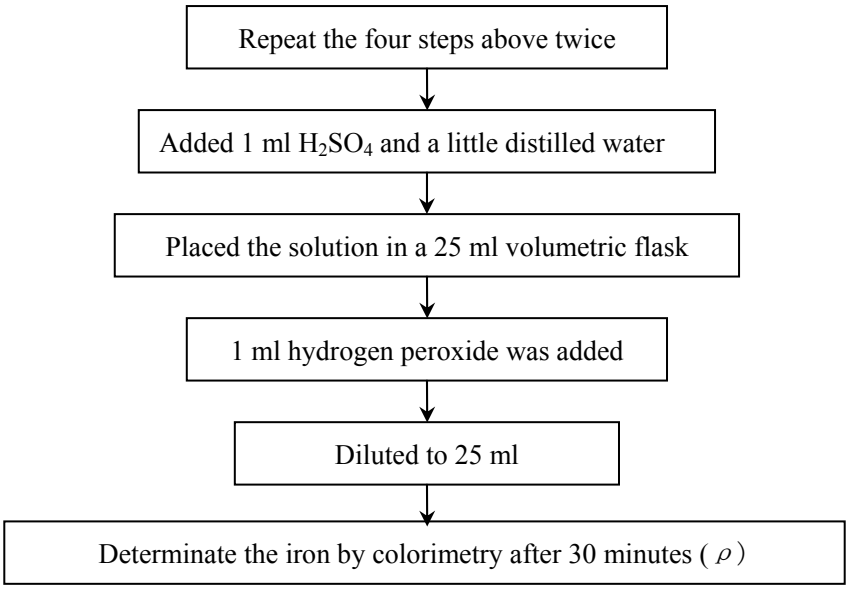
Thereinto: $\omega(Al_2O_3)$: Content of $Al_2O_3$ in soil, %;

$\omega(TiO_2)$: Content of $TiO_2$ in soil, %;

$m$: Mass of air-drying soil, g.

**9. Analytical methods for Ti (Lu, 1998)**



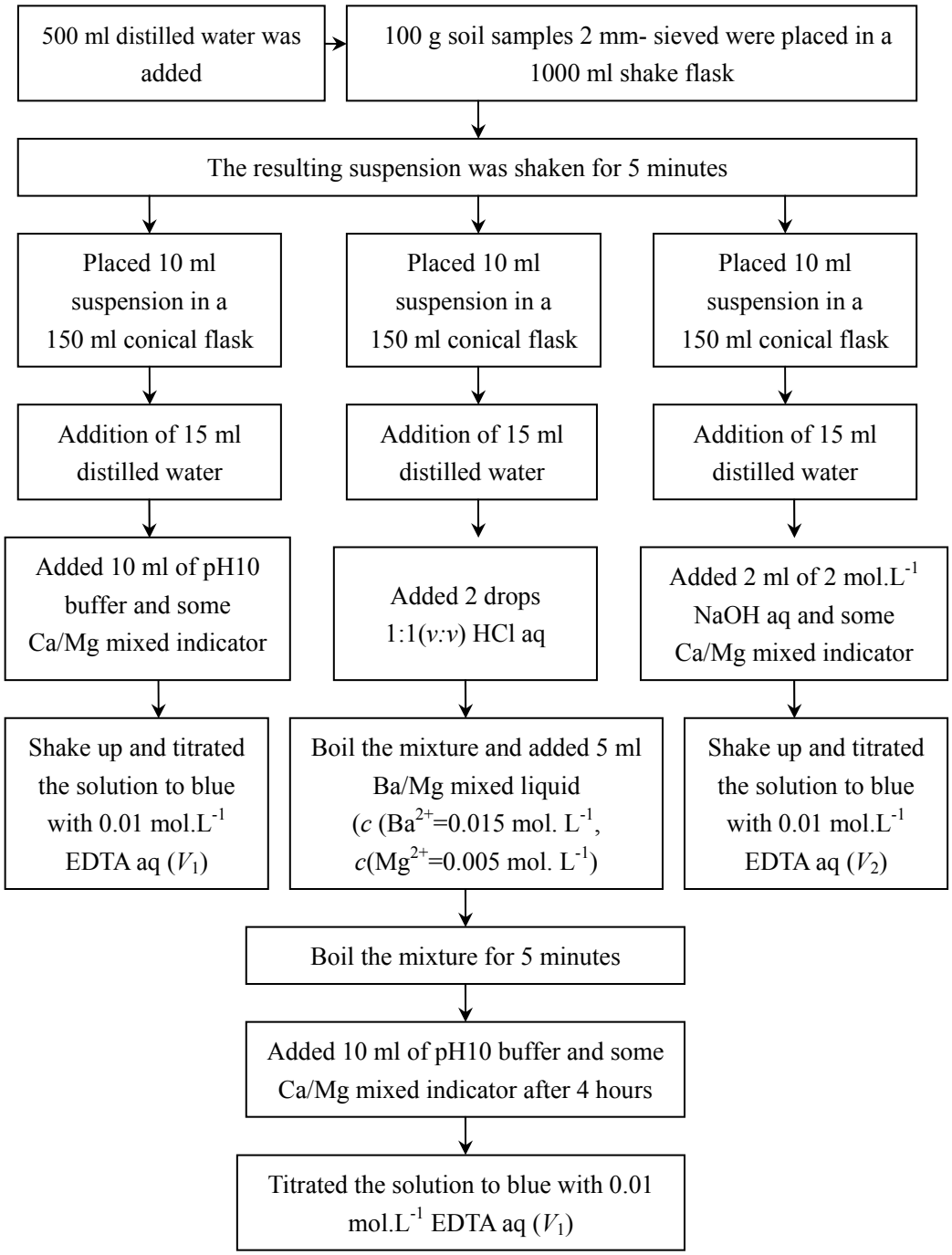



$$\omega(TiO_2)=\frac{\rho \times 25 \times 5}{m \times 10^6} \times 100$$

Thereinto: $\omega(TiO_2)$: Content of $SiO_2$ in soil, %;

$m$: Mass of air-drying soil, g.

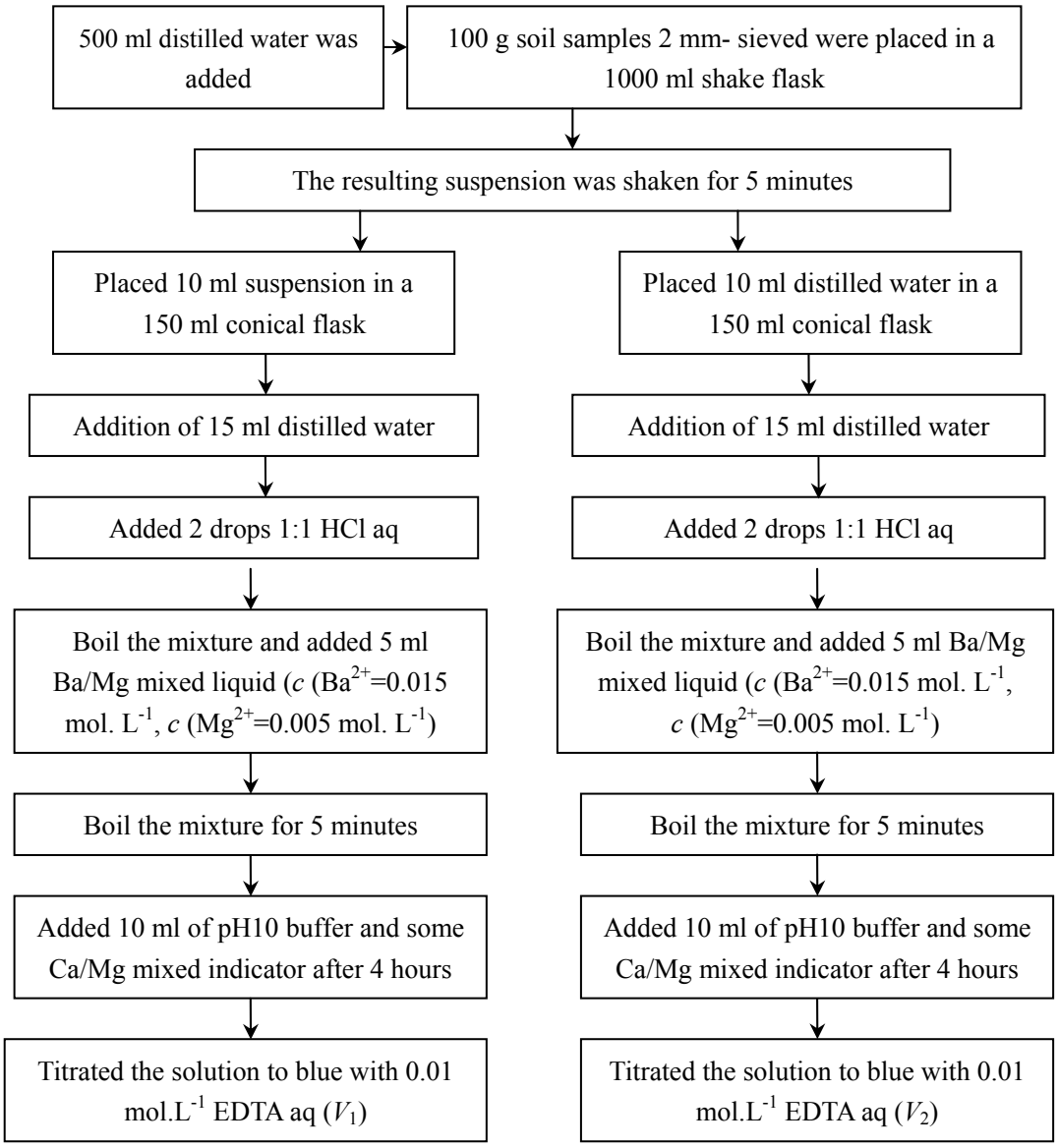
## 10. Analytical methods for $SO_4^{2-}$ (Lu, 1998)




$$\omega(SO_4^{2-})=\frac{[V_0-(V_1-V_2)]\times 0.01\times 0.096}{2}\times 1000$$

Thereinto: $\omega(SO_4^{2-})$: Content of $SO_4^{2-}$ in soil, g $kg^{-1}$

## 11. Analytical methods for $Ca^{2+}$ and $Mg^{2+}$ (Lu, 1998)



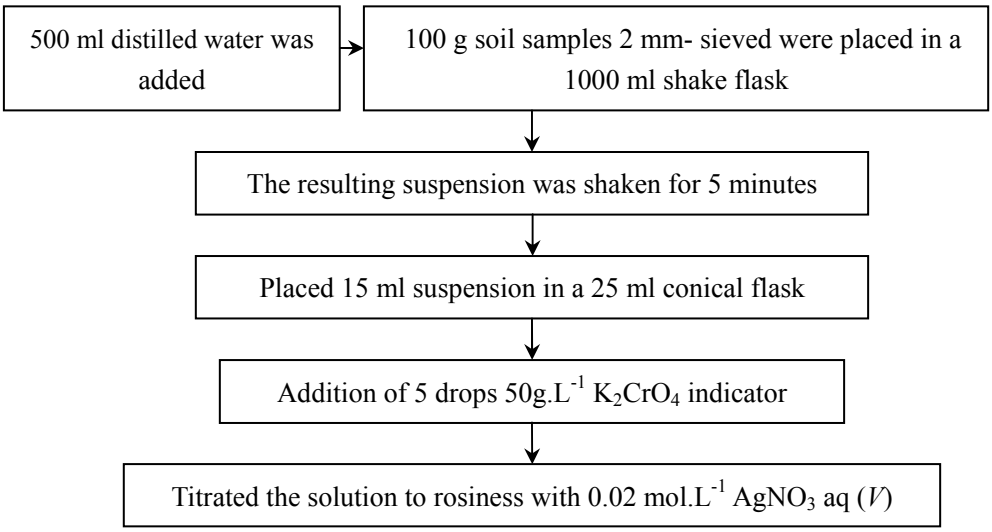

$$\omega(Ca^{2+})=\frac{V_2\times 0.01\times 0.04008}{2}\times 10^6$$

$$\omega(Mg^{2+})=\frac{V_2\times 0.01\times 0.02432}{2}\times 10^6$$

Thereinto: $\omega(Ca^{2+})$: Content of $Ca^{2+}$ in soil, mg $kg^{-1}$

$\omega(Mg^{2+})$: Content of $Mg^{2+}$ in soil, mg $kg^{-1}$

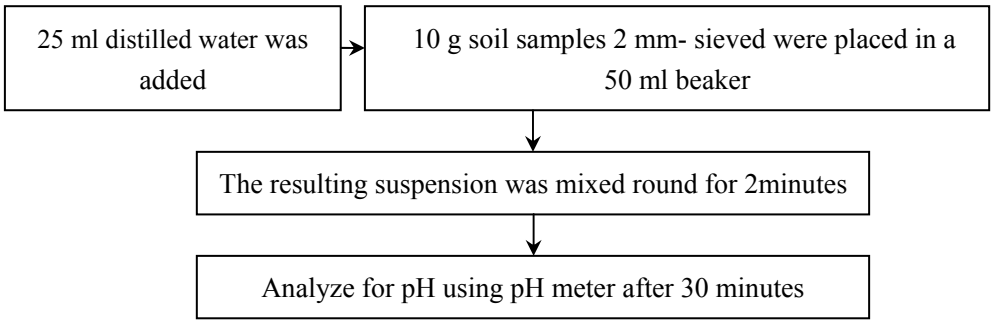
## 12. Analytical methods for $Cl^-$ (Lu, 1998)



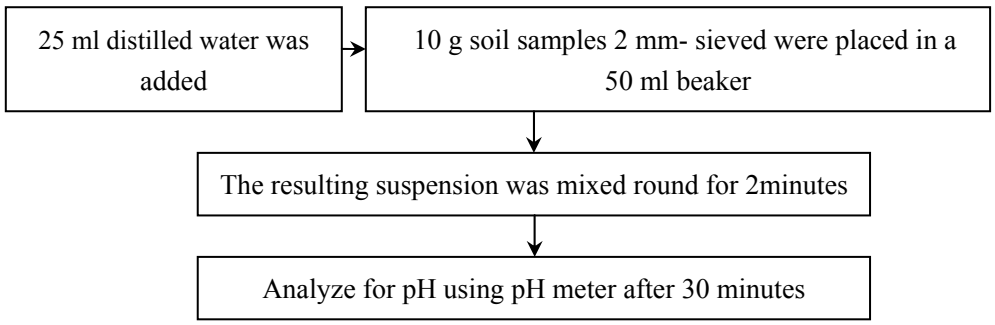

$$\omega(Cl^-)=\frac{V\times 0.02\times 0.0355}{5}\times 10^6$$

$\omega(Cl^-)$: Content of $Cl^-$ in soil, mg $kg^{-1}$

## 13. Analytical methods for pH ($H_2O$) (Lu, 1998)




## 14. Analytical methods for pH (KCl) (Lu, 1998)



# 3. Results and discussion

## 3.1 Effects of land use change on the distribution and mobility of soil iron in Sanjiang Plain

Between two upper reaches of Amur River－Naoli River and Nonjiang River in Sanjiang Plain, soil samples were collected from 16 sites having four land cover types including natural wetlands, forest, paddy field and upland field converted from wetland (Table 1). Data of 12 sampling sites including four land covers, *i.e.*, wetland, paddy field, and upland field were chosen to elucidate the characteristics and affecting factors of the vertical distribution and mobility of soil iron under different land use patterns in Sanjiang Plain, with a purpose to evaluate the effects of land use change in the region on adjacent marine ecosystems.

**Table 2 Sampling sites in Sanjiang Plain region**

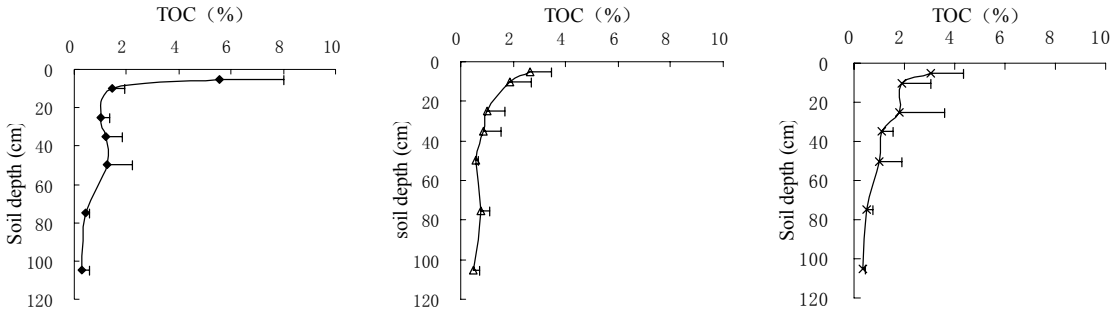
| Sampling sites. | Location | Soil type | Land use type | Reclamation history |
|---|---|---|---|---|
| Site 1 | 47°16.152′N, 133°45.797′E | Marsh soil | Wetland | Without reclamation |
| Site 2 | 47°17.122′N, 133°46.110′E | | Wetland (adjacent to Site 4 ) | Without reclamation |
| Site 3 | 47°31.706′N, 133°52.871′E | | Paddy field | 5 years |
| Site 4 | 47°17.122N, 133°46.076′E | | Paddy field | 23 years |
| Site 7 | 47°31.708′N, 133°52.872′E | | Upland field | 5 years |
| Site 8 | 47°17.073′N, 133°45.877′E | | Upland field | 23 years |
| Site 9 | 47°35.269′N, 133°30.146′E | Albic soil | Wetland | Without reclamation |
| Site 10 | 47°44.244′N, 133°31.212′E | | Wetland | Without reclamation |
| Site 11 | 47°44.216′N, 133°30.580′E | | Paddy field | 2 years |

| | | | |
|---|---|---|---|
| Site 12 | 47°39.479′N, 133°30.471′E | Paddy field | 11 years |
| Site 15 | 47°44.482′N, 133°31.253′E | Upland field | 4 years |
| Site 16 | 47°44.236′N, 133°30.625′E | Upland field | 15 years |

## 3.1.1 Results

## (1) Vertical distribution of soil OC and pH

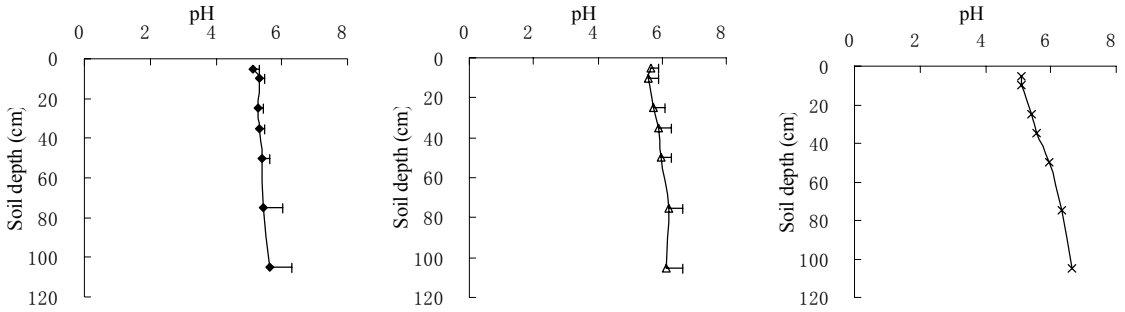
The soil OC content in wetland and cultivated fields had a marked decrease from 0-10 cm to 40-60 cm and a less change downward. In 0-10 cm layer, there was a significant difference in OC content in different land covers ($P < 0.05$), with the sequence of wetland > paddy field > upland field. Compared with that in wetland, the OC content in 0-10 cm layer in paddy field and upland field was decreased by 52.4% ($P < 0.05$) and 44.7% ($P < 0.05$), respectively (Figure 1).




a) wetlands b) paddy c) upland

**Figure 1 Vertical distribution of OC in soils under three land cover types**

Soil pH decreased with depth in wetland, but increased with depth in paddy field and upland field. Below 40 cm, the pH values of paddy field and upland field were higher than that in wetland (Figure 2).

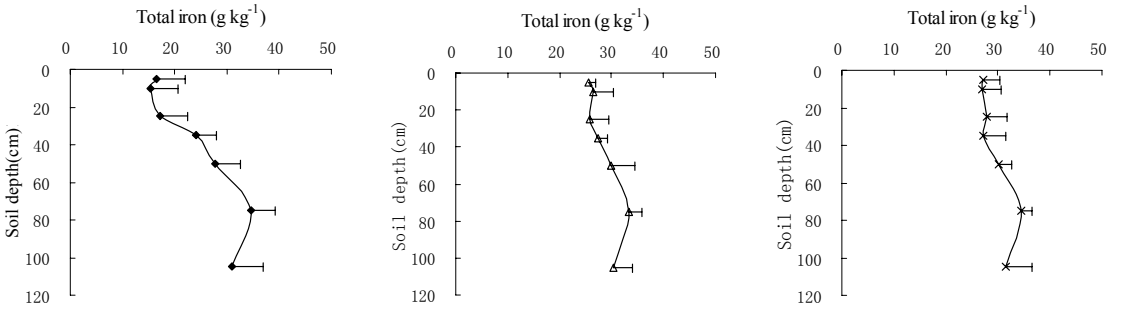



a) wetlands b) paddy c) upland

**Figure 2 Vertical distribution of pH in soils under three land cover types**

## (2) Vertical distribution of Total iron

Soil $Fe_t$ in wetland was increased with depth, and its concentration at the depth of 60-90 cm was 76.2% higher ($p < 0.05$) than that at the depth of 0-10 cm. $Fe_t$ in the profiles were decreased in the sequence of upland field > paddy field > wetland. Significant differences were observed at the soil depth of 10-20 cm, i.e., the $Fe_t$ increased by 73.3% ($p < 0.05$) in paddy field and 75.8 % ($p < 0.05$) in upland field, compared to wetland (Figure 3).



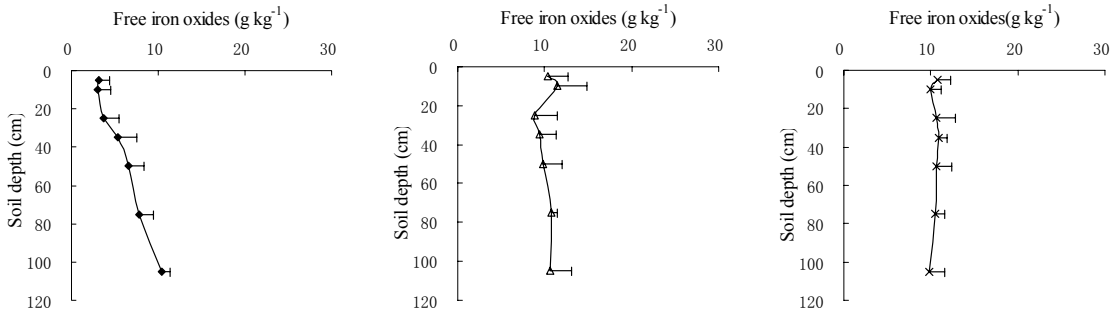

a) wetlands b) paddy c) upland

**Figure 3 Vertical distribution of total iron in soils under three land cover types**

## (3) Vertical distribution of free iron oxides and weathering ratio

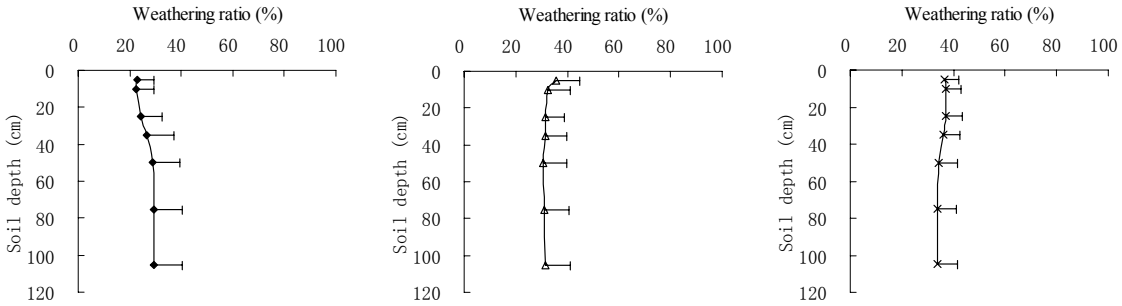
Soil $Fe_d$ in the profiles were decreased in the sequence of upland field > paddy field > wetland. In wetland, the $Fe_d$ concentration at the depth of 60-90 cm was 150.6% higher ($p < 0.05$) than that at the depth of 0-10 cm. At the depth of 10-20 cm, it increased by 270.9 % ($p < 0.05$) in paddy field and231.4% ($p < 0.05$) in upland field, compared to wetland (Figure 4).

Soil weathering ratio ($Fe_d/Fe_t$) was increased with depth below 10 cm in wetland which had a similar pattern with the distribution of $Fe_d$. Land use change led to a $Fe_d/Fe_t$ increase of 44.0 % ($P < 0.05$) in paddy field and of 65.9 % ($P < 0.05$) in upland field at the depth of 20-40 cm (Figure 5).




a) wetlands b) paddy c) upland

**Figure 4 Vertical distribution of free iron oxides in soils under three land cover types**



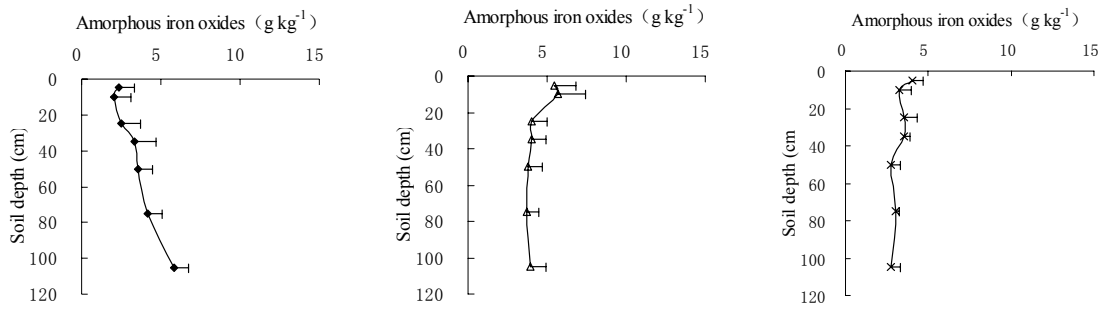

a) wetlands b) paddy c) upland

**Figure 5 Vertical distribution of weathering ratio in soils under three land cover types**

## (4) Vertical distribution of amorphous iron oxides and active ratio

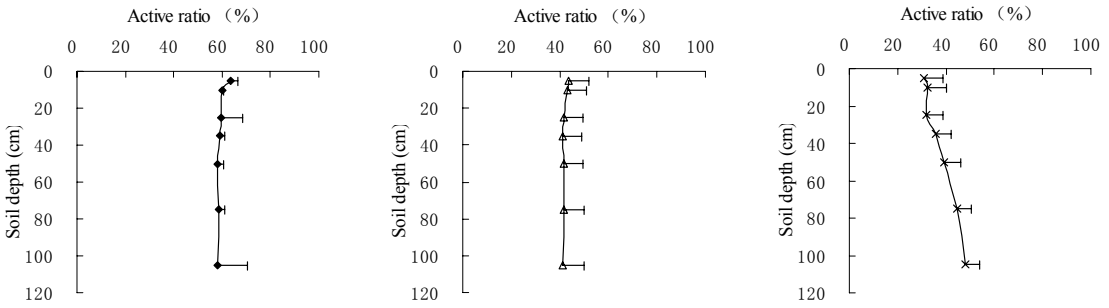
The total mass of $Fe_o$ in the upper soil layers (0–40 cm) tended to be greater ($P < 0.05$) in cultivated land than in wetland, but wetland stored a higher amount of $Fe_o$ at the depth below 60 cm (Figure 6).

Active ratio ($Fe_o/Fe_d$) is used as a measure of the proportion of amorphous iron in total iron oxides, and characterizes the inhibition of better crystallized forms by organic matter or other components (Blume and Schwertmann, 1969). The $Fe_o/Fe_d$ distribution at the 12 sites showed that land use change led to a significant decrease of the $Fe_o/Fe_d$ along the profile ($P < 0.05$). In the top 20 cm layer, the $Fe_o/Fe_d$ in paddy field was higher than that in upland field, while no significant differences were found below 40 cm (Figure 7).




a) wetlands b) paddy c) upland

**Figure 6 Vertical distribution of amorphous iron oxides in soils under three land cover types**



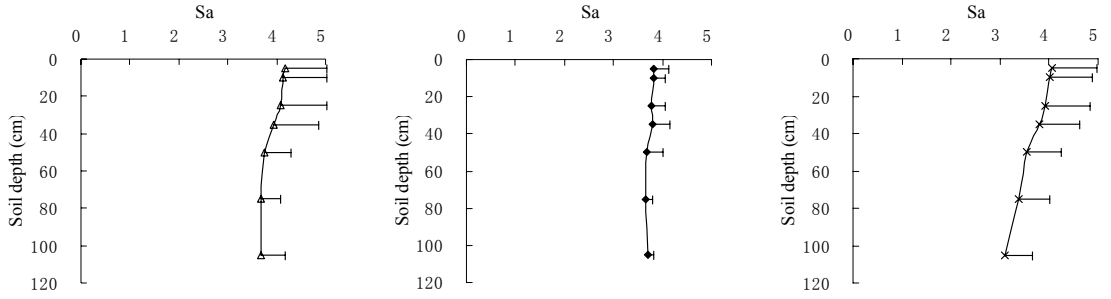

a) wetlands b) paddy c) upland

**Figure 7 Vertical distribution of active ratio in soils under three land cover types**

## (5) Vertical distribution of Sa value

Soil Sa value ($SiO_2/Al_2O_3$) was decreased in the sequence of paddy field > upland field > wetland in the upper soil layers (0–40 cm) (Figure 8). Sa value is used as a measure of the ratio of $SiO_2/Al_2O_3$, and characterizes the soil eluviation degree. The lower Sa value indicates a higher eluviation degree in wetland than in paddy field

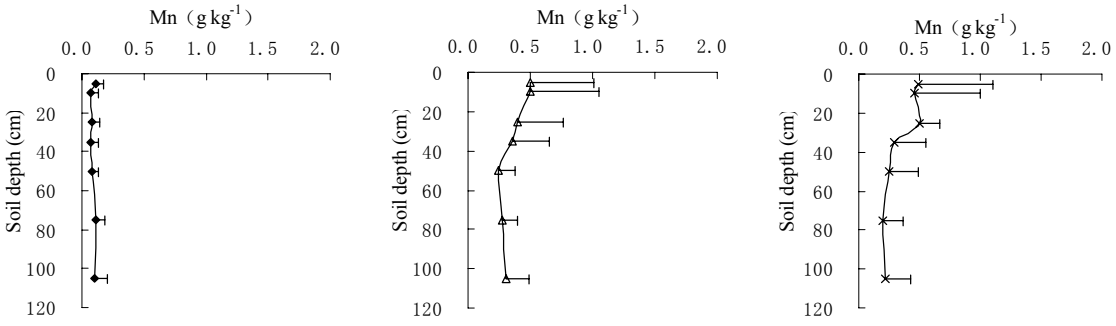
and upland field.




a) wetlands b) paddy c) upland

**Figure 8 Vertical distribution of Sa in soils under three land cover types**

Soil Mn value in wetland was higher than that in paddy field and upland field (Figure 9). Manganese is mobilized under less reducing conditions than iron. Thus, higher amounts of Mn in the well-drained soils and progressively less in the wetter soils were found. Continuously, high Mn contents were detected in the aerobic soils. Horizons with high accumulation of Mn and Fe were characterized by highly variable redox conditions. The lower Mn value indicates a higher eluviation degree in wetland than in paddy field and upland field.




a) wetlands b) paddy c) upland

**Figure 8 Vertical distribution of Mn in soils under three land cover types**

## (7) Correlation analysis

The correlation analysis among the iron compounds revealed that $Fe_t$ was positively correlated with $Fe_d$ and $Fe_d/Fe_t$, and negatively correlated with $Fe_o/Fe_d$ (Table 3). The correlations among the iron compounds and soil physical and chemical

properties showed that $Fe_o/Fe_d$ was correlated positively with soil OC and moisture content, and negatively with pH ($p < 0.01$) (Table 3).

**Table 3 Correlation coefficient (r) among the iron compounds and physical and chemical properties of soil in sample sites**

| | $Fe_t$ | $Fe_d$ | $Fe_o$ | $Fe_d/Fe_t$ | $Fe_o/Fe_d$ | OC | Moisture content | pH |
|---|---|---|---|---|---|---|---|---|
| $Fe_t$ | 1 | 0.655** | 0.403** | -0.036 | -0.307** | -0.451** | -0.182* | 0.324** |
| $Fe_d$ | | 1 | 0.657** | 0.132 | -0.308** | -0.297** | -0.108 | 0.282** |
| $Fe_o$ | | | 1 | -0.054 | -0.007 | -0.171* | 0.119 | 0.021 |
| $Fe_d/Fe_t$ | | | | 1 | -0.492** | 0.164* | -0.052 | -0.065 |
| $Fe_o/Fe_d$ | | | | | 1 | 0.182* | 0.307** | -0.313** |
| OC | | | | | | 1 | 0.490** | -0.441** |
| Moisture content | | | | | | | 1 | -0.267** |
| pH | | | | | | | | 1 |

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

## 3.1.2 Discussion

## (1) Effects of land use change on the vertical distribution of soil OC and pH

The higher storage of OC in surface soil layer was closely related with the

accumulation of plant materials, while the differences in the dynamics of OC in this soil layer should have close relations with the amount and quality of plant residues, as well as the environmental and soil conditions (Dick 1983; Wander and others 1998; Needelman and others 1999). Greater amounts of soil OC in wetland than in cultivated land are often accompanied by its concentration gradient from surface to subsurface layers (Dick 1983). Under cultivation, the OC in upper soil layers reduced, due to the oxidation resulted from a relatively well mixing of soil body during farming practices (Thomas and others 2007).

Higher weathering rates as a result of farming practices promoted the higher concentrations of base cations and bicarbonate alkalinity, and hence, maintain the pH near neutral. Near-neutral pH was an indicator of high soil $Ca^{2+}$ concentration, which was desirable for crop growth, as opposed to low pH values (Bohn and others 2001). $Ca^{2+}$ concentrations were highly correlated with pH in all test sites ($r$ = -0.325, $P$ < 0.01), which indicated that $Ca^{2+}$ was a strong competitor with $H^{+}$ and $Al^{3+}$ for exchange sites on the soil particle surface (Richter and Markewitz 1995; Bohn and others 2001; Reich and others 2005).

## (2) Effects of land use change on the vertical distribution of Total iron

$Fe_t$ concentration in wetland increased with depth, and was greatly higher at the depth of 90-120 cm than in surface soil. Such a vertical distribution could be explained by gleization which often occurred in flooded soil, and implied that a significant amount of iron was leached out from topsoil (Schwertmann and Murad 1990). The weathering and activation in surface soil was most likely enhanced by the iron reduction in wetland which would increase the solubility of iron. These dissolved iron migrated downwards in the soil profile, and precipitated in the bottom. Our results corresponded with the results of Fiedler and Sommer (2004), who found the low level of $Fe_t$ in the topsoil where permanent water saturation occurs.

Under cultivation, a redox layer at lower positions occurred due to the artificial disturbances, and the horizons with high accumulation of iron were characterized by highly variable redox conditions. The leached iron from topsoil moved vertically within the soil profile, and precipitated in subsurface soil (20 cm - 40 cm). Significant amounts of leached iron from topsoil, which moved vertically within the soil profile, were deposited in subsurface soil where a good aeration occurred, preventing the

further loss of iron as a solute. Due to the limitation of accurate mineralogical and geochemical data, we were not able to reveal all the processes involved in the mobilization and precipitation of iron at the study sites, but the spatial distribution of $Fe_t$ gave clear evidence of the mobilization and precipitation.

## (3) Effects of land use change on the vertical distribution of free iron oxides and weathering ratio

The similar trend and remarkable positive correlation relationship between $Fe_t$ and $Fe_t$ showed that different $Fe_t$ concentration undoubtedly contributed to the observed differences in mean concentrations of $Fe_d$ in the wetland, paddy field and upland field. Similar trends were found in other studies which a parallel trend of $Fe_t$ and $Fe_d$ in soil occurred and $Fe_d$ preferentially accumulates in well-aerated horizons (Blume and Schwertmann 1969).

Weathering ratio ($Fe_d/Fe_t$) is considered as a useful indicator of soil formation processes and pedogenic environments, and of importance in distinguishing soil types and differentiating soil horizons (McKeague and Day 1966; Blume and Schwertmann 1969). In our study, the higher $Fe_d/Fe_t$ in cultivated land revealed that the impact of reclamation might also add to the $Fe_d$ concentration difference by modifying weathering rate. Weathering is known to be related to soil temperature and moisture content, and is likely to be increased by farming practices. The increased $Fe_d$ concentration promoted by increased weathering and erosion rates has been reported in other studies (Collins and Jenkins 1996).

## (4) Effects of land use change on the vertical distribution of amorphous iron oxides and active ratio

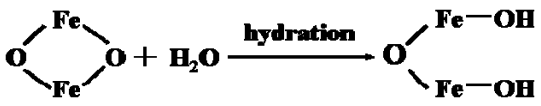
Iron oxides can be presented in soils in various forms. The less crystallized the iron oxides, the more readily reduced by microbes. The greater reduction of less crystallized forms of iron oxides might reflect the fact that the less crystalline iron oxide forms were more soluble, and had greater surface area than highly crystalline iron oxide forms (Lovley 1987). Therefore, $Fe_o$ identified in numerous soil environments was the most reactive iron oxide in soils (Chen and Barak 1982). The spatial distribution of $Fe_o$ and $Fe_o/Fe_d$ reflected a more dynamic aspect of the removal processes of iron oxide associated with podzolization and gleyization than that of $Fe_t$

and $Fe_d$.

Comparing with wetland, the total mass of $Fe_o$ in cultivated land was greater in upper soil layers (0–40 cm) and less in 90–120 cm layer, while the active ratio ($Fe_o/Fe_d$) was decreased in the whole profile. These differences could be explained by the low level of $Fe_t$ which might have played a role in the $Fe_o$ concentrations in the upper layers of wetland (although there was no a significant correlation between $Fe_o$ and $Fe_t$). The results of $Fe_o$, $Fe_d$ and $Fe_o/Fe_d$ suggested that reclamation could promote the production of $Fe_d$ and retarded the formation of $Fe_o$. In comparing with $Fe_o$ concentration which was proposed as an indicator of crystallization of soil iron oxides, $Fe_o/Fe_d$ ratio could better reflect the effects of land use change on the mobility of soil iron oxides. The decrease of the $Fe_o/Fe_d$ after reclamation were due to the changes of soil physical and chemical properties such as OC, pH and moisture content which had great correlate relationships with $Fe_o/Fe_d$.

Soil OC played an important role on the solubility and availability of iron (Linndsay 1991). The negative relationship between soil OC and $Fe_o/Fe_d$ in our study suggested that OC might have an inhibitory effect on the crystallization of $Fe_o$. One reason was that the strong adsorption of organic anions by $Fe_o$ could disturb and even prevent the rapid crystallization of $Fe_o$ (Schwertmann 1966), and the other was that most soils had the microsites where OC was actively metabolized. OC was the carbon source utilized by many soil organisms. If oxygen was present, it was utilized as the electron acceptor. Therefore, OC and microorganisms were responsible for the reduction and increase of $Fe_o$ (Linndsay 1991).

$Fe_o/Fe_d$ was correlated positively with soil moisture content, which could be supported by related studies. Linndsay (1991) suggested that in flooded soil, crystalline iron oxides were rapidly converted into $Fe_o$ by microorganisms. This transformation appeared to be a pre-requisite for the microbial reduction of $Fe_o$. Since the dehydration of ferrihydrite resulted in the formation of $Fe_o$, the probable mechanism of the transformation of crystalline iron into $Fe_o$ could be the reverse process, hydration:

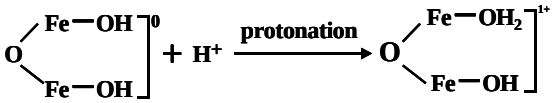



(1)

Moreover, when soil microsites became water-saturated, oxygen entry was restricted, and the sites became partially anaerobic. Parts of iron oxides dissolved,

releasing $Fe^{3+}$ and $Fe^{2+}$ that combined into multi-valence and less stable ferrous hydroxides (Linndsay 1991).

$Fe_o/Fe_d$ was decreased with increasing pH after reclamation, since the positive charge of the iron oxide surface increased with decreasing pH would speed up the dissolution process by further weakening of the Fe-O bond. These could be explained by the following scheme:




(2)

Furthermore, land use type had a stronger effect on the distribution and mobility of soil iron in upland field than in paddy field, which might be due to the differences in soil OC and moisture contents.

## 3.2 Effects of land use change on the soil iron activation in Sanjiang Plain

Data of 12 sampling sites including four land covers, *i.e.*, wetland, paddy field, and upland field were chosen to research effects of land use change on the soil Fe (III) reduction in Sanjiang Plain (Table 2).

There are three principal activation reactions by which solid Fe (III) oxides may release iron an aqueous solution: Protonation, reduction and complexation producing Fe (III) cations, Fe (II) or Fe (III) complexes, respectively. The respective reactions are as follows

$$FeOOH+H^+ \longrightarrow Fe(OH)_2^+ \quad (3)$$

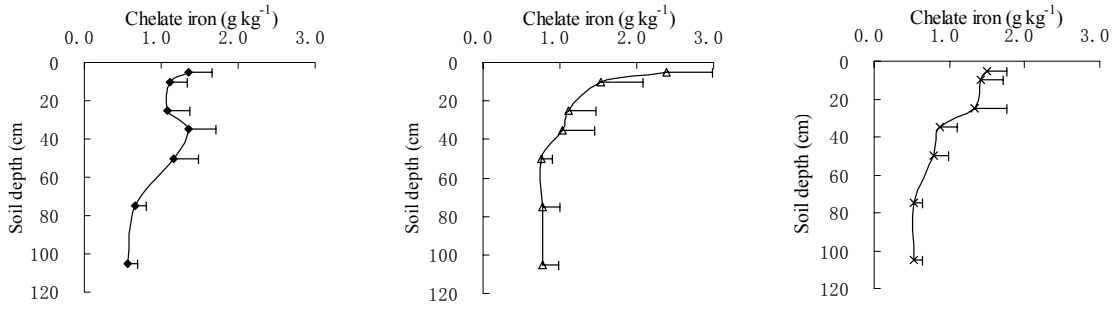
$$FeOOH+e^++3H^+ \longrightarrow Fe^{2+}+H_2O \quad (4)$$

$$FeOOH+e^++nL^- +3H^+ \longrightarrow [FeL_n]^{3-n}+2H_2O \text{ (L=ligand)} \quad (5)$$

In soil systems and particularly within the rhizosphere, reaction (5) and even more so reaction (4) are much more important than reaction (3). $Fe_p$ (chelate iron) and Fe (II) are the activation forms of iron oxides, respectively.

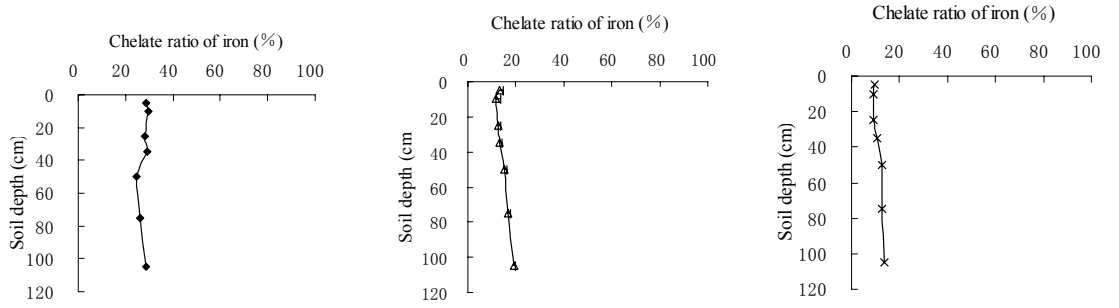
### (1) Soil iron complexation

Chelate ratio is used as a measure of the proportion of $Fe_p$ in total iron oxides Comparing with wetland, the total mass of $Fe_p$ in cultivated land was greater in upper soil layers (0–40 cm) while the chelate ratio was lower than wetland in the whole profile (Figure 11). Furthermore, the chelate ratio had a more positive relationship (0.508, $P < 0.01$) with OC than $Fe_p$ (0.501, $P < 0.01$, Table 5) These observations could be explained by the low level of $Fe_t$ (Figure 3) which might have played a role in the $Fe_p$ concentrations in the upper layers of wetland. The results of $Fe_p$ and chelate ratio suggested that reclamation could prevent the production of $Fe_P$. The decrease of chelate ratio after reclamation was mainly affected by OC content which had great correlate relationships with chelate ratio and $Fe_p$.




a) wetlands b) paddy c) upland

**Figure 9 Vertical distribution of chelate iron in soils under three land cover types**




a) wetlands b) paddy c) upland

**Figure 9 Vertical distribution of chelate ratio in soils under three land cover types**

**Table 5 Correlation coefficient (r) among the $Fe_P$, chelate ratio and OC of soil in four sample sites**

| | OC | chelate ratio | $Fe_P$ |
|---|---|---|---|
| OC | 1 | 0.508** | 0.501** |
| chelate ratio | | 1 | 0.464** |
| $Fe_P$ | | | 1 |

** Correlation is significant at the 0.01 level (2-tailed).

# 4. suggestions on this research in future

To further study the effects of land use type on various forms of iron, acid-leachable iron should be added. In addition, soil dissolved organic carbon (DOC) should be determined, which might have remarkable effects on soil dissolved Fe.

Soil profile would be studied for each land use type, i.e., natural, wetland, paddy field, upland field and meadow near Nongjiang river and Yalu river including general descriptions of soil profile such as horizon sequence, soil texture, diagnostic horizon and mottling, etc.(the presence or absence of reducing horizon might be a very important indicator).

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# Appendix Ⅰ: Analytical results for 2005

**Table 1 Sampling sites in Sanjiang Plain region**

| Sampling sites | Location | Land use type | Reclamation history | Sampling date |
|---|---|---|---|---|
| Site 1 | 133°52.987′E 47°31.918′N | Wetland (several hundred meters away from the main drain ditch of Bielahong River, comparative region of paddy field) | Without reclamation | June 17th, 2005 |
| Site 2 | 133°53.047′E 47°31.609′N | Paddy field (5 meters away from the main drain ditch of Bielahong River) | 10 years | June 17th, 2005 |
| Site 3 | 133°53.054′E 47°31.673′N | Paddy field (100 meters away from the main drain ditch of Bielahong River) | 10 years | June 17th, 2005 |
| Site 4 | 133°30.610′E 47°32.272′N | Paddy field | 25 years | June 18th, 2005 |
| Site 5 | 133°30.781′E 47°32.375′N | Forest Land (comparative region of upland field) | Without reclamation | June 18th, 2005 |
| Site 6 | 133°30.172′E 47°35.299′N | Upland field (soybean) | 5 years | June 18th, 2005 |
| Site 7 | 133°30.012′E 47°35.405′N | Upland field (soybean) | 18 years | June 18th, 2005 |

**Table 2 Analytical results for $Fe_t$ (total iron) (g $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 19.8 | 22.0 | 22.6 | 22.8 | 27.7 | 34.3 |
| | 21.5 | 22.4 | 22.0 | 27.8 | 30.0 | 38.7 |
| Site 2 | 31.1 | 31.1 | 31.5 | 39.4 | 41.5 | 38.1 |
| | 30.4 | 30.5 | 29.0 | 40.4 | 33.6 | 41.2 |
| Site 3 | 27.0 | 35.1 | 24.1 | 32.5 | 33.5 | 36.2 |
| | 27.7 | 29.2 | 32.2 | 24.2 | 31.7 | 37.4 |
| Site 4 | 27.9 | 24.7 | 40.0 | 32.3 | 29.8 | 38.0 |
| | 22.3 | 22.3 | 34.6 | 35.7 | 30.0 | 38.8 |
| Site 5 | 28.4 | 35.7 | 26.9 | 33.2 | 36.6 | 30.6 |
| | 32.1 | 35.2 | 30.2 | 32.6 | 32.9 | 33.5 |
| Site 6 | 31.6 | 39.0 | 27.8 | 35.7 | 32.8 | 34.1 |
| | 32.1 | 36.3 | 26.2 | 30.8 | 33.2 | 36.1 |
| Site 7 | 27.8 | 26.5 | 37.7 | 38.7 | 38.2 | 38.7 |
| | 26.2 | 25.9 | 40.0 | 36.9 | 36.9 | 34.6 |

**Table3 Analytical results for $Fe_d$ (free iron oxide iron) (g $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 3.32 | 2.56 | 2.81 | 3.86 | 7.07 | 13.86 |
| | 2.79 | 2.36 | 2.66 | 4.48 | 7.41 | 14.06 |
| Site 2 | 14.48 | 14.78 | 12.19 | 13.83 | 13.67 | 13.64 |
| | 16.33 | 14.79 | 14.08 | 12.66 | 12.85 | 13.17 |
| Site 3 | 11.80 | 15.40 | 11.50 | 15.40 | 10.70 | 13.10 |
| | 12.30 | 9.90 | 11.70 | 12.50 | 11.60 | 11.10 |
| Site 4 | 11.31 | 6.79 | 11.75 | 10.92 | 7.96 | 14.56 |
| | 9.30 | 7.97 | 11.98 | 10.30 | 8.64 | 13.92 |
| Site 5 | 10.04 | 8.46 | 8.65 | 8.72 | 10.30 | 8.43 |
| | 10.04 | 7.02 | 9.40 | 10.02 | 7.59 | 10.24 |
| Site 6 | 11.56 | 13.77 | 9.28 | 10.17 | 9.29 | 11.36 |
| | 11.36 | 12.08 | 10.78 | 9.45 | 11.18 | 11.45 |
| Site 7 | 12.31 | 12.30 | 17.07 | 13.78 | 12.88 | 12.54 |
| | 12.27 | 11.29 | 17.71 | 13.97 | 13.17 | 15.83 |

**Table4 Analytical results for $Fe_s$ (alumino-silicate iron) (g $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 16.52 | 19.39 | 19.84 | 18.91 | 20.62 | 20.42 |
| | 18.67 | 20.01 | 19.35 | 23.32 | 22.61 | 24.65 |
| Site 2 | 15.23 | 19.67 | 12.58 | 17.11 | 22.77 | 23.07 |
| | 15.40 | 19.27 | 20.53 | 11.74 | 20.07 | 26.33 |
| Site 3 | 16.62 | 16.37 | 19.29 | 25.59 | 27.84 | 24.42 |
| | 14.09 | 15.69 | 14.96 | 27.74 | 20.80 | 28.07 |
| Site 4 | 16.62 | 17.87 | 28.26 | 21.41 | 21.81 | 23.48 |
| | 13.02 | 14.35 | 22.65 | 25.36 | 21.39 | 24.83 |
| Site 5 | 16.32 | 37.20 | 18.25 | 14.47 | 26.33 | 22.17 |
| | 22.01 | 18.16 | 24.82 | 32.58 | 25.30 | 23.24 |
| Site 6 | 20.74 | 25.20 | 25.13 | 26.18 | 23.54 | 22.77 |
| | 21.48 | 24.21 | 8.87 | 22.70 | 22.07 | 24.62 |
| Site 7 | 15.46 | 14.15 | 20.68 | 24.97 | 25.29 | 26.15 |
| | 13.89 | 14.57 | 22.34 | 22.91 | 23.76 | 18.79 |

**Table5 Analytical results for $Fe_o$ (amorphous iron oxides) (g $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 2.72 | 1.84 | 1.92 | 2.31 | 3.31 | 6.76 |
| | 2.18 | 1.63 | 1.63 | 2.23 | 4.35 | 8.47 |
| Site 2 | 6.65 | 5.58 | 3.61 | 2.91 | 4.36 | 5.03 |
| | 7.64 | 7.49 | 6.05 | 3.33 | 3.93 | 4.48 |
| Site 3 | 5.88 | 6.79 | 5.43 | 2.72 | 4.20 | 4.88 |
| | 4.90 | 6.65 | 5.92 | 3.15 | 3.76 | 4.32 |
| Site 4 | 4.89 | 5.33 | 3.20 | 2.30 | 1.81 | 2.67 |
| | 2.45 | 2.84 | 3.16 | 2.48 | 1.20 | 2.27 |
| Site 5 | 3.78 | 3.38 | 1.49 | 1.06 | 1.13 | 1.53 |
| | 4.39 | 3.89 | 3.51 | 1.35 | 1.68 | 1.98 |
| Site 6 | 4.40 | 4.28 | 4.36 | 4.20 | 4.52 | 4.62 |
| | 4.34 | 5.02 | 3.77 | 4.09 | 3.42 | 4.50 |
| Site 7 | 5.66 | 4.38 | 5.06 | 3.44 | 2.20 | 2.92 |
| | 5.57 | 4.85 | 5.04 | 2.87 | 2.59 | 2.08 |

**Table6 Analytical results for $Fe_c$ (crystal iron oxide) (g $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 0.61 | 0.73 | 1.03 | 2.25 | 3.07 | 5.60 |
| | 0.61 | 0.73 | 0.96 | 1.90 | 3.41 | 6.35 |
| Site 2 | 5.51 | 8.75 | 6.37 | 9.67 | 8.22 | 7.21 |
| | 5.72 | 6.88 | 6.49 | 11.31 | 7.57 | 7.96 |
| Site 3 | 8.68 | 7.30 | 8.03 | 9.33 | 8.91 | 8.69 |
| | 8.26 | 8.25 | 8.31 | 10.12 | 9.11 | 8.65 |
| Site 4 | 6.72 | 2.20 | 9.21 | 8.82 | 7.44 | 11.65 |
| | 6.25 | 2.66 | 9.34 | 9.22 | 7.30 | 12.27 |
| Site 5 | 5.64 | 4.04 | 5.89 | 8.66 | 5.91 | 8.27 |
| | 5.84 | 4.01 | 6.53 | 8.16 | 7.54 | 7.58 |
| Site 6 | 6.32 | 7.05 | 3.52 | 3.96 | 7.76 | 6.95 |
| | 6.39 | 8.27 | 4.92 | 5.66 | 6.26 | 6.84 |
| Site 7 | 6.70 | 5.45 | 12.67 | 11.10 | 10.58 | 13.76 |
| | 7.01 | 6.18 | 12.33 | 10.72 | 10.63 | 11.69 |

**Table7 Analytical results for $Fe_p$ (chelate iron) (g $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 1.09 | 0.55 | 0.63 | 0.70 | 0.87 | 0.76 |
| | 1.41 | 0.87 | 0.74 | 0.83 | 1.17 | 0.81 |
| Site 2 | 1.32 | 0.81 | 0.58 | 0.36 | 0.32 | 0.30 |
| | 1.85 | 1.15 | 0.85 | 0.31 | 0.27 | 0.44 |
| Site 3 | 1.22 | 0.99 | 0.68 | 0.46 | 0.47 | 0.42 |
| | 1.53 | 0.7 | 0.4 | 0.59 | 0.48 | 0.32 |
| Site 4 | 2.38 | 1.61 | 0.78 | 0.25 | 0.13 | 0.28 |
| | 2.05 | 2.08 | 0.20 | 0.25 | 0.19 | 0.15 |
| Site 5 | 3.19 | 0.90 | 0.38 | 0.28 | 0.25 | 0.21 |
| | 3.13 | 1.32 | 0.52 | 0.23 | 0.18 | 0.16 |
| Site 6 | 0.18 | 0.53 | 0.53 | 0.43 | 0.24 | 0.26 |
| | 0.66 | 0.62 | 0.56 | 0.28 | 0.39 | 0.30 |
| Site 7 | 1.47 | 1.61 | 0.62 | 0.12 | 0.24 | 0.25 |
| | 1.10 | 1.60 | 0.45 | 0.22 | 0.28 | 0.18 |

**Table8 Analytical results for weathering ratio ($Fe_d/Fe_t$) (%)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 16.7 | 11.7 | 12.4 | 16.9 | 25.5 | 40.4 |
| | 13.0 | 10.6 | 12.1 | 16.1 | 24.7 | 36.3 |
| Site 2 | 43.7 | 43.9 | 47.8 | 47.4 | 32.0 | 36.2 |
| | 44.4 | 33.9 | 36.3 | 51.6 | 36.6 | 29.7 |
| Site 3 | 46.6 | 47.4 | 38.7 | 35.1 | 32.9 | 35.8 |
| | 53.7 | 48.5 | 48.5 | 31.3 | 38.2 | 31.9 |
| Site 4 | 40.5 | 27.5 | 26.9 | 33.8 | 26.7 | 38.3 |
| | 41.7 | 35.7 | 31.7 | 28.9 | 28.8 | 35.9 |
| Site 5 | 35.4 | 23.7 | 32.2 | 26.3 | 28.1 | 27.5 |
| | 31.3 | 20.0 | 31.1 | 30.7 | 23.1 | 30.6 |
| Site 6 | 36.6 | 35.3 | 33.4 | 28.4 | 28.3 | 33.3 |
| | 35.3 | 33.3 | 41.2 | 30.7 | 33.6 | 31.7 |
| Site 7 | 44.3 | 46.5 | 45.2 | 35.6 | 33.8 | 32.4 |
| | 46.9 | 43.7 | 44.2 | 37.9 | 35.7 | 45.7 |

**Table9 Analytical results for active ratio ($Fe_o/Fe_d$) (%)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 81.9 | 71.9 | 68.4 | 59.9 | 46.9 | 48.8 |
| | 78.0 | 69.1 | 61.3 | 49.7 | 58.6 | 60.2 |
| Site 2 | 45.9 | 37.8 | 29.6 | 21.1 | 31.9 | 36.9 |
| | 46.8 | 50.7 | 43.0 | 26.3 | 30.6 | 34.0 |
| Site 3 | 49.8 | 49.5 | 42.5 | 15.9 | 35.3 | 33.5 |
| | 55.2 | 43.2 | 45.5 | 22.7 | 29.2 | 35.0 |
| Site 4 | 46.7 | 53.8 | 25.1 | 16.5 | 22.7 | 18.3 |
| | 57.6 | 47.3 | 24.4 | 18.6 | 13.9 | 16.3 |
| Site 5 | 39.9 | 52.8 | 17.2 | 12.2 | 11.0 | 18.1 |
| | 43.9 | 42.5 | 37.3 | 13.5 | 22.2 | 19.3 |
| Site 6 | 38.1 | 31.1 | 47.0 | 41.3 | 48.7 | 40.7 |
| | 38.2 | 41.6 | 34.9 | 43.3 | 30.6 | 39.3 |
| Site 7 | 46.0 | 35.6 | 29.7 | 24.9 | 17.1 | 25.3 |
| | 45.4 | 42.9 | 28.5 | 20.6 | 19.7 | 21.1 |

**Table10 Analytical results for chelate ratio ($Fe_p/Fe_d$) (%)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 32.8 | 21.6 | 22.5 | 18.2 | 12.3 | 5.5 |
| | 50.6 | 36.7 | 27.6 | 18.4 | 15.7 | 5.8 |
| Site 2 | 10.3 | 6.4 | 5.9 | 3.0 | 4.4 | 3.2 |
| | 12.4 | 7.1 | 3.4 | 4.7 | 4.1 | 2.9 |
| Site 3 | 9.1 | 5.5 | 4.7 | 2.6 | 2.3 | 2.2 |
| | 11.3 | 7.8 | 6.0 | 2.4 | 2.1 | 3.3 |
| Site 4 | 21.1 | 23.8 | 6.1 | 1.8 | 1.7 | 1.9 |
| | 22.0 | 26.1 | 1.5 | 1.9 | 2.2 | 1.0 |
| Site 5 | 31.8 | 10.6 | 4.4 | 3.2 | 2.4 | 2.5 |
| | 31.2 | 18.7 | 5.5 | 2.3 | 2.3 | 1.6 |
| Site 6 | 1.6 | 3.9 | 5.7 | 4.2 | 2.5 | 2.3 |
| | 5.8 | 5.1 | 5.2 | 3.0 | 3.5 | 2.6 |
| Site 7 | 11.9 | 13.0 | 3.6 | 0.9 | 1.9 | 2.0 |
| | 9.0 | 14.2 | 2.5 | 1.6 | 2.2 | 1.1 |

**Table11 Analytical results for Fe(Ⅱ) (mg $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 123.0 | 131.3 | 58.5 | 127.9 | 155.5 | 167.4 |
| | 139.3 | 49.9 | 112.9 | 152.1 | 193.9 | 153.8 |
| Site 2 | 181.5 | 126.0 | 83.7 | 41.7 | 30.1 | 35.1 |
| | 176.8 | 160.6 | 182.3 | 51.7 | 37.9 | 33.0 |
| Site 3 | 207.9 | 170.0 | 162.0 | 60.9 | 39.7 | 57.5 |
| | 191.9 | 161.8 | 170.2 | 61.7 | 70.4 | 50 |
| Site 4 | 210.6 | 162.6 | 32.6 | 37 | 24.3 | 21.5 |
| | 205.2 | 183.3 | 101.5 | 29.9 | 34.2 | 34.7 |
| Site 5 | 223.1 | 161.9 | 160.1 | 153.6 | 124.8 | 122.3 |
| | 171.5 | 160.8 | 152.8 | 134.4 | 131.9 | 124 |
| Site 6 | 93.7 | 40.9 | 68.0 | 35.4 | 94.5 | 68.6 |
| | 60.1 | 58.5 | 135.1 | 73.9 | 61.9 | 41.5 |
| Site 7 | 148.2 | 151.7 | 46.8 | 37.3 | 28.3 | 37.2 |
| | 124.9 | 157.8 | 60.3 | 37.2 | 32.6 | 29.1 |

**Table12 Analytical results for Mn(Ⅱ) (mg $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 26.2 | 15.5 | 13.1 | 28.7 | 83.6 | 109.9 |
| | 12.26 | 9.4 | 21.9 | 29.4 | 154.3 | 94.6 |
| Site 2 | 312.1 | 96.2 | 33.3 | 24.1 | 14.1 | 9.1 |
| | 344.8 | 305.9 | 232.9 | 16.7 | 11.7 | 17.5 |
| Site 3 | 469.1 | 233.5 | 66.6 | 19.4 | 12.3 | 21.8 |
| | 404.2 | 190.6 | 143.3 | 19.1 | 32.0 | 14.4 |
| Site 4 | 59.3 | 27.6 | 16.0 | 37.0 | 8.4 | 7.8 |
| | 20.8 | 13.1 | 10.1 | 14.4 | 26.0 | 14.4 |
| Site 5 | 29.2 | 10.2 | 36.3 | 4.9 | 12.1 | 6.3 |
| | 8.1 | 10.2 | 9.4 | 6.6 | 4.4 | 6.3 |
| Site 6 | 7.9 | 10.5 | 78.5 | 16.6 | 21.9 | 12.4 |
| | 10.3 | 12.6 | 16.3 | 6.0 | 6.8 | 7.9 |
| Site 7 | 5.6 | 4.2 | 3.2 | 17.9 | 5.5 | 9.5 |
| | 2.6 | 9.3 | 5.1 | 1.8 | 3.7 | 5.7 |

**Table13 Analytical results for Sa ($SiO_3/Al_2O_3$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 49.53 | 28.02 | 12.01 | 8.22 | 5.10 | 3.83 |
| | 53.04 | 29.61 | 16.87 | 6.34 | 6.72 | 6.13 |
| Site 2 | 26.40 | 19.04 | 11.10 | 6.09 | 4.01 | 3.07 |
| | 25.56 | 24.64 | 12.88 | 7.52 | 6.24 | 5.71 |
| Site 3 | 30.81 | 14.89 | 8.66 | 6.19 | 5.40 | 5.94 |
| | 24.77 | 16.14 | 5.35 | 13.57 | 6.28 | 5.06 |
| Site 4 | 36.17 | 26.50 | 5.16 | 4.88 | 3.51 | 1.38 |
| | 41.61 | 26.60 | 5.70 | 3.68 | 2.37 | 3.34 |
| Site 5 | 81.70 | 22.24 | 10.20 | 10.92 | 2.74 | 2.46 |
| | 78.84 | 20.91 | 10.50 | 9.45 | 3.52 | 2.11 |
| Site 6 | 14.55 | 7.56 | 7.04 | 8.46 | 3.44 | 1.06 |
| | 14.55 | 12.26 | 9.82 | 7.93 | 0.68 | 4.63 |
| Site 7 | 26.21 | 18.74 | 6.06 | 5.66 | 3.29 | 2.53 |
| | 24.67 | 20.04 | 7.51 | 5.76 | 3.82 | 2.38 |

**Table14 Analytical results for OC (g $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 49.53 | 28.02 | 12.01 | 8.22 | 5.10 | 3.83 |
| | 53.04 | 29.61 | 16.87 | 6.34 | 6.72 | 6.13 |
| Site 2 | 26.40 | 19.04 | 11.10 | 6.09 | 4.01 | 3.07 |
| | 25.56 | 24.64 | 12.88 | 7.52 | 6.24 | 5.71 |
| Site 3 | 30.81 | 14.89 | 8.66 | 6.19 | 5.40 | 5.94 |
| | 24.77 | 16.14 | 5.35 | 13.57 | 6.28 | 5.06 |
| Site 4 | 36.17 | 26.50 | 5.16 | 4.88 | 3.51 | 1.38 |
| | 41.61 | 26.60 | 5.70 | 3.68 | 2.37 | 3.34 |
| Site 5 | 81.70 | 22.24 | 10.20 | 10.92 | 2.74 | 2.46 |
| | 78.84 | 20.91 | 10.50 | 9.45 | 3.52 | 2.11 |
| Site 6 | 14.55 | 7.56 | 7.04 | 8.46 | 3.44 | 1.06 |
| | 14.55 | 12.26 | 9.82 | 7.93 | 0.68 | 4.63 |
| Site 7 | 26.21 | 18.74 | 6.06 | 5.66 | 3.29 | 2.53 |
| | 24.67 | 20.04 | 7.51 | 5.76 | 3.82 | 2.38 |

**Table15 Analytical results for pH ($H_2O$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 5.24 | 5.34 | 5.18 | 5.08 | 5.02 | 5.10 |
| | 5.47 | 5.33 | 5.23 | 5.14 | 4.92 | 5.16 |
| Site 2 | 5.67 | 5.78 | 5.85 | 6.07 | 5.87 | 6.39 |
| | 5.79 | 5.84 | 5.98 | 5.96 | 6.25 | 6.35 |
| Site 3 | 5.56 | 5.66 | 5.73 | 5.93 | 5.75 | 6.22 |
| | 5.67 | 5.72 | 5.85 | 5.83 | 6.09 | 6.18 |
| Site 4 | 5.55 | 5.65 | 5.95 | 6.00 | 6.08 | 6.19 |
| | 5.55 | 5.66 | 5.75 | 5.70 | 5.87 | 6.00 |
| Site 5 | 5.66 | 5.32 | 5.74 | 5.84 | 6.25 | 6.31 |
| | 5.65 | 5.34 | 5.51 | 6.25 | 6.33 | 6.18 |
| Site 6 | 5.72 | 5.83 | 5.69 | 5.72 | 5.58 | 5.79 |
| | 5.73 | 5.82 | 5.45 | 5.72 | 5.68 | 5.98 |
| Site 7 | 4.94 | 5.27 | 5.68 | 5.85 | 6.08 | 6.15 |
| | 4.95 | 5.27 | 5.75 | 5.92 | 6.03 | 6.42 |

**Table16 Analytical results for pH (KCl)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | **0-10** | **10-20** | **20-40** | **40-60** | **60-90** | **90-120** |
| Site 1 | 4.80 | 4.03 | 3.83 | 3.71 | 3.64 | 3.79 |
| | 4.62 | 4.03 | 4.04 | 3.66 | 3.62 | 3.86 |
| Site 2 | 4.72 | 4.67 | 4.52 | 4.44 | 4.53 | 4.60 |
| | 4.41 | 4.57 | 4.56 | 4.43 | 4.51 | 4.54 |
| Site 3 | 4.60 | 4.41 | 4.33 | 4.36 | 4.33 | 4.59 |
| | 4.20 | 4.16 | 3.91 | 4.10 | 4.10 | 4.12 |
| Site 4 | 4.74 | 4.95 | 4.99 | 4.67 | 4.73 | 4.78 |
| | 4.57 | 4.34 | 4.46 | 4.55 | 4.46 | 4.48 |
| Site 5 | 3.80 | 3.94 | 4.16 | 4.22 | 4.51 | 4.55 |
| | 3.93 | 3.97 | 3.95 | 4.75 | 4.52 | 4.61 |
| Site 6 | 4.31 | 4.36 | 4.38 | 4.61 | 4.30 | 4.46 |
| | 4.56 | 4.39 | 4.36 | 4.31 | 4.44 | 4.58 |
| Site 7 | 4.05 | 4.10 | 4.28 | 4.39 | 4.45 | 4.51 |
| | 4.03 | 4.13 | 4.39 | 4.43 | 4.50 | 4.60 |

**Table17 Analytical results for $Ca^{2+}$ (mg $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | **0-10** | **10-20** | **20-40** | **40-60** | **60-90** | **90-120** |
| Site 1 | 328.5 | 123.2 | 82.1 | 123.2 | 164.3 | 164.3 |
| | 287.5 | 82.1 | 123.2 | 123.2 | 123.2 | 79.0 |
| Site 2 | 123.2 | 131.4 | 123.2 | 82.1 | 123.2 | 147.8 |
| | 164.3 | 164.3 | 82.1 | 123.2 | 41.1 | 164.3 |
| Site 3 | 82.1 | 41.1 | 164.3 | 123.2 | 164.3 | 123.2 |
| | 123.2 | 82.1 | 82.1 | 82.1 | 164.3 | 123.2 |
| Site 4 | 205.3 | 123.2 | 123.2 | 41.1 | 123.2 | 82.1 |
| | 164.3 | 123.2 | 82.1 | 82.1 | 139.6 | 82.1 |
| Site 5 | 37.0 | 32.9 | 32.9 | 32.9 | 73.9 | 73.9 |
| | 32.9 | 32.9 | 73.9 | 32.9 | 73.9 | 115.0 |
| Site 6 | 402.4 | 156.0 | 32.9 | 115.0 | 197.1 | 156.0 |
| | 484.6 | 115.0 | 156.0 | 156.0 | 115.0 | 73.9 |
| Site 7 | 361.4 | 115.0 | 156.0 | 82.1 | 82.1 | 41.1 |
| | 443.5 | 156.0 | 115.0 | 82.1 | 41.1 | 82.1 |

**Table18 Analytical results for $Mg^{2+}$ (mg $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 99.7 | 49.8 | 24.9 | 49.8 | 87.2 | 49.8 |
| | 149.5 | 74.8 | 49.8 | 49.8 | 162.0 | 143.8 |
| Site 2 | 598.0 | 231.7 | 186.9 | 249.2 | 99.7 | 59.8 |
| | 398.7 | 261.6 | 162.0 | 149.5 | 124.6 | 149.5 |
| Site 3 | 124.6 | 149.5 | 49.8 | 49.8 | 24.9 | 49.8 |
| | 99.7 | 74.8 | 99.7 | 74.8 | 24.9 | 49.8 |
| Site 4 | 174.4 | 99.7 | 74.8 | 124.6 | 99.7 | 49.8 |
| | 224.3 | 99.7 | 99.7 | 49.8 | 114.6 | 49.8 |
| Site 5 | 371.3 | 299.0 | 311.5 | 249.2 | 236.7 | 99.7 |
| | 348.9 | 299.0 | 261.6 | 249.2 | 162.0 | 74.8 |
| Site 6 | 485.9 | 436.1 | 186.9 | 211.8 | 174.4 | 174.4 |
| | 461.0 | 261.6 | 186.9 | 211.8 | 199.3 | 224.3 |
| Site 7 | 573.1 | 224.3 | 261.6 | 24.9 | 49.8 | 87.2 |
| | 473.4 | 224.3 | 261.6 | 24.9 | 49.8 | 87.2 |

**Table19 Analytical results for $Cl^-$ (mg $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 25.1 | 5.6 | 4.2 | 1.4 | 34.8 | 33.4 |
| | 13.9 | 1.4 | 1.4 | 2.1 | 39.0 | 32.6 |
| Site 2 | 18.6 | 1.2 | 42.9 | 1.2 | 1.2 | 1.2 |
| | 18.6 | 18.6 | 37.7 | 1.2 | 1.2 | 9.9 |
| Site 3 | 52.9 | 19.5 | 23.0 | 29.9 | 40.4 | 18.1 |
| | 20.9 | 5.6 | 9.0 | 9.0 | 26.5 | 13.9 |
| Site 4 | 27.3 | 9.9 | 5.5 | 1.2 | 9.9 | 16.8 |
| | 27.3 | 1.2 | 22.9 | 9.9 | 9.9 | 11.6 |
| Site 5 | 160.1 | 132.3 | 45.2 | 26.5 | 24.4 | 18.8 |
| | 154.5 | 114.9 | 41.8 | 23.0 | 31.3 | 20.9 |
| Site 6 | 52.2 | 19.5 | 13.9 | 12.5 | 15.3 | 36.2 |
| | 68.2 | 15.3 | 20.9 | 9.0 | 8.4 | 40.4 |
| Site 7 | 69.6 | 33.4 | 17.4 | 62.1 | 27.3 | 42.1 |
| | 20.9 | 15.3 | 24.4 | 64.7 | 36.0 | 29.9 |

**Table20 Analytical results for $SO_4^{2-}$ (g $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 1.44 | 0.58 | 1.83 | 0.49 | 0.94 | 1.24 |
| | 2.78 | 1.17 | 2.35 | 0.78 | 1.37 | 1.6 |
| Site 2 | 1.08 | 1.31 | 1.57 | 1.97 | 1.15 | 1.18 |
| | 0.72 | 1.64 | 1.34 | 1.67 | 1.28 | 1.64 |
| Site 3 | 1.4 | 0.65 | 0.45 | 0.68 | 1.76 | 2.26 |
| | 0.91 | 0.65 | 1.04 | 0.98 | 2.26 | 2.26 |
| Site 4 | 2.16 | 0.66 | 1.28 | 1.38 | 1.74 | 1.15 |
| | 1.74 | 0.95 | 0.98 | 1.34 | 1.51 | 1.25 |
| Site 5 | 2.31 | 2.41 | 1.36 | 1.3 | 1.53 | 1.46 |
| | 2.25 | 2.12 | 1.1 | 1.1 | 1 | 1.17 |
| Site 6 | 2.51 | 1.3 | 1.33 | 1.13 | 2.15 | 1.5 |
| | 2.38 | 1.66 | 1 | 1.99 | 1 | 2.09 |
| Site 7 | 1.89 | 1.56 | 1.63 | 0.98 | 1.34 | 1.18 |
| | 2.25 | 2.02 | 1.56 | 1.28 | 0.79 | 1.15 |

**Table21 Analytical results for $K^+$ (mg $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 18.0 | 6.9 | 8.4 | 9.3 | 6.0 | 6.6 |
| | 14.4 | 6.3 | 7.2 | 6.9 | 6.6 | 6.6 |
| Site 2 | 3.6 | 2.7 | 2.7 | 2.7 | 2.4 | 3.6 |
| | 6.0 | 3.9 | 3.3 | 3.3 | 3.0 | 3.6 |
| Site 3 | 17.7 | 5.7 | 4.8 | 5.7 | 4.8 | 10.8 |
| | 6.3 | 3.3 | 2.4 | 2.7 | 4.2 | 3.0 |
| Site 4 | 14.8 | 6.9 | 7.8 | 7.8 | 9.3 | 7.5 |
| | 7.1 | 4.5 | 8.4 | 7.8 | 8.1 | 8.1 |
| Site 5 | 29.7 | 5.1 | 5.1 | 5.1 | 5.1 | 6.0 |
| | 29.4 | 5.7 | 4.5 | 5.7 | 5.1 | 6.5 |
| Site 6 | 30.3 | 9.7 | 8.4 | 8.4 | 8.2 | 7.9 |
| | 35.6 | 8.7 | 8.9 | 8.4 | 8.2 | 7.9 |
| Site 7 | 18.9 | 5.8 | 5.1 | 4.8 | 3.8 | 5.1 |
| | 8.7 | 5.3 | 6.6 | 4.3 | 4.3 | 5.6 |

**Table22 Analytical results for $Na^+$ (mg $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 33.7 | 11.2 | 11.5 | 12.6 | 7.7 | 8.5 |
| | 20.7 | 11.2 | 10.4 | 8.8 | 8.3 | 9.6 |
| Site 2 | 38.5 | 26.6 | 29.1 | 21.5 | 28.5 | 27.2 |
| | 32.6 | 34.2 | 30.1 | 23.7 | 26.9 | 39.1 |
| Site 3 | 33.1 | 30.7 | 41.2 | 53.1 | 46.6 | 47.2 |
| | 35.8 | 36.1 | 32 | 37.4 | 36.4 | 46.1 |
| Site 4 | 13.5 | 48.0 | 31.5 | 21.8 | 18.3 | 12.6 |
| | 47.0 | 35.0 | 28.2 | 23.4 | 16.6 | 19.6 |
| Site 5 | 22.8 | 8.7 | 12.1 | 12.1 | 10.3 | 10.5 |
| | 22.3 | 9.2 | 7.9 | 12.7 | 9.70 | 9.50 |
| Site 6 | 22.0 | 15.6 | 15.8 | 13.1 | 11.4 | 12.6 |
| | 21.0 | 16.0 | 19.5 | 14.9 | 12.4 | 11.2 |
| Site 7 | 21.3 | 17.2 | 17.6 | 18.6 | 13.7 | 16.0 |
| | 13.1 | 17.6 | 19.5 | 19.9 | 16.0 | 16.0 |

**Table23 Analytical results for Mn (g $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 0.29 | 0.48 | 0.25 | 0.32 | 0.34 | 0.52 |
| | 0.27 | 0.24 | 0.26 | 0.3 | 0.39 | 0.48 |
| Site 2 | 0.91 | 1.07 | 0.64 | 0.34 | 0.39 | 0.34 |
| | 0.76 | 0.94 | 0.55 | 0.33 | 0.42 | 0.56 |
| Site 3 | 0.70 | 1.20 | 0.33 | 0.35 | 0.29 | 0.43 |
| | 0.84 | 0.87 | 0.32 | 0.40 | 0.34 | 0.27 |
| Site 4 | 0.22 | 0.19 | 0.25 | 0.25 | 0.23 | 0.32 |
| | 0.17 | 0.33 | 0.16 | 0.19 | 0.23 | 0.33 |
| Site 5 | 0.28 | 0.18 | 0.16 | 0.16 | 0.24 | 0.4 |
| | 0.24 | 0.19 | 0.16 | 0.3 | 0.32 | 0.32 |
| Site 6 | 0.29 | 0.25 | 0.21 | 0.25 | 0.35 | 0.29 |
| | 0.28 | 0.58 | 0.29 | 0.25 | 0.26 | 0.42 |
| Site 7 | 0.41 | 0.43 | 0.56 | 0.3 | 0.31 | 0.3 |
| | 0.34 | 0.39 | 0.49 | 0.23 | 0.22 | 0.37 |

**Table24 Analytical results for P (g $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | **0-10** | **10-20** | **20-40** | **40-60** | **60-90** | **90-120** |
| Site 1 | 0.79 | 0.44 | 0.47 | 0.52 | 0.56 | 0.78 |
| | 0.68 | 0.44 | 0.5 | 0.52 | 0.62 | 1.05 |
| Site 2 | 1.07 | 0.8 | 0.65 | 0.68 | 0.67 | 0.77 |
| | 0.99 | 1.09 | 0.87 | 0.73 | 0.65 | 0.8 |
| Site 3 | 1.1 | 0.68 | 0.7 | 0.58 | 0.61 | 0.64 |
| | 1.14 | 1.03 | 0.46 | 0.87 | 0.74 | 0.64 |
| Site 4 | 0.9 | 0.54 | 0.57 | 0.45 | 0.21 | 0.54 |
| | 0.58 | 0.61 | 0.41 | 0.29 | 0.34 | 0.64 |
| Site 5 | 1.32 | 0.49 | 0.57 | 0.17 | 0.27 | 0.2 |
| | 0.82 | 0.48 | 0.41 | 0.56 | 0.29 | 0.24 |
| Site 6 | 0.95 | 0.73 | 0.74 | 0.81 | 0.41 | 0.63 |
| | 0.83 | 0.75 | 0.82 | 0.72 | 0.77 | 0.71 |
| Site 7 | 0.99 | 0.88 | 0.91 | 0.82 | 0.71 | 0.57 |
| | 1.07 | 0.98 | 0.88 | 0.55 | 0.71 | 0.56 |

**Table25 Analytical results for Na (g $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | **0-10** | **10-20** | **20-40** | **40-60** | **60-90** | **90-120** |
| Site 1 | 12.5 | 13.39 | 14.14 | 14.41 | 14.45 | 13.81 |
| | 12.5 | 13.58 | 15.03 | 13.74 | 13.22 | 13.24 |
| Site 2 | 15.73 | 16.43 | 16.11 | 11.92 | 11.18 | 11.36 |
| | 14.84 | 16.23 | 15.25 | 13.38 | 10.63 | 11.67 |
| Site 3 | 14.61 | 15.61 | 15.84 | 14.76 | 12.95 | 13.34 |
| | 15.04 | 14.97 | 15.84 | 15.43 | 13.77 | 11.88 |
| Site 4 | 12.1 | 14.8 | 12.01 | 14.19 | 15.15 | 15.17 |
| | 15.11 | 23.31 | 14.77 | 15.42 | 12.35 | 14.25 |
| Site 5 | 11.78 | 11.33 | 14.67 | 14.65 | 12 | 13.49 |
| | 12.16 | 12.97 | 13.11 | 12.07 | 13.5 | 12.94 |
| Site 6 | 12.22 | 11.23 | 12.14 | 13.27 | 12.8 | 12.75 |
| | 10.98 | 12.78 | 12.99 | 11.7 | 12.23 | 11.89 |
| Site 7 | 12.7 | 13.93 | 12.61 | 11.62 | 11.75 | 12.96 |
| | 15.37 | 14.09 | 11.77 | 12.72 | 10.76 | 14.4 |

**Table26 Analytical results for Mg (g $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 5.23 | 5.33 | 6.1 | 5.52 | 5.69 | 5.64 |
| | 5.69 | 5.51 | 6.28 | 5.9 | 5.78 | 5.94 |
| Site 2 | 5.22 | 5.07 | 5.47 | 6.71 | 7.18 | 6.88 |
| | 5.09 | 5.36 | 5.14 | 6.94 | 6.53 | 6.67 |
| Site 3 | 4.93 | 5.87 | 5.04 | 6.17 | 6.63 | 6.8 |
| | 5.02 | 4.98 | 5.76 | 5.08 | 6.35 | 6.88 |
| Site 4 | 5.52 | 5.43 | 6.22 | 5.98 | 5.84 | 6.56 |
| | 4.81 | 4.85 | 5.48 | 6.07 | 5.86 | 6.49 |
| Site 5 | 4.51 | 6.06 | 5.83 | 5.9 | 6.74 | 7.38 |
| | 5.68 | 5.37 | 6.23 | 7.21 | 6.79 | 6.69 |
| Site 6 | 6.4 | 6.65 | 6.74 | 6.49 | 6.36 | 6.18 |
| | 6.21 | 6.55 | 6.08 | 6.35 | 6.05 | 6.29 |
| Site 7 | 5.11 | 5.02 | 6.12 | 6.87 | 6.83 | 6.95 |
| | 6.57 | 5.06 | 6.5 | 6.74 | 7.16 | 6.96 |

**Table27 Analytical results for K (g $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 16.26 | 17.09 | 19.03 | 19.10 | 19.62 | 17.83 |
| | 16.75 | 19.43 | 19.84 | 18.28 | 18.75 | 18.18 |
| Site 2 | 18.83 | 17.87 | 17.22 | 17.24 | 17.00 | 17.20 |
| | 18.29 | 18.16 | 17.53 | 18.25 | 16.47 | 16.65 |
| Site 3 | 16.50 | 17.96 | 19.47 | 19.69 | 19.33 | 18.73 |
| | 16.48 | 17.91 | 19.47 | 18.97 | 18.26 | 17.07 |
| Site 4 | 17.87 | 20.07 | 20.57 | 21.39 | 21.73 | 22.32 |
| | 19.92 | 18.84 | 21.02 | 22.13 | 19.91 | 20.17 |
| Site 5 | 14.54 | 18.28 | 19.91 | 19.62 | 18.42 | 18.89 |
| | 18.72 | 18.77 | 18.65 | 19.05 | 19.88 | 18.69 |
| Site 6 | 15.10 | 16.65 | 18.88 | 18.69 | 18.65 | 18.32 |
| | 17.15 | 18.82 | 18.11 | 17.84 | 18.50 | 18.07 |
| Site 7 | 15.72 | 19.25 | 20.33 | 20.37 | 19.55 | 20.70 |
| | 19.68 | 19.43 | 19.74 | 20.33 | 19.61 | 20.08 |

**Table28 Analytical results for Ca (g $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 10.39 | 7.22 | 8.90 | 32.86 | 8.86 | 3.52 |
| | 15.99 | 8.39 | 63.20 | 2.34 | 7.87 | 17.79 |
| Site 2 | 9.97 | 9.84 | 9.89 | 10.73 | 10.28 | 10.01 |
| | 9.15 | 16.07 | 15.01 | 8.47 | 5.78 | 10.05 |
| Site 3 | 6.83 | 7.40 | 7.82 | 8.81 | 8.92 | 8.78 |
| | 5.62 | 10.49 | 7.08 | 7.46 | 7.54 | 6.90 |
| Site 4 | 5.19 | 5.08 | 4.53 | 4.46 | 6.14 | 9.01 |
| | 5.08 | 5.63 | 4.53 | 4.65 | 7.95 | 11.45 |
| Site 5 | 5.34 | 4.83 | 4.57 | 3.61 | 4.89 | 7.26 |
| | 5.11 | 4.98 | 6.14 | 3.53 | 5.55 | 9.59 |
| Site 6 | 6.64 | 6.46 | 8.02 | 7.49 | 7.58 | 8.50 |
| | 6.80 | 8.22 | 6.52 | 6.94 | 6.35 | 7.64 |
| Site 7 | 8.44 | 6.72 | 7.82 | 6.92 | 5.05 | 6.42 |
| | 6.08 | 6.72 | 6.70 | 5.06 | 4.90 | 7.49 |

**Table29 Analytical results for Al (g $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 84.43 | 87.08 | 84.03 | 80.42 | 85.24 | 80.55 |
| | 87.88 | 86.50 | 85.51 | 90.19 | 86.73 | 83.40 |
| Site 2 | 68.43 | 71.48 | 75.25 | 87.5 | 90.52 | 87.88 |
| | 68.4 | 64.15 | 69.3 | 94.33 | 90.09 | 87.92 |
| Site 3 | 67.98 | 68.44 | 73.32 | 86.04 | 88.70 | 88.58 |
| | 68.43 | 68.36 | 79.66 | 71.57 | 85.28 | 94.28 |
| Site 4 | 77.21 | 82.74 | 97.09 | 78.72 | 88.31 | 88.84 |
| | 75.25 | 70.37 | 81.09 | 86.84 | 92.41 | 87.99 |
| Site 5 | 63.43 | 79.19 | 86.33 | 81.64 | 85.98 | 77.54 |
| | 73.02 | 81.50 | 87.59 | 93.82 | 89.42 | 83.63 |
| Site 6 | 68.71 | 81.63 | 88.48 | 87.23 | 86.18 | 85.51 |
| | 66.57 | 84.96 | 79.51 | 86.75 | 86.67 | 85.69 |
| Site 7 | 74.94 | 70.64 | 84.64 | 94.09 | 93.51 | 91.60 |
| | 73.91 | 71.26 | 87.94 | 91.77 | 89.81 | 88.52 |

**Table30 Analytical results for $SiO_2$ (g $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 541.2 | 614.0 | 617.4 | 653.4 | 577.2 | 690.1 |
| | 583.8 | 617.6 | 629.8 | 608.8 | 565.4 | 669.4 |
| Site 2 | 644.5 | 663.5 | 685.3 | 549.7 | 578.4 | 591.6 |
| | 640.8 | 622.8 | 670.1 | 549.0 | 602.8 | 580.4 |
| Site 3 | 638.5 | 677.0 | 640.3 | 624.9 | 603.1 | 600.0 |
| | 641.3 | 651.4 | 651.7 | 644.0 | 603.6 | 581.0 |
| Site 4 | 562.8 | 611.4 | 580.6 | 616.1 | 640.6 | 617.4 |
| | 640.3 | 613.8 | 637.2 | 613.6 | 600.4 | 615.9 |
| Site 5 | 563.9 | 647.3 | 678.5 | 670.2 | 611.4 | 622.3 |
| | 586.1 | 681.5 | 673.0 | 595.4 | 615.3 | 622.9 |
| Site 6 | 593.5 | 586.7 | 588.4 | 586.5 | 593.3 | 589.7 |
| | 588.3 | 580.1 | 576.2 | 585.7 | 586.6 | 622.0 |
| Site 7 | 631.4 | 617.7 | 601.9 | 581.6 | 561.9 | 577.8 |
| | 629.5 | 636.1 | 603.3 | 582.0 | 566.9 | 599.1 |

**Table31 Analytical results for Ti (g $kg^{-1}$)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 1.86 | 2.07 | 2.38 | 2.21 | 1.95 | 2.09 |
| | 1.89 | 2.16 | 2.30 | 2.21 | 2.16 | 2.19 |
| Site 2 | 2.07 | 2.20 | 1.86 | 2.01 | 2.25 | 2.02 |
| | 2.12 | 2.18 | 2.11 | 2.20 | 2.12 | 2.13 |
| Site 3 | 2.10 | 2.02 | 2.49 | 1.97 | 2.00 | 2.15 |
| | 2.06 | 2.05 | 2.69 | 2.01 | 1.92 | 1.96 |
| Site 4 | 1.98 | 1.95 | 1.68 | 2.12 | 2.16 | 1.97 |
| | 2.07 | 2.21 | 1.94 | 0.93 | 1.98 | 2.18 |
| Site 5 | 2.35 | 2.24 | 2.32 | 2.22 | 2.32 | 2.59 |
| | 2.09 | 2.23 | 2.38 | 2.34 | 2.47 | 2.48 |
| Site 6 | 2.30 | 2.71 | 2.06 | 2.04 | 2.03 | 1.74 |
| | 2.32 | 2.14 | 2.00 | 1.95 | 1.81 | 1.79 |
| Site 7 | 1.85 | 1.85 | 2.12 | 2.18 | 2.10 | 2.17 |
| | 1.80 | 2.63 | 2.12 | 2.07 | 2.13 | 1.92 |

**Table32 Analytical results for water content (%)**

| Sampling sites | Soil depths (cm) | | | | | |
|---|---|---|---|---|---|---|
| | **0-10** | **10-20** | **20-40** | **40-60** | **60-90** | **90-120** |
| Site 1 | 37.1 | 24.1 | 27.2 | 22.2 | 21.8 | 24.5 |
| | 29.5 | 22.6 | 28.4 | 22.1 | 22.6 | 25.7 |
| Site 2 | 29.2 | 29.0 | 28.4 | 25.3 | 22.4 | 24.0 |
| | 33.7 | 29.8 | 33.0 | 26.3 | 23.9 | 26.8 |
| Site 3 | 35.4 | 25.0 | 25.1 | 25.0 | 24.2 | 22.9 |
| | 31.7 | 28.6 | 26.3 | 22.9 | 26.5 | 20.7 |
| Site 4 | 33.2 | 27.3 | 25.8 | 24.2 | 20.9 | 21.7 |
| | 32.7 | 29.5 | 24.9 | 21.5 | 18.9 | 23.9 |
| Site 5 | 40.7 | 24.4 | 20.5 | 21.7 | 19.8 | 19.6 |
| | 42.6 | 25.4 | 17.0 | 21.3 | 20.7 | 19.4 |
| Site 6 | 22.6 | 24.1 | 25.1 | 25.4 | 25.9 | 25.4 |
| | 24 | 24.8 | 25.2 | 26.3 | 24.9 | 24.4 |
| Site 7 | 21.7 | 24.3 | 21.8 | 22.9 | 23.7 | 21.6 |
| | 22.6 | 25.3 | 21.3 | 21.6 | 24.1 | 20.9 |

# Appendix Ⅱ: Analytical results for 2006

**Table1 Sampling sites in Sanjiang Plain region**

| Sampling sites. | Location | Soil type | Land use type | Reclamation history |
|---|---|---|---|---|
| Site 1 | 47°16.152′N, 133°45.797′E | Marsh soil | Wetland | Without reclamation |
| Site 2 | 47°17.122′N, 133°46.110′E | | Wetland (adjacent to Site 4 ) | Without reclamation |
| Site 3 | 47°31.706′N, 133°52.871′E | | Paddy field | 5 years |
| Site 4 | 47°17.122N, 133°46.076′E | | Paddy field | 23 years |
| Site 5 | 47°25.825′N, 133°52.517′E | | Forest | Without reclamation |
| Site 6 | 47°25.635′N, 133°52.577′E | | Forest | Without reclamation |
| Site 7 | 47°31.708′N, 133°52.872′E | | Upland field | 5 years |
| Site 8 | 47°17.073′N, 133°45.877′E | | Upland field | 23 years |
| Site 9 | 47°35.269′N, 133°30.146′E | Albic soil | Wetland | Without reclamation |
| Site 10 | 47°44.244′N, 133°31.212′E | | Wetland | Without reclamation |
| Site 11 | 47°44.216′N, 133°30.580′E | | Paddy field | 2 years |
| Site 12 | 47°39.479′N, 133°30.471′E | | Paddy field | 11 years |
| Site 13 | 47°23.082′N, 133°52.537′E | | Forest | Without reclamation |
| Site 14 | 47°22.633′N, 133°52.503′E | | Forest | Without reclamation |
| Site 15 | 47°44.482′N, 133°31.253′E | | Upland field | 4 years |
| Site 16 | 47°44.236′N, 133°30.625′E | | Upland field | 15 years |

**Table2 Analytical results for water content (%)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **0-10** | **10-20** | **20-30** | **30-40** | **40-60** | **60-90** | **90-120** |
| Site 1 | 35.1 | 19.6 | 20.7 | 21.4 | 22.7 | 20.5 | 20.1 |
| | 21.5 | 20.7 | 18.4 | 21.2 | 29.0 | 19.9 | 17.6 |
| Site 2 | 31.2 | 25.8 | 19.3 | 17.2 | 18.9 | 18.5 | 17.5 |
| | 23.5 | 27.3 | 22.9 | 21.3 | 23.3 | 28.5 | 14.9 |
| Site 3 | 30.1 | 21.2 | 18.0 | 19.8 | 21.6 | 19.9 | 23.2 |
| | 28.8 | 23.7 | 22.3 | 19.6 | 19.9 | 22.8 | 20.7 |
| Site 4 | 30.8 | 26.2 | 22.3 | 16.2 | 15.4 | 21.4 | 18.7 |
| | 30.0 | 24.8 | 19.1 | 19.7 | 20.8 | 21.1 | 14.9 |
| Site 5 | 22.3 | 23.6 | 24.0 | 20.6 | 17.9 | 18.8 | 19.1 |
| | 22.5 | 22.6 | 23.1 | 18.1 | 18.2 | 16.7 | 18.4 |
| Site 6 | 30.4 | 23.4 | 19.3 | 19.3 | 21.7 | 22.1 | 21.7 |
| | 26.3 | 25.2 | 20.0 | 20.0 | 19.6 | 21.8 | 21.5 |
| Site 7 | 23.9 | 26.7 | 25.6 | 22.0 | 21.5 | 21.0 | 21.4 |
| | 24.7 | 23.0 | 24.2 | 21.6 | 22.3 | 21.4 | 20.2 |
| Site 8 | 12.6 | 20.1 | 15.3 | 13.7 | 14.6 | 17.9 | 14.2 |
| | 16.0 | 20.5 | 18.4 | 17.1 | 17.0 | 16.6 | 18.6 |
| Site 9 | 38.6 | 24.8 | 19.1 | 19.1 | 20.9 | 20.5 | 18.6 |
| | 30.6 | 20.0 | 23.3 | 23.2 | 22.7 | 16.7 | 21.0 |
| Site 10 | 35.1 | 19.6 | 20.7 | 21.4 | 22.7 | 20.5 | 20.1 |
| | 21.5 | 20.7 | 18.4 | 21.2 | 29.0 | 19.9 | 17.6 |
| Site 11 | 32.7 | 33.2 | 32.5 | 25.5 | 19.5 | 25.0 | 21.7 |
| | 30.9 | 32.0 | 20.3 | 20.6 | 21.3 | 20.0 | 20.6 |
| Site 12 | 32.3 | 24.9 | 21.1 | 28.3 | 21.3 | 20.0 | 23.8 |
| | 32.5 | 20.6 | 19.8 | 21.8 | 19.8 | 15.6 | 22.6 |
| Site 13 | 31.8 | 22.6 | 16.0 | 17.0 | 17.2 | 16.6 | 11.6 |
| | 22.8 | 19.7 | 16.2 | 18.4 | 17.7 | 17.4 | 16.9 |
| Site 14 | 21.0 | 20.6 | 17.8 | 17.3 | 21.5 | 18.6 | 18.2 |
| | 18.6 | 19.5 | 20.8 | 20.1 | 21.4 | 20.1 | 18.0 |
| Site 15 | 23.5 | 18.5 | 20.9 | 21.7 | 25.9 | 18.8 | 23.9 |
| | 24.6 | 24.3 | 21.3 | 21.8 | 24.3 | 21.6 | 20.2 |
| Site 16 | 18.0 | 19.6 | 20.5 | 19.9 | 17.2 | 20.0 | 19.2 |
| | 18.6 | 23.6 | 19.3 | 19.9 | 19.1 | 21.8 | 20.7 |

**Table3 Analytical results for pH ($H_2O$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 4.82 | 5.25 | 5.40 | 5.35 | 5.27 | 5.25 | 5.22 |
| | 4.91 | 5.18 | 5.32 | 5.20 | 5.10 | 4.89 | 5.08 |
| Site 2 | 5.04 | 5.18 | 5.17 | 5.10 | 5.20 | 4.73 | 4.76 |
| | 5.19 | 5.31 | 5.02 | 5.19 | 5.27 | 4.96 | 5.01 |
| Site 3 | 5.73 | 6.16 | 6.32 | 6.55 | 6.50 | 6.50 | 6.32 |
| | 5.96 | 5.91 | 6.21 | 6.10 | 6.27 | 6.20 | 6.50 |
| Site 4 | 5.63 | 5.63 | 5.60 | 5.81 | 6.07 | 6.39 | 6.75 |
| | 5.69 | 5.33 | 5.75 | 6.31 | 6.02 | 7.08 | 6.62 |
| Site 5 | 5.24 | 5.25 | 5.29 | 5.29 | 5.58 | 5.81 | 6.07 |
| | 5.19 | 5.15 | 5.27 | 5.61 | 5.53 | 5.83 | 6.16 |
| Site 6 | 5.17 | 5.18 | 5.43 | 5.65 | 5.79 | 5.92 | 5.98 |
| | 5.34 | 5.16 | 5.49 | 5.60 | 5.64 | 5.92 | 6.08 |
| Site 7 | 5.28 | 5.24 | 5.40 | 5.06 | 5.31 | 5.28 | 6.80 |
| | 5.32 | 5.47 | 5.53 | 5.58 | 5.75 | 6.54 | 6.65 |
| Site 8 | 5.14 | 5.35 | 5.70 | 6.46 | 6.77 | 6.83 | 6.91 |
| | 5.15 | 5.29 | 5.70 | 5.90 | 6.58 | 6.74 | 6.90 |
| Site 9 | 5.10 | 5.12 | 5.23 | 5.42 | 5.73 | 5.75 | 5.79 |
| | 5.07 | 5.32 | 5.42 | 5.27 | 5.65 | 5.93 | 6.12 |
| Site 10 | 5.31 | 5.65 | 5.44 | 5.65 | 5.41 | 6.03 | 6.26 |
| | 5.41 | 5.43 | 5.33 | 5.37 | 5.53 | 6.09 | 6.70 |
| Site 11 | 5.59 | 5.42 | 5.37 | 5.62 | 5.56 | 5.83 | 5.18 |
| | 5.16 | 5.15 | 5.40 | 5.32 | 5.55 | 5.99 | 5.99 |
| Site 12 | 5.80 | 5.58 | 5.75 | 5.76 | 5.80 | 5.81 | 6.04 |
| | 5.71 | 5.24 | 5.52 | 5.55 | 5.89 | 5.77 | 5.52 |
| Site 13 | 5.00 | 5.10 | 5.43 | 5.38 | 5.43 | 5.64 | 5.83 |
| | 5.22 | 5.21 | 5.38 | 5.32 | 5.44 | 5.71 | 5.88 |
| Site 14 | 5.27 | 5.53 | 5.72 | 5.67 | 5.72 | 6.00 | 6.28 |
| | 5.30 | 5.51 | 5.61 | 5.66 | 5.73 | 5.93 | 6.27 |
| Site 15 | 4.87 | 4.97 | 5.33 | 5.68 | 6.20 | 6.61 | 6.76 |
| | 4.79 | 5.01 | 5.28 | 5.43 | 6.19 | 6.75 | 6.77 |
| Site 16 | 5.18 | 5.22 | 5.19 | 5.10 | 5.56 | 6.04 | 6.20 |
| | 5.10 | 4.27 | 5.06 | 5.19 | 5.36 | 5.93 | 6.04 |

**Table4 Analytical results for pH (KCl)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 4.82 | 5.25 | 5.40 | 5.35 | 5.27 | 5.25 | 5.22 |
| | 4.91 | 5.18 | 5.32 | 3.91 | 3.44 | 4.89 | 5.08 |
| Site 2 | 4.42 | 4.66 | 4.20 | 5.31 | 5.28 | 3.19 | 3.30 |
| | 4.38 | 4.34 | 4.35 | 4.33 | 4.12 | 3.78 | 3.35 |
| Site 3 | 4.65 | 4.66 | 4.70 | 4.74 | 4.86 | 4.98 | 4.75 |
| | 4.64 | 4.50 | 4.79 | 4.67 | 4.50 | 4.88 | 4.65 |
| Site 4 | 4.60 | 4.37 | 3.92 | 3.87 | 3.99 | 4.62 | 4.84 |
| | 4.46 | 4.10 | 3.94 | 3.96 | 4.37 | 4.94 | 4.91 |
| Site 5 | 4.28 | 4.28 | 4.35 | 4.15 | 4.27 | 4.11 | 4.32 |
| | 4.40 | 4.45 | 4.40 | 4.38 | 4.04 | 4.20 | 4.29 |
| Site 6 | 4.46 | 4.23 | 4.22 | 4.24 | 4.19 | 4.14 | 4.25 |
| | 4.60 | 4.28 | 4.33 | 4.29 | 4.15 | 4.21 | 4.30 |
| Site 7 | 4.03 | 4.26 | 4.85 | 4.13 | 3.81 | 4.52 | 4.12 |
| | 4.67 | 4.04 | 4.08 | 4.20 | 4.25 | 4.98 | 5.13 |
| Site 8 | 4.30 | 4.44 | 4.38 | 4.87 | 4.89 | 4.86 | 5.02 |
| | 4.35 | 4.43 | 4.57 | 4.80 | 5.01 | 4.93 | 4.97 |
| Site 9 | 3.86 | 3.62 | 3.49 | 3.51 | 3.53 | 3.61 | 3.78 |
| | 3.73 | 3.50 | 3.48 | 3.50 | 3.50 | 3.70 | 3.93 |
| Site 10 | 4.45 | 4.31 | 4.09 | 3.86 | 3.68 | 4.25 | 4.64 |
| | 4.33 | 4.17 | 3.88 | 3.72 | 3.74 | 4.32 | 4.90 |
| Site 11 | 4.61 | 4.45 | 4.18 | 4.42 | 4.00 | 4.20 | 4.40 |
| | 4.22 | 4.11 | 4.02 | 3.96 | 3.99 | 4.15 | 4.31 |
| Site 12 | 4.46 | 3.77 | 3.66 | 3.64 | 3.63 | 3.82 | 3.92 |
| | 4.59 | 3.91 | 3.82 | 3.79 | 3.71 | 3.90 | 4.00 |
| Site 13 | 3.91 | 3.71 | 3.74 | 3.60 | 3.58 | 3.55 | 3.75 |
| | 4.35 | 3.85 | 3.83 | 3.83 | 3.78 | 3.84 | 3.81 |
| Site 14 | 4.29 | 4.27 | 4.17 | 3.96 | 3.89 | 4.04 | 4.24 |
| | 4.13 | 3.93 | 3.73 | 3.72 | 3.76 | 3.89 | 4.25 |
| Site 15 | 4.03 | 4.05 | 4.00 | 4.18 | 4.55 | 4.88 | 4.87 |
| | 4.12 | 3.96 | 3.96 | 4.11 | 4.67 | 5.05 | 4.95 |
| Site 16 | 4.40 | 4.45 | 3.98 | 4.10 | 3.91 | 4.10 | 4.18 |
| | 4.38 | 4.29 | 4.06 | 3.95 | 3.86 | 4.06 | 4.22 |

**Table5 Analytical results for total iron (g $kg^{-1}$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 22.3 | 18.2 | 22.5 | 25.6 | 24.1 | 38.3 | 30.9 |
| | 19.6 | 16.8 | 21.2 | 26.8 | 27.9 | 27.3 | 38.4 |
| Site 2 | 11.3 | 9.6 | 11.2 | 18.5 | 22.3 | 42.0 | 38.8 |
| | 9.3 | 8.9 | 10.1 | 20.6 | 21.2 | 38.2 | 34.9 |
| Site 3 | 26.8 | 23.5 | 30.4 | 29.1 | 32.2 | 30.4 | 24.8 |
| | 24.3 | 29.8 | 27.4 | 26.2 | 27.1 | 36.9 | 27.6 |
| Site 4 | 26.4 | 27.3 | 24.8 | 25.3 | 21.2 | 32.7 | 34.2 |
| | 24.0 | 24.8 | 26.6 | 27.0 | 34.3 | 33.5 | 27.7 |
| Site 5 | 25.8 | 26.7 | 24.4 | 24.3 | 30.1 | 35.1 | 34.6 |
| | 29.6 | 26.0 | 33.5 | 25.4 | 29.3 | 39.9 | 32.3 |
| Site 6 | 26.2 | 26.8 | 31.2 | 28.4 | 32.0 | 38.5 | 34.8 |
| | 27.5 | 27.9 | 34.9 | 33.0 | 33.0 | 36.3 | 35.4 |
| Site 7 | 28.2 | 26.2 | 25.2 | 27.9 | 31.0 | 35.5 | 28.2 |
| | 26.1 | 25.6 | 28.2 | 29.5 | 30.6 | 36.5 | 32.5 |
| Site 8 | 30.4 | 28.1 | 26.4 | 27.9 | 31.0 | 34.3 | 22.7 |
| | 25.3 | 25.6 | 29.5 | 24.3 | 26.9 | 36.5 | 36.9 |
| Site 9 | 21.8 | 23.4 | 21.2 | 26.8 | 30.7 | 33.9 | 25.8 |
| | 22.5 | 20.5 | 22.0 | 24.6 | 31.4 | 33.9 | 24.6 |
| Site 10 | 14.3 | 12.9 | 12.2 | 20.7 | 30.6 | 31.6 | 25.4 |
| | 11.9 | 12.2 | 17.8 | 29.8 | 34.6 | 32.8 | 29.8 |
| Site 11 | 27.8 | 31.4 | 25.4 | 25.6 | 26.6 | 35.6 | 34.3 |
| | 26.5 | 30.9 | 30.1 | 30.5 | 32.8 | 35.6 | 34.0 |
| Site 12 | 24.2 | 22.3 | 21.7 | 28.1 | 33.3 | 30.9 | 31.7 |
| | 24.9 | 22.2 | 20.6 | 27.8 | 32.5 | 30.2 | 28.4 |
| Site 13 | 20.1 | 25.1 | 30.3 | 28.7 | 40.0 | 38.2 | 38.0 |
| | 22.2 | 23.9 | 24.8 | 29.5 | 28.3 | 35.7 | 37.6 |
| Site 14 | 30.5 | 28.5 | 34.6 | 30.4 | 33.1 | 34.6 | 36.8 |
| | 23.4 | 26.7 | 30.0 | 32.7 | 36.2 | 35.6 | 34.9 |
| Site 15 | 23.8 | 29.6 | 36.9 | 35.5 | 34.0 | 32.2 | 32.0 |
| | 25.1 | 33.9 | 26.0 | 20.8 | 32.3 | 30.6 | 28.2 |
| Site 16 | 24.8 | 23.7 | 25.2 | 26.5 | 26.8 | 34.8 | 35.6 |
| | 33.5 | 22.6 | 25.6 | 25.7 | 28.9 | 35.3 | 36.3 |

**Table6 Analytical results for free iron oxide iron (g $kg^{-1}$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **0-10** | **10-20** | **20-30** | **30-40** | **40-60** | **60-90** | **90-120** |
| Site 1 | 3.11 | 3.53 | 4.51 | 5.73 | 6.34 | 8.36 | 11.25 |
| | 3.15 | 3.36 | 4.59 | 6.00 | 6.82 | 7.63 | 11.28 |
| Site 2 | 1.54 | 1.65 | 2.35 | 2.15 | 3.64 | 10.14 | 10.63 |
| | 2.12 | 1.85 | 2.05 | 2.56 | 4.83 | 9.99 | 11.66 |
| Site 3 | 11.66 | 11.99 | 11.74 | 9.37 | 9.09 | 9.92 | 10.53 |
| | 11.98 | 16.49 | 12.18 | 12.08 | 9.23 | 10.54 | 12.02 |
| Site 4 | 5.23 | 5.00 | 4.22 | 5.61 | 6.64 | 10.34 | 10.50 |
| | 9.08 | 8.72 | 6.90 | 8.32 | 7.20 | 11.17 | 5.50 |
| Site 5 | 10.20 | 9.60 | 8.90 | 9.50 | 11.50 | 11.20 | 10.50 |
| | 11.14 | 10.35 | 9.94 | 8.90 | 10.90 | 10.06 | 11.39 |
| Site 6 | 10.85 | 11.35 | 10.20 | 10.72 | 10.60 | 11.50 | 11.90 |
| | 11.68 | 13.23 | 16.45 | 11.10 | 13.29 | 10.80 | 12.50 |
| Site 7 | 9.60 | 10.50 | 9.80 | 11.20 | 12.50 | 10.26 | 12.50 |
| | 8.80 | 11.20 | 8.70 | 11.80 | 11.90 | 11.04 | 11.54 |
| Site 8 | 12.50 | 10.60 | 9.80 | 9.20 | 7.40 | 11.20 | 10.50 |
| | 11.26 | 11.02 | 11.03 | 10.90 | 12.50 | 11.70 | 10.37 |
| Site 9 | 4.92 | 5.25 | 5.89 | 8.20 | 8.57 | 5.77 | 9.64 |
| | 4.90 | 5.12 | 6.04 | 7.90 | 8.25 | 6.55 | 9.02 |
| Site 10 | 2.93 | 1.50 | 2.13 | 4.07 | 7.50 | 6.00 | 10.50 |
| | 2.21 | 1.88 | 2.51 | 5.67 | 7.10 | 7.90 | 8.90 |
| Site 11 | 9.83 | 10.06 | 9.20 | 9.01 | 11.20 | 11.50 | 9.70 |
| | 10.88 | 13.00 | 9.50 | 10.81 | 10.80 | 10.10 | 12.50 |
| Site 12 | 11.86 | 13.15 | 8.88 | 10.13 | 12.30 | 11.43 | 12.99 |
| | 12.21 | 13.08 | 8.46 | 10.01 | 12.03 | 11.17 | 11.65 |
| Site 13 | 9.32 | 9.18 | 11.80 | 14.63 | 16.12 | 19.00 | 18.86 |
| | 11.43 | 11.59 | 12.13 | 16.55 | 15.60 | 17.07 | 19.46 |
| Site 14 | 14.23 | 14.43 | 15.80 | 11.84 | 10.84 | 11.17 | 15.58 |
| | 11.11 | 16.24 | 16.90 | 13.03 | 12.10 | 12.50 | 13.95 |
| Site 15 | 10.20 | 10.17 | 14.95 | 12.29 | 9.92 | 9.79 | 9.51 |
| | 9.28 | 10.20 | 12.50 | 11.20 | 11.31 | 8.55 | 6.96 |
| Site 16 | 11.86 | 8.16 | 8.84 | 10.18 | 10.14 | 10.24 | 8.41 |
| | 12.65 | 8.16 | 8.95 | 10.83 | 9.88 | 11.29 | 8.29 |

**Table7 Analytical results for alumino-silicate iron (g $kg^{-1}$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **0-10** | **10-20** | **20-30** | **30-40** | **40-60** | **60-90** | **90-120** |
| Site 1 | 19.14 | 14.67 | 17.99 | 19.87 | 17.75 | 29.89 | 19.69 |
| | 16.47 | 13.44 | 16.61 | 20.82 | 21.06 | 19.65 | 27.12 |
| Site 2 | 9.74 | 7.95 | 8.85 | 16.35 | 18.64 | 31.82 | 28.18 |
| | 7.23 | 7.05 | 8.05 | 18.04 | 16.37 | 28.21 | 23.27 |
| Site 3 | 15.14 | 11.54 | 18.67 | 19.76 | 23.07 | 20.48 | 14.23 |
| | 12.34 | 13.34 | 15.23 | 14.14 | 17.89 | 26.35 | 15.58 |
| Site 4 | 21.14 | 22.27 | 20.62 | 19.64 | 14.60 | 22.40 | 23.66 |
| | 14.95 | 16.03 | 19.65 | 18.72 | 27.09 | 22.29 | 22.24 |
| Site 5 | 15.59 | 17.12 | 15.50 | 14.80 | 18.60 | 23.85 | 24.07 |
| | 18.44 | 15.69 | 23.58 | 16.49 | 18.43 | 29.80 | 20.86 |
| Site 6 | 15.33 | 15.41 | 20.99 | 17.68 | 21.44 | 26.97 | 22.94 |
| | 15.83 | 14.63 | 18.48 | 21.92 | 19.73 | 25.47 | 22.90 |
| Site 7 | 18.60 | 15.70 | 15.40 | 16.66 | 18.54 | 25.24 | 15.70 |
| | 17.30 | 14.39 | 19.50 | 17.70 | 18.70 | 25.50 | 20.96 |
| Site 8 | 17.87 | 17.49 | 16.57 | 18.66 | 23.64 | 23.06 | 12.17 |
| | 14.04 | 14.57 | 18.43 | 13.36 | 14.38 | 24.84 | 26.51 |
| Site 9 | 16.84 | 18.17 | 15.32 | 18.60 | 22.10 | 28.12 | 16.16 |
| | 17.56 | 15.35 | 15.95 | 16.74 | 23.14 | 27.33 | 15.54 |
| Site 10 | 11.36 | 11.35 | 10.09 | 16.58 | 23.06 | 25.56 | 14.91 |
| | 9.72 | 10.29 | 15.26 | 24.08 | 27.52 | 24.94 | 20.85 |
| Site 11 | 17.94 | 21.31 | 16.23 | 16.62 | 15.36 | 24.10 | 24.55 |
| | 15.64 | 17.90 | 20.62 | 19.73 | 22.00 | 25.48 | 21.48 |
| Site 12 | 12.34 | 9.13 | 12.79 | 18.00 | 20.95 | 19.46 | 18.70 |
| | 12.71 | 9.09 | 12.18 | 17.79 | 20.48 | 19.03 | 16.76 |
| Site 13 | 10.79 | 15.95 | 18.46 | 14.07 | 23.83 | 19.17 | 19.17 |
| | 10.77 | 12.30 | 12.66 | 12.97 | 12.65 | 18.67 | 18.10 |
| Site 14 | 16.28 | 14.11 | 18.76 | 18.52 | 22.28 | 23.40 | 21.24 |
| | 12.24 | 10.49 | 13.12 | 19.62 | 24.14 | 23.12 | 20.90 |
| Site 15 | 13.63 | 19.43 | 21.93 | 23.24 | 24.07 | 22.40 | 22.44 |
| | 15.83 | 23.65 | 13.50 | 9.64 | 21.03 | 22.09 | 21.19 |
| Site 16 | 12.91 | 15.56 | 16.36 | 16.32 | 16.70 | 24.57 | 27.21 |
| | 20.81 | 14.39 | 16.65 | 14.87 | 19.02 | 23.99 | 27.99 |

**Table8 Analytical results for amorphous iron oxides (g $kg^{-1}$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 2.11 | 2.34 | 2.82 | 3.31 | 3.31 | 3.95 | 5.76 |
| | 2.25 | 2.13 | 2.53 | 3.23 | 2.85 | 3.72 | 5.47 |
| Site 2 | 1.24 | 1.22 | 1.55 | 1.52 | 2.11 | 5.31 | 7.76 |
| | 1.62 | 1.38 | 1.61 | 1.73 | 2.63 | 5.53 | 6.47 |
| Site 3 | 5.75 | 6.55 | 5.16 | 4.61 | 3.21 | 3.96 | 5.12 |
| | 6.19 | 7.12 | 5.29 | 5.15 | 3.53 | 4.23 | 5.18 |
| Site 4 | 2.83 | 2.71 | 2.47 | 2.49 | 2.66 | 2.63 | 3.53 |
| | 3.98 | 3.20 | 2.98 | 3.51 | 2.55 | 3.18 | 2.28 |
| Site 5 | 3.81 | 4.02 | 3.57 | 2.98 | 2.16 | 2.52 | 3.23 |
| | 4.20 | 4.60 | 3.98 | 2.81 | 2.05 | 2.28 | 3.16 |
| Site 6 | 3.21 | 4.53 | 4.15 | 3.56 | 2.12 | 2.26 | 2.90 |
| | 3.50 | 4.75 | 4.26 | 3.51 | 2.25 | 2.18 | 2.98 |
| Site 7 | 3.35 | 3.38 | 3.03 | 3.56 | 3.10 | 2.98 | 3.51 |
| | 3.30 | 3.52 | 3.22 | 3.73 | 2.99 | 3.06 | 3.38 |
| Site 8 | 3.87 | 3.90 | 4.28 | 3.96 | 2.34 | 3.10 | 2.82 |
| | 4.25 | 4.47 | 4.75 | 3.94 | 3.77 | 3.49 | 2.98 |
| Site 9 | 3.93 | 3.78 | 4.20 | 5.17 | 4.56 | 2.94 | 5.30 |
| | 3.83 | 3.33 | 4.43 | 5.14 | 4.30 | 3.41 | 4.69 |
| Site 10 | 2.20 | 1.06 | 1.25 | 2.82 | 4.58 | 4.22 | 5.78 |
| | 1.89 | 1.41 | 1.51 | 3.57 | 3.91 | 4.35 | 5.63 |
| Site 11 | 5.41 | 5.53 | 4.23 | 3.78 | 4.92 | 4.97 | 3.93 |
| | 6.63 | 6.76 | 4.66 | 4.86 | 4.98 | 4.23 | 4.25 |
| Site 12 | 6.52 | 6.70 | 3.70 | 4.22 | 4.43 | 3.00 | 3.86 |
| | 6.35 | 6.80 | 3.55 | 3.80 | 3.85 | 3.46 | 3.61 |
| Site 13 | 3.26 | 3.86 | 4.25 | 4.68 | 4.19 | 3.42 | 4.71 |
| | 3.66 | 4.52 | 4.61 | 4.80 | 3.43 | 3.58 | 4.09 |
| Site 14 | 4.98 | 5.63 | 5.06 | 3.79 | 2.38 | 2.79 | 2.96 |
| | 4.11 | 6.17 | 5.93 | 4.17 | 3.04 | 2.76 | 2.93 |
| Site 15 | 3.98 | 2.85 | 3.89 | 3.69 | 2.48 | 2.84 | 2.38 |
| | 3.48 | 2.75 | 3.88 | 3.14 | 2.94 | 2.74 | 2.02 |
| Site 16 | 4.63 | 2.37 | 2.48 | 2.95 | 2.33 | 2.97 | 2.69 |
| | 5.31 | 2.61 | 2.86 | 3.03 | 2.17 | 3.05 | 2.32 |

**Table9 Analytical results for crystal iron oxide (g $kg^{-1}$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 1.00 | 1.19 | 1.69 | 2.42 | 3.03 | 4.41 | 5.49 |
| | 0.90 | 1.22 | 2.06 | 2.77 | 3.98 | 3.91 | 5.81 |
| Site 2 | 0.30 | 0.43 | 0.80 | 0.63 | 1.53 | 4.83 | 2.87 |
| | 0.50 | 0.48 | 0.44 | 0.83 | 2.20 | 4.46 | 5.20 |
| Site 3 | 5.90 | 5.44 | 6.58 | 4.75 | 5.87 | 5.96 | 5.41 |
| | 5.79 | 9.37 | 6.88 | 6.93 | 5.70 | 6.31 | 6.84 |
| Site 4 | 2.40 | 2.29 | 1.75 | 3.13 | 3.98 | 7.71 | 6.98 |
| | 5.10 | 5.52 | 3.91 | 4.82 | 4.64 | 7.99 | 3.22 |
| Site 5 | 6.39 | 5.58 | 5.33 | 6.53 | 9.34 | 8.68 | 7.27 |
| | 6.94 | 5.75 | 5.96 | 6.10 | 8.85 | 7.78 | 8.24 |
| Site 6 | 7.64 | 6.82 | 6.05 | 7.16 | 8.48 | 9.24 | 9.00 |
| | 8.17 | 8.47 | 12.19 | 7.60 | 11.04 | 8.62 | 9.52 |
| Site 7 | 6.25 | 7.12 | 6.77 | 7.64 | 9.40 | 7.27 | 8.99 |
| | 5.50 | 7.68 | 5.48 | 8.07 | 8.91 | 7.98 | 8.16 |
| Site 8 | 8.63 | 6.70 | 5.52 | 5.24 | 5.07 | 8.10 | 7.68 |
| | 7.01 | 6.55 | 6.29 | 6.96 | 8.73 | 8.21 | 7.40 |
| Site 9 | 0.99 | 1.47 | 1.69 | 3.03 | 4.01 | 2.83 | 4.34 |
| | 1.07 | 1.79 | 1.61 | 2.77 | 3.95 | 3.14 | 4.33 |
| Site 10 | 0.73 | 0.43 | 0.87 | 1.25 | 2.93 | 1.78 | 4.73 |
| | 0.32 | 0.47 | 1.00 | 2.10 | 3.20 | 3.56 | 3.27 |
| Site 11 | 4.42 | 4.53 | 4.97 | 5.23 | 6.28 | 6.53 | 5.78 |
| | 4.24 | 6.24 | 4.85 | 5.95 | 5.82 | 5.87 | 8.25 |
| Site 12 | 5.34 | 6.44 | 5.19 | 5.91 | 7.87 | 8.43 | 9.13 |
| | 5.86 | 6.28 | 4.92 | 6.20 | 8.18 | 7.71 | 8.03 |
| Site 13 | 6.06 | 5.32 | 7.55 | 9.95 | 11.93 | 15.58 | 14.14 |
| | 7.77 | 7.07 | 7.52 | 11.75 | 12.17 | 13.48 | 15.37 |
| Site 14 | 9.25 | 8.81 | 10.74 | 8.05 | 8.45 | 8.38 | 12.62 |
| | 7.00 | 10.07 | 10.97 | 8.86 | 9.06 | 9.74 | 11.02 |
| Site 15 | 6.22 | 7.32 | 11.06 | 8.60 | 7.44 | 6.95 | 7.13 |
| | 5.80 | 7.45 | 8.63 | 8.06 | 8.37 | 5.81 | 4.94 |
| Site 16 | 7.23 | 5.79 | 6.37 | 7.23 | 7.81 | 7.27 | 5.72 |
| | 7.34 | 5.55 | 6.09 | 7.80 | 7.70 | 8.24 | 5.97 |

**Table10 Analytical results for chelate iron (g $kg^{-1}$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 1.16 | 0.99 | 1.28 | 1.33 | 1.37 | 0.89 | 0.52 |
| | 1.25 | 1.21 | 1.56 | 1.57 | 1.21 | 0.87 | 0.55 |
| Site 2 | 1.12 | 1.24 | 0.93 | 1.57 | 1.61 | 0.63 | 0.68 |
| | 1.08 | 1.03 | 0.87 | 1.83 | 1.45 | 0.73 | 0.78 |
| Site 3 | 1.85 | 0.91 | 0.61 | 0.63 | 0.50 | 0.56 | 0.86 |
| | 1.96 | 1.50 | 1.32 | 1.06 | 0.76 | 0.58 | 1.11 |
| Site 4 | 1.99 | 1.50 | 1.35 | 0.94 | 0.82 | 0.99 | 0.71 |
| | 1.82 | 2.17 | 1.28 | 0.83 | 0.78 | 0.59 | 0.49 |
| Site 5 | 1.71 | 1.76 | 1.61 | 1.34 | 0.88 | 0.68 | 0.68 |
| | 1.68 | 1.72 | 1.53 | 1.07 | 1.00 | 0.73 | 0.68 |
| Site 6 | 1.81 | 1.48 | 0.90 | 0.65 | 0.82 | 0.62 | 0.30 |
| | 1.81 | 1.26 | 0.89 | 0.66 | 0.88 | 0.64 | 0.36 |
| Site 7 | 1.19 | 1.06 | 1.78 | 1.24 | 1.15 | 0.68 | 0.64 |
| | 1.12 | 1.06 | 1.12 | 0.93 | 0.95 | 0.62 | 0.60 |
| Site 8 | 1.83 | 1.81 | 1.26 | 0.69 | 0.57 | 0.51 | 0.43 |
| | 1.74 | 1.77 | 1.43 | 0.70 | 0.81 | 0.56 | 0.61 |
| Site 9 | 1.28 | 1.57 | 0.79 | 0.95 | 0.65 | 0.60 | 0.63 |
| | 1.98 | 0.83 | 0.74 | 0.77 | 0.78 | 0.52 | 0.39 |
| Site 10 | 1.56 | 0.94 | 1.20 | 1.33 | 1.04 | 0.50 | 0.50 |
| | 1.46 | 1.10 | 1.27 | 1.52 | 1.20 | 0.58 | 0.50 |
| Site 11 | 2.59 | 2.36 | 1.57 | 1.97 | 0.66 | 0.76 | 0.59 |
| | 2.39 | 0.94 | 0.70 | 0.78 | 0.71 | 0.60 | 0.73 |
| Site 12 | 3.22 | 1.80 | 1.25 | 1.21 | 1.00 | 1.17 | 0.96 |
| | 3.28 | 1.12 | 0.80 | 0.90 | 0.86 | 0.90 | 0.79 |
| Site 13 | 1.69 | 1.03 | 0.62 | 0.73 | 0.81 | 0.71 | 0.64 |
| | 1.43 | 0.94 | 0.64 | 0.58 | 0.53 | 0.66 | 0.71 |
| Site 14 | 1.21 | 0.83 | 0.62 | 0.68 | 0.71 | 0.71 | 0.54 |
| | 0.98 | 0.63 | 0.57 | 0.72 | 0.60 | 0.56 | 0.56 |
| Site 15 | 1.50 | 1.48 | 0.79 | 0.60 | 0.70 | 0.55 | 0.62 |
| | 1.78 | 1.12 | 0.73 | 0.76 | 0.82 | 0.57 | 0.56 |
| Site 16 | 1.45 | 1.42 | 1.88 | 1.09 | 0.74 | 0.34 | 0.37 |
| | 1.38 | 1.58 | 1.66 | 1.03 | 0.55 | 0.42 | 0.41 |

**Table11 Analytical results for chelate ratio (%)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 26.35 | 19.54 | 19.75 | 23.22 | 21.61 | 10.64 | 4.62 |
| | 26.69 | 23.54 | 17.87 | 26.16 | 17.73 | 11.40 | 4.88 |
| Site 2 | 72.3 | 74.7 | 39.3 | 73.0 | 44.2 | 6.2 | 6.4 |
| | 50.8 | 55.3 | 42.1 | 71.5 | 30.0 | 7.3 | 6.7 |
| Site 3 | 15.9 | 7.6 | 5.2 | 6.7 | 5.5 | 5.6 | 8.2 |
| | 16.4 | 9.1 | 10.8 | 8.8 | 8.2 | 5.5 | 9.2 |
| Site 4 | 38.1 | 30.0 | 32.0 | 16.7 | 12.3 | 9.6 | 6.8 |
| | 20.0 | 24.9 | 18.6 | 10.0 | 10.8 | 5.3 | 8.9 |
| Site 5 | 16.76 | 18.33 | 18.09 | 14.11 | 7.65 | 6.07 | 6.48 |
| | 15.08 | 16.62 | 15.39 | 12.02 | 9.17 | 7.25 | 5.97 |
| Site 6 | 16.68 | 13.04 | 8.78 | 6.07 | 7.71 | 5.35 | 2.52 |
| | 15.50 | 9.54 | 5.44 | 5.95 | 6.60 | 5.94 | 2.91 |
| Site 7 | 12.40 | 10.10 | 18.16 | 11.07 | 9.20 | 6.63 | 5.12 |
| | 12.73 | 9.46 | 12.87 | 7.88 | 7.98 | 5.62 | 5.20 |
| Site 8 | 14.64 | 17.08 | 12.86 | 7.50 | 7.70 | 4.55 | 4.10 |
| | 15.46 | 16.07 | 12.96 | 6.38 | 6.48 | 4.79 | 5.88 |
| Site 9 | 26.06 | 29.85 | 13.48 | 11.59 | 7.62 | 10.44 | 6.50 |
| | 40.50 | 16.25 | 12.21 | 9.68 | 9.48 | 7.94 | 4.37 |
| Site 10 | 53.11 | 62.73 | 56.41 | 32.65 | 13.84 | 8.32 | 4.78 |
| | 65.85 | 58.46 | 50.52 | 26.77 | 16.92 | 7.37 | 5.66 |
| Site 11 | 26.34 | 23.46 | 17.07 | 21.86 | 5.89 | 6.61 | 6.08 |
| | 21.98 | 7.23 | 7.37 | 7.22 | 6.57 | 5.94 | 5.84 |
| Site 12 | 27.15 | 13.69 | 14.07 | 11.95 | 8.13 | 10.24 | 7.39 |
| | 26.86 | 8.56 | 9.45 | 8.99 | 7.15 | 8.05 | 6.78 |
| Site 13 | 18.14 | 11.22 | 5.25 | 4.99 | 5.02 | 3.74 | 3.39 |
| | 12.51 | 8.11 | 5.28 | 3.50 | 3.40 | 3.87 | 3.65 |
| Site 14 | 8.50 | 5.75 | 3.92 | 5.74 | 6.55 | 6.36 | 3.47 |
| | 8.82 | 3.88 | 3.37 | 5.53 | 4.96 | 4.48 | 4.01 |
| Site 15 | 14.66 | 14.55 | 5.25 | 4.84 | 7.06 | 5.62 | 6.52 |
| | 19.13 | 10.98 | 5.80 | 6.74 | 7.25 | 6.67 | 8.05 |
| Site 16 | 12.23 | 17.40 | 21.26 | 10.74 | 7.30 | 3.32 | 4.40 |
| | 10.91 | 19.36 | 18.54 | 9.51 | 5.57 | 3.72 | 4.94 |

**Table12 Analytical results for active ratio (%)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 67.9 | 66.3 | 62.6 | 57.8 | 52.3 | 47.2 | 51.2 |
| | 71.4 | 63.5 | 55.2 | 53.8 | 41.7 | 48.7 | 48.5 |
| Site 2 | 80.6 | 73.8 | 65.9 | 70.8 | 58.1 | 52.4 | 73.0 |
| | 76.4 | 74.3 | 78.5 | 67.7 | 54.5 | 55.3 | 55.4 |
| Site 3 | 49.4 | 54.6 | 44.0 | 49.2 | 35.4 | 39.9 | 48.6 |
| | 51.7 | 43.2 | 43.5 | 42.6 | 38.2 | 40.2 | 43.1 |
| Site 4 | 54.1 | 54.2 | 58.6 | 44.3 | 40.1 | 25.4 | 33.6 |
| | 43.8 | 36.7 | 43.3 | 42.1 | 35.5 | 28.5 | 41.4 |
| Site 5 | 37.3 | 41.8 | 40.1 | 31.3 | 18.8 | 22.5 | 30.7 |
| | 37.7 | 44.5 | 40.0 | 31.5 | 18.8 | 22.7 | 27.7 |
| Site 6 | 29.6 | 39.9 | 40.7 | 33.2 | 20.0 | 19.7 | 24.3 |
| | 30.0 | 35.9 | 25.9 | 31.6 | 17.0 | 20.2 | 23.8 |
| Site 7 | 34.9 | 32.2 | 30.9 | 31.8 | 24.8 | 29.1 | 28.1 |
| | 37.5 | 31.4 | 37.1 | 31.6 | 25.1 | 27.7 | 29.3 |
| Site 8 | 31.0 | 36.8 | 43.7 | 43.1 | 31.5 | 27.7 | 26.8 |
| | 37.8 | 40.5 | 43.0 | 36.1 | 30.2 | 29.8 | 28.7 |
| Site 9 | 79.8 | 72.0 | 71.3 | 63.0 | 53.2 | 51.0 | 55.0 |
| | 78.2 | 65.0 | 73.3 | 65.0 | 52.1 | 52.0 | 52.0 |
| Site 10 | 75.0 | 71.0 | 58.9 | 69.4 | 61.0 | 70.3 | 55.0 |
| | 85.6 | 75.0 | 60.0 | 63.0 | 55.0 | 55.0 | 63.2 |
| Site 11 | 55.1 | 54.5 | 45.7 | 42.2 | 43.8 | 43.5 | 40.2 |
| | 60.6 | 52.3 | 49.5 | 45.4 | 46.3 | 41.6 | 34.4 |
| Site 12 | 54.8 | 51.0 | 41.6 | 41.5 | 35.8 | 26.2 | 30.0 |
| | 52.0 | 52.0 | 41.9 | 38.0 | 32.0 | 31.0 | 31.0 |
| Site 13 | 35.4 | 42.5 | 35.6 | 32.1 | 26.1 | 17.9 | 24.9 |
| | 32.0 | 39.0 | 38.0 | 29.0 | 22.0 | 21.0 | 21.0 |
| Site 14 | 35.1 | 38.8 | 32.3 | 32.1 | 22.1 | 25.1 | 19.3 |
| | 37.0 | 38.0 | 35.1 | 32.0 | 25.1 | 22.1 | 21.0 |
| Site 15 | 39.2 | 27.5 | 26.1 | 30.1 | 25.2 | 28.6 | 25.2 |
| | 37.5 | 27.0 | 31.0 | 28.0 | 26.0 | 32.0 | 29.0 |
| Site 16 | 38.7 | 29.3 | 28.4 | 29.4 | 22.8 | 29.4 | 32.1 |
| | 41.7 | 31.7 | 32.2 | 27.8 | 22.2 | 26.5 | 27.7 |

**Table13 Analytical results for Fe(Ⅱ) (mg $kg^{-1}$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **0-10** | **10-20** | **20-30** | **30-40** | **40-60** | **60-90** | **90-120** |
| Site 1 | 25.8 | 26.0 | 16.4 | 14.6 | 17.5 | 17.2 | 17.8 |
| | 57.6 | 20.6 | 15.5 | 242.7 | 208.8 | 25.2 | 18.0 |
| Site 2 | 153.3 | 156.9 | 144.8 | 212.5 | 251.2 | 249.5 | 226.1 |
| | 135.0 | 113.5 | 123.4 | 239.8 | 255.0 | 251.3 | 207.0 |
| Site 3 | 28.0 | 27.5 | 19.3 | 20.7 | 15.4 | 15.3 | 33.5 |
| | 52.2 | 41.5 | 37.2 | 38.5 | 36.9 | 17.5 | 21.0 |
| Site 4 | 185.3 | 87.4 | 39.7 | 38.7 | 30.8 | 27.7 | 21.0 |
| | 197.9 | 82.3 | 38.1 | 35.9 | 25.9 | 14.8 | 17.3 |
| Site 5 | 32.2 | 22.8 | 34.1 | 37.4 | 37.2 | 20.6 | 21.0 |
| | 23.8 | 26.7 | 26.9 | 26.7 | 20.9 | 17.9 | 20.5 |
| Site 6 | 66.9 | 61.6 | 54.6 | 50.3 | 46.6 | 50.7 | 36.6 |
| | 32.6 | 38.3 | 19.4 | 22.1 | 21.7 | 17.3 | 18.4 |
| Site 7 | 42.3 | 43.3 | 45.8 | 62.1 | 62.0 | 34.6 | 28.5 |
| | 94.1 | 77.4 | 65.4 | 73.6 | 93.6 | 50.3 | 50.3 |
| Site 8 | 34.2 | 27.1 | 36.2 | 24.4 | 26.0 | 20.5 | 18.8 |
| | 40.3 | 37.3 | 32.0 | 26.6 | 24.1 | 19.1 | 19.0 |
| Site 9 | 83.0 | 31.9 | 85.5 | 86.5 | 64.7 | 50.9 | 49.3 |
| | 81.0 | 46.6 | 36.2 | 30.8 | 33.1 | 31.1 | 23.1 |
| Site 10 | 143.0 | 76.8 | 113.9 | 128.3 | 90.2 | 46.6 | 51.4 |
| | 44.9 | 74.0 | 52.1 | 69.0 | 57.9 | 29.5 | 22.3 |
| Site 11 | 260.9 | 177.1 | 43.7 | 15.4 | 28.1 | 21.9 | 18.6 |
| | 45.2 | 40.4 | 24.2 | 18.4 | 19.0 | 20.8 | 17.6 |
| Site 12 | 254.4 | 90.3 | 47.5 | 30.1 | 32.3 | 24.0 | 22.4 |
| | 228.3 | 33.1 | 25.9 | 30.3 | 30.0 | 21.8 | 23.3 |
| Site 13 | 33.1 | 37.3 | 28.7 | 29.7 | 24.2 | 25.7 | 20.6 |
| | 23.2 | 32.0 | 23.4 | 24.7 | 24.0 | 22.4 | 22.7 |
| Site 14 | 21.4 | 18.4 | 17.1 | 20.9 | 23.0 | 20.7 | 15.7 |
| | 26.7 | 23.9 | 22.7 | 27.6 | 29.9 | 18.7 | 26.0 |
| Site 15 | 93.3 | 38.5 | 41.1 | 52.4 | 52.8 | 37.6 | 95.6 |
| | 91.3 | 53.4 | 58.0 | 53.4 | 18.7 | 14.0 | 15.3 |
| Site 16 | 34.9 | 34.9 | 42.8 | 52.4 | 40.5 | 22.0 | 19.3 |
| | 29.8 | 28.1 | 64.2 | 52.8 | 46.2 | 24.8 | 18.7 |

**Table14 Analytical results for OC (g $kg^{-1}$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 61.7 | 22.9 | 12.9 | 6.7 | 2.8 | 1.3 | 0.5 |
| | 68.8 | 14.5 | 10.4 | 21.5 | 28.8 | 1.8 | 0.6 |
| Site 2 | 82.6 | 15.8 | 11.3 | 20.8 | 19.0 | 5.3 | 1.1 |
| | 88.6 | 13.2 | 15.9 | 16.5 | 23.7 | 4.6 | 1.0 |
| Site 3 | 23.9 | 9.2 | 6.7 | 6.9 | 7.2 | 7.9 | 9.7 |
| | 20.6 | 15.7 | 9.7 | 8.1 | 6.5 | 5.9 | 5.2 |
| Site 4 | 26.7 | 25.1 | 9.6 | 3.4 | 3.8 | 8.3 | 3.8 |
| | 12.5 | 20.7 | 15.7 | 5.3 | 4.8 | 3.1 | 2.1 |
| Site 5 | 28.5 | 23.9 | 24.2 | 15.5 | 7.0 | 5.6 | 5.1 |
| | 33.2 | 37.4 | 25.8 | 13.4 | 8.0 | 7.0 | 4.5 |
| Site 6 | 31.2 | 2.6 | 6.9 | 6.1 | 6.3 | 5.4 | 5.8 |
| | 30.3 | 23.3 | 11.1 | 7.2 | 6.2 | 4.9 | 2.7 |
| Site 7 | 8.2 | 16.3 | 61.1 | 13.3 | 7.3 | 10.5 | 4.1 |
| | 51.2 | 7.2 | 7.2 | 7.7 | 8.8 | 2.4 | 3.7 |
| Site 8 | 23.5 | 3.7 | 10.7 | 4.4 | 4.8 | 3.6 | 1.8 |
| | 26.3 | 26.9 | 16.0 | 14.4 | 7.8 | 4.7 | 2.9 |
| Site 9 | 41.7 | 16.6 | 5.8 | 6.8 | 5.7 | 6.4 | 7.5 |
| | 22.6 | 5.9 | 5.3 | 6.9 | 6.4 | 5.4 | 5.3 |
| Site 10 | 52.9 | 11.7 | 11.1 | 8.7 | 7.6 | 4.4 | 5.0 |
| | 24.3 | 14.3 | 8.3 | 9.1 | 7.6 | 4.0 | 2.8 |
| Site 11 | 32.9 | 33.1 | 23.8 | 25.1 | 5.7 | 14.4 | 5.2 |
| | 39.7 | 23.2 | 5.0 | 7.0 | 6.4 | 4.7 | 4.2 |
| Site 12 | 28.4 | 12.8 | 6.6 | 8.0 | 5.9 | 7.3 | 6.0 |
| | 26.4 | 9.0 | 4.1 | 4.1 | 4.1 | 9.9 | 3.8 |
| Site 13 | 39.6 | 11.1 | 5.3 | 4.1 | 4.2 | 3.4 | 2.7 |
| | 54.9 | 13.4 | 4.6 | 4.9 | 3.7 | 3.0 | 3.7 |
| Site 14 | 22.7 | 10.8 | 5.6 | 6.2 | 5.6 | 6.0 | 4.1 |
| | 18.7 | 8.1 | 4.8 | 6.3 | 4.6 | 4.7 | 5.1 |
| Site 15 | 35.8 | 27.4 | 9.2 | 8.6 | 5.9 | 4.2 | 4.3 |
| | 41.5 | 9.3 | 8.8 | 10.8 | 6.6 | 3.9 | 3.2 |
| Site 16 | 29.5 | 27.3 | 16.7 | 18.9 | 32.6 | 4.3 | 4.3 |
| | 29.3 | 34.7 | 14.9 | 8.3 | 4.9 | 5.3 | 5.1 |

**Table15 Analytical results for $SiO_2$ (g $kg^{-1}$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 548.7 | 512.2 | 532.6 | 512.3 | 535.5 | 616.3 | 687.5 |
| | 529.6 | 506.6 | 514.9 | 553.2 | 577.3 | 632.8 | 626.8 |
| Site 2 | 332.2 | 154.2 | 240.9 | 557.8 | 580.9 | 386.5 | 572.0 |
| | 389.8 | 202.5 | 199.5 | 483.5 | 288.7 | 593.6 | 518.2 |
| Site 3 | 602.2 | 530.4 | 669.9 | 719.7 | 553.1 | 465.2 | 628.8 |
| | 643.1 | 609.8 | 665.1 | 671.0 | 568.7 | 574.6 | 621.3 |
| Site 4 | 584.3 | 638.6 | 684.4 | 657.4 | 710.2 | 596.0 | 565.4 |
| | 641.2 | 660.3 | 693.6 | 621.4 | 574.7 | 566.4 | 565.6 |
| Site 5 | 720.3 | 633.3 | 598.0 | 504.8 | 744.9 | 591.1 | 582.5 |
| | 659.4 | 525.1 | 405.1 | 632.4 | 655.2 | 617.3 | 756.7 |
| Site 6 | 547.9 | 655.8 | 667.8 | 644.6 | 621.7 | 539.4 | 615.5 |
| | 605.3 | 655.7 | 631.5 | 558.5 | 596.1 | 613.0 | 644.7 |
| Site 7 | 614.3 | 584.7 | 546.3 | 626.8 | 620.0 | 505.8 | 514.6 |
| | 597.0 | 784.0 | 518.5 | 629.6 | 561.9 | 689.1 | 443.0 |
| Site 8 | 610.8 | 625.5 | 371.4 | 581.6 | 533.8 | 531.5 | 601.4 |
| | 530.6 | 607.2 | 635.7 | 662.3 | 698.7 | 543.5 | 546.7 |
| Site 9 | 647.7 | 721.2 | 720.9 | 656.4 | 622.9 | 597.9 | 625.6 |
| | 616.2 | 684.3 | 615.0 | 664.4 | 609.5 | 519.5 | 596.7 |
| Site 10 | 528.4 | 688.9 | 611.4 | 706.2 | 653.2 | 632.3 | 600.1 |
| | 624.7 | 607.1 | 578.9 | 580.5 | 548.1 | 578.1 | 604.8 |
| Site 11 | 625.5 | 588.8 | 623.9 | 601.6 | 480.6 | 596.0 | 595.6 |
| | 519.3 | 640.4 | 610.6 | 604.2 | 697.0 | 598.0 | 585.7 |
| Site 12 | 574.7 | 605.9 | 742.6 | 626.6 | 764.5 | 655.6 | 658.8 |
| | 670.9 | 738.9 | 774.1 | 596.0 | 569.2 | 734.0 | 806.1 |
| Site 13 | 603.9 | 774.8 | 656.4 | 666.4 | 641.6 | 627.6 | 614.1 |
| | 571.3 | 687.6 | 765.6 | 684.3 | 693.4 | 741.5 | 577.8 |
| Site 14 | 608.7 | 618.6 | 601.9 | 559.6 | 607.6 | 580.5 | 653.9 |
| | 688.7 | 698.6 | 681.9 | 639.6 | 687.6 | 660.5 | 733.9 |
| Site 15 | 578.0 | 574.0 | 686.1 | 580.3 | 513.5 | 524.2 | 530.3 |
| | 575.7 | 572.2 | 670.4 | 660.3 | 593.5 | 604.2 | 610.2 |
| Site 16 | 654.7 | 608.6 | 652.9 | 736.7 | 673.1 | 544.3 | 359.1 |
| | 744.7 | 608.3 | 742.9 | 726.7 | 763.1 | 634.3 | 449.1 |

**Table16 Analytical results for $Al_2O_3$ (g $kg^{-1}$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 96.3 | 82.1 | 79.6 | 62.4 | 82.5 | 58.9 | 97.5 |
| | 92.9 | 80.3 | 77.6 | 96.3 | 88.5 | 86.3 | 98.8 |
| Site 2 | 87.6 | 57.1 | 56.6 | 83.8 | 63.2 | 89.7 | 86.5 |
| | 82.7 | 55.8 | 53.6 | 80.2 | 66.3 | 93.0 | 87.0 |
| Site 3 | 79.0 | 78.9 | 86.3 | 97.6 | 81.9 | 72.8 | 91.1 |
| | 85.7 | 84.3 | 88.5 | 87.5 | 97.6 | 81.6 | 92.5 |
| Site 4 | 62.5 | 83.4 | 88.0 | 42.4 | 85.8 | 87.5 | 89.1 |
| | 83.4 | 87.1 | 85.5 | 87.6 | 57.4 | 86.3 | 91.3 |
| Site 5 | 83.3 | 82.0 | 85.9 | 80.4 | 87.9 | 86.2 | 83.3 |
| | 82.3 | 79.9 | 79.6 | 71.7 | 78.7 | 89.2 | 86.8 |
| Site 6 | 84.3 | 86.5 | 89.3 | 94.5 | 85.1 | 81.7 | 88.1 |
| | 81.8 | 88.3 | 91.6 | 90.0 | 87.7 | 84.6 | 80.4 |
| Site 7 | 89.5 | 89.5 | 90.9 | 84.8 | 92.0 | 73.9 | 83.9 |
| | 93.6 | 89.3 | 75.3 | 85.5 | 90.8 | 73.6 | 72.1 |
| Site 8 | 84.0 | 69.5 | 71.2 | 73.5 | 87.0 | 91.9 | 89.7 |
| | 68.2 | 68.9 | 71.6 | 87.6 | 79.6 | 89.9 | 84.4 |
| Site 9 | 63.0 | 68.6 | 68.9 | 66.6 | 81.7 | 93.0 | 86.7 |
| | 68.6 | 65.4 | 63.3 | 68.9 | 78.6 | 89.7 | 74.1 |
| Site 10 | 56.3 | 48.7 | 81.3 | 72.1 | 82.8 | 83.8 | 75.2 |
| | 76.1 | 78.0 | 87.9 | 86.2 | 83.5 | 95.2 | 88.3 |
| Site 11 | 68.5 | 72.3 | 66.0 | 73.4 | 84.5 | 83.0 | 93.9 |
| | 68.0 | 69.9 | 71.7 | 87.5 | 87.8 | 91.3 | 92.2 |
| Site 12 | 73.6 | 69.7 | 66.0 | 78.9 | 93.8 | 94.9 | 87.5 |
| | 65.1 | 67.9 | 74.5 | 81.4 | 89.3 | 90.5 | 88.9 |
| Site 13 | 65.2 | 63.8 | 70.5 | 87.8 | 86.4 | 95.2 | 88.2 |
| | 70.1 | 68.9 | 77.4 | 77.1 | 85.1 | 82.5 | 90.2 |
| Site 14 | 79.2 | 68.9 | 66.1 | 78.1 | 89.7 | 93.7 | 91.4 |
| | 64.0 | 70.7 | 88.3 | 93.7 | 96.9 | 96.0 | 90.0 |
| Site 15 | 73.7 | 75.3 | 83.5 | 77.3 | 89.4 | 90.3 | 88.1 |
| | 64.6 | 60.8 | 66.6 | 68.3 | 76.8 | 91.5 | 88.5 |
| Site 16 | 64.7 | 66.5 | 62.3 | 73.5 | 85.3 | 81.8 | 91.5 |
| | 62.8 | 70.8 | 70.5 | 64.1 | 79.5 | 80.9 | 95.5 |

**Table17 Analytical results for Sa ($SiO_3/Al_2O_3$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 3.0 | 3.3 | 3.5 | 4.3 | 3.4 | 5.5 | 3.7 |
| | 3.0 | 3.3 | 3.5 | 3.0 | 3.5 | 3.9 | 3.4 |
| Site 2 | 2.0 | 1.4 | 2.3 | 3.5 | 4.9 | 2.3 | 3.5 |
| | 2.5 | 1.9 | 2.0 | 3.2 | 2.3 | 3.4 | 3.2 |
| Site 3 | 4.0 | 3.6 | 4.1 | 3.9 | 3.6 | 3.4 | 3.7 |
| | 4.0 | 3.8 | 4.0 | 4.1 | 3.1 | 3.7 | 3.6 |
| Site 4 | 4.9 | 4.1 | 4.1 | 8.2 | 4.4 | 3.6 | 3.4 |
| | 4.1 | 4.0 | 4.3 | 3.8 | 5.3 | 3.5 | 3.3 |
| Site 5 | 4.6 | 4.1 | 3.7 | 3.3 | 4.5 | 3.6 | 3.7 |
| | 4.2 | 3.5 | 2.7 | 4.7 | 4.4 | 3.7 | 4.6 |
| Site 6 | 3.4 | 4.0 | 4.0 | 3.6 | 3.9 | 3.5 | 3.7 |
| | 3.9 | 3.9 | 3.6 | 3.3 | 3.6 | 3.8 | 4.2 |
| Site 7 | 3.6 | 3.5 | 3.2 | 3.9 | 3.6 | 3.6 | 3.2 |
| | 3.4 | 4.6 | 3.6 | 3.9 | 3.3 | 5.0 | 3.3 |
| Site 8 | 3.8 | 4.8 | 2.8 | 4.2 | 3.2 | 3.1 | 3.5 |
| | 4.1 | 4.7 | 4.7 | 4.0 | 4.6 | 3.2 | 3.4 |
| Site 9 | 5.4 | 5.6 | 5.5 | 5.2 | 4.0 | 3.4 | 3.8 |
| | 4.8 | 5.5 | 5.1 | 5.1 | 4.1 | 3.1 | 4.3 |
| Site 10 | 5.0 | 7.5 | 4.0 | 5.2 | 4.2 | 4.0 | 4.2 |
| | 4.3 | 4.1 | 3.5 | 3.6 | 3.5 | 3.2 | 3.6 |
| Site 11 | 4.8 | 4.3 | 5.0 | 4.3 | 3.0 | 3.8 | 3.4 |
| | 4.0 | 4.8 | 4.5 | 3.7 | 4.2 | 3.5 | 3.4 |
| Site 12 | 4.1 | 4.6 | 6.0 | 4.2 | 4.3 | 3.7 | 4.0 |
| | 5.5 | 5.8 | 5.5 | 3.9 | 3.4 | 4.3 | 4.8 |
| Site 13 | 4.9 | 6.4 | 4.9 | 4.0 | 3.9 | 3.5 | 3.7 |
| | 4.3 | 5.3 | 5.2 | 4.7 | 4.3 | 4.8 | 3.4 |
| Site 14 | 4.1 | 4.8 | 4.8 | 3.8 | 3.6 | 3.3 | 3.8 |
| | 5.7 | 5.2 | 4.1 | 3.6 | 3.8 | 3.6 | 4.3 |
| Site 15 | 4.2 | 4.0 | 4.3 | 4.0 | 3.0 | 3.1 | 3.2 |
| | 4.7 | 5.0 | 5.3 | 5.1 | 4.1 | 3.5 | 3.6 |
| Site 16 | 5.4 | 4.8 | 5.5 | 5.3 | 4.2 | 3.5 | 2.1 |
| | 6.3 | 4.5 | 5.6 | 6.0 | 5.1 | 4.1 | 2.5 |

**Table18 Analytical results for $K^+$ (mg $kg^{-1}$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 15.6 | 6.2 | 6.2 | 6.2 | 9.5 | 7.5 | 8.4 |
| | 12.5 | 6.2 | 6.2 | 8.8 | 6.2 | 8.1 | 7.5 |
| Site 2 | 17.5 | 15.1 | 18.4 | 7.5 | 8.8 | 7.5 | 7.5 |
| | 14.9 | 12.1 | 14.2 | 14.2 | 8.8 | 8.8 | 7.5 |
| Site 3 | 7.0 | 5.6 | 5.6 | 5.6 | 5.6 | 5.6 | 4.9 |
| | 7.0 | 5.6 | 5.6 | 6.3 | 5.6 | 5.6 | 5.9 |
| Site 4 | 5.6 | 4.2 | 3.6 | 4.2 | 4.2 | 5.6 | 5.6 |
| | 4.9 | 4.2 | 3.6 | 4.2 | 4.2 | 4.9 | 7.0 |
| Site 5 | 5.5 | 6.3 | 5.1 | 7.3 | 5.6 | 4.9 | 5.3 |
| | 8.7 | 6.3 | 5.6 | 5.3 | 4.9 | 4.9 | 7.0 |
| Site 6 | 9.9 | 2.9 | 2.0 | 2.0 | 2.0 | 2.0 | 1.2 |
| | 8.3 | 8.9 | 6.4 | 3.8 | 3.8 | 2.0 | 3.8 |
| Site 7 | 14.7 | 12.6 | 5.6 | 16.1 | 10.4 | 14.0 | 13.3 |
| | 12.9 | 11.9 | 9.7 | 10.4 | 9.1 | 19.7 | 16.1 |
| Site 8 | 9.4 | 6.3 | 4.9 | 6.7 | 6.0 | 4.9 | 5.3 |
| | 8.4 | 7.3 | 5.3 | 3.6 | 4.6 | 3.6 | 6.0 |
| Site 9 | 17.8 | 2.0 | 1.2 | 1.2 | 2.0 | 2.9 | 2.9 |
| | 10.8 | 2.0 | 1.2 | 1.2 | 2.0 | 2.0 | 2.9 |
| Site 10 | 14.3 | 9.1 | 8.2 | 8.2 | 4.7 | 4.7 | 7.3 |
| | 15.3 | 8.2 | 7.3 | 5.5 | 4.7 | 6.4 | 6.4 |
| Site 11 | 9.5 | 8.8 | 5.5 | 6.8 | 4.9 | 4.9 | 6.2 |
| | 6.8 | 6.2 | 4.9 | 4.9 | 4.9 | 5.5 | 4.9 |
| Site 12 | 6.3 | 4.9 | 5.6 | 8.4 | 4.9 | 7.7 | 5.6 |
| | 7.7 | 6.3 | 6.3 | 8.4 | 5.6 | 7.7 | 5.6 |
| Site 13 | 7.7 | 3.9 | 6.6 | 6.3 | 6.3 | 7.7 | 5.6 |
| | 8.3 | 5.5 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Site 14 | 14.7 | 6.3 | 4.9 | 4.9 | 5.6 | 6.3 | 6.3 |
| | 17.6 | 4.9 | 5.6 | 7.7 | 6.3 | 5.6 | 6.3 |
| Site 15 | 10.1 | 10.4 | 6.3 | 6.3 | 6.3 | 8.7 | 8.0 |
| | 11.5 | 7.3 | 6.3 | 7.0 | 9.1 | 9.7 | 11.2 |
| Site 16 | 8.8 | 8.8 | 5.5 | 5.5 | 6.2 | 5.5 | 6.8 |
| | 8.1 | 8.8 | 5.5 | 5.5 | 5.5 | 5.5 | 6.2 |

**Table19 Analytical results for $Na^+$ (mg $kg^{-1}$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 32.1 | 28.6 | 30.2 | 27.6 | 14.6 | 11.8 | 11.3 |
| | 34.3 | 22.5 | 23.1 | 24.4 | 14.6 | 23.7 | 13.5 |
| Site 2 | 59.7 | 51.7 | 56.5 | 32.9 | 27.6 | 13.5 | 12.9 |
| | 50.2 | 42.8 | 31.5 | 32.6 | 29.1 | 27.6 | 12.9 |
| Site 3 | 77.8 | 51.2 | 50.3 | 35.7 | 31.5 | 35.7 | 30.7 |
| | 67.9 | 54.7 | 49.4 | 32.4 | 26.6 | 30.7 | 34.0 |
| Site 4 | 45.1 | 49.4 | 25.8 | 25.0 | 30.7 | 49.4 | 47.7 |
| | 42.5 | 45.1 | 32.4 | 37.4 | 38.2 | 44.2 | 49.4 |
| Site 5 | 22.6 | 18.1 | 16.1 | 15.0 | 25.0 | 30.1 | 25.8 |
| | 13.1 | 14.6 | 15.7 | 19.5 | 22.6 | 22.3 | 29.4 |
| Site 6 | 18.2 | 19.4 | 18.8 | 22.5 | 21.8 | 26.3 | 20.0 |
| | 19.2 | 33.6 | 21.8 | 20.6 | 28.2 | 17.0 | 26.3 |
| Site 7 | 22.6 | 28.3 | 36.5 | 25.8 | 17.9 | 19.5 | 19.5 |
| | 26.6 | 16.3 | 14.8 | 15.5 | 14.8 | 16.3 | 30.7 |
| Site 8 | 39.9 | 21.5 | 16.5 | 15.0 | 22.3 | 27.0 | 25.8 |
| | 13.8 | 13.5 | 14.2 | 16.0 | 44.1 | 36.6 | 28.2 |
| Site 9 | 26.3 | 21.2 | 21.2 | 27.6 | 30.9 | 45.7 | 62.9 |
| | 25.6 | 25.0 | 25.0 | 32.2 | 28.2 | 38.5 | 65.4 |
| Site 10 | 32.9 | 18.2 | 16.4 | 18.8 | 12.4 | 11.2 | 9.0 |
| | 15.8 | 17.6 | 22.5 | 18.2 | 15.8 | 15.2 | 8.5 |
| Site 11 | 28.9 | 26.9 | 26.9 | 25.6 | 26.3 | 31.6 | 30.9 |
| | 28.2 | 20.0 | 19.4 | 25.0 | 28.2 | 27.6 | 26.3 |
| Site 12 | 52.5 | 48.8 | 55.2 | 69.1 | 35.8 | 65.4 | 62.56.06 |
| | 54.3 | 39.5 | 6.2 | 50.6 | 48.8 | 61.9 | 65.4 |
| Site 13 | 15.7 | 13.8 | 45.8 | 34.6 | 41.3 | 52.6 | 51.7 |
| | 17.0 | 17.0 | 16.4 | 18.2 | 20.6 | 27.6 | 28.2 |
| Site 14 | 20.2 | 25.0 | 17.9 | 29.9 | 35.7 | 36.5 | 34.9 |
| | 32.4 | 17.1 | 28.3 | 31.5 | 54.7 | 41.6 | 48.6 |
| Site 15 | 50.9 | 37.7 | 43.7 | 34.4 | 33.0 | 38.6 | 39.5 |
| | 46.0 | 32.0 | 33.2 | 28.3 | 26.6 | 28.7 | 29.9 |
| Site 16 | 28.2 | 26.9 | 23.7 | 23.7 | 25.6 | 30.9 | 30.9 |
| | 28.2 | 28.2 | 22.5 | 23.7 | 26.9 | 32.2 | 37.8 |

**Table20 Analytical results for $Cl^-$ (mg $kg^{-1}$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 30.8 | 33.6 | 12.1 | 13.1 | 13.5 | 31.3 | 23.3 |
| | 30.4 | 23.3 | 13.5 | 11.7 | 8.9 | 14.5 | 18.2 |
| Site 2 | 25.2 | 24.6 | 21.4 | 23.8 | 13.5 | 10.3 | 14.5 |
| | 28.3 | 24.2 | 22.6 | 25.7 | 28.5 | 19.1 | 25.2 |
| Site 3 | 28.2 | 10.8 | 39.0 | 39.0 | 43.3 | 26.0 | 26.0 |
| | 28.2 | 19.5 | 39.0 | 21.7 | 13.0 | 26.0 | 58.5 |
| Site 4 | 36.8 | 28.2 | 39.0 | 30.3 | 41.1 | 23.8 | 26.0 |
| | 13.0 | 19.5 | 43.3 | 15.2 | 34.7 | 19.5 | 17.3 |
| Site 5 | 65.0 | 26.0 | 20.6 | 15.2 | 9.7 | 20.6 | 18.4 |
| | 16.2 | 18.4 | 15.5 | 16.3 | 11.9 | 2.2 | 23.8 |
| Site 6 | 25.2 | 10.7 | 8.9 | 11.7 | 9.8 | 8.4 | 16.3 |
| | 25.2 | 9.3 | 8.9 | 13.1 | 15.4 | 4.7 | 11.2 |
| Site 7 | 32.5 | 47.6 | 93.1 | 49.8 | 30.3 | 30.3 | 21.7 |
| | 34.7 | 32.5 | 32.5 | 30.3 | 28.2 | 34.7 | 116.9 |
| Site 8 | 47.6 | 42.2 | 35.7 | 20.6 | 21.7 | 31.4 | 26.0 |
| | 55.2 | 37.9 | 43.3 | 96.4 | 18.4 | 24.9 | 20.6 |
| Site 9 | 26.7 | 19.6 | 7.9 | 11.7 | 3.7 | 22.4 | 28.5 |
| | 25.7 | 11.7 | 12.1 | 14.5 | 5.1 | 12.6 | 28.5 |
| Site 10 | 17.8 | 26.1 | 23.3 | 19.1 | 17.3 | 14.9 | 12.1 |
| | 17.7 | 16.8 | 27.1 | 18.2 | 23.3 | 17.3 | 12.3 |
| Site 11 | 31.3 | 27.5 | 23.3 | 17.3 | 18.2 | 11.2 | 20.1 |
| | 18.7 | 19.2 | 18.2 | 23.8 | 32.2 | 12.3 | 15.1 |
| Site 12 | 15.2 | 45.3 | 33.1 | 17.7 | 24.3 | 19.1 | 29.4 |
| | 15.6 | 13.1 | 11.4 | 22.4 | 16.3 | 16.8 | 24.7 |
| Site 13 | 18.4 | 20.6 | 22.7 | 16.2 | 23.8 | 21.7 | 21.7 |
| | 16.3 | 21.5 | 16.3 | 10.3 | 18.6 | 21.6 | 19.7 |
| Site 14 | 56.3 | 28.2 | 30.3 | 39.0 | 57.9 | 41.1 | 11.2 |
| | 30.3 | 32.5 | 21.7 | 43.3 | 62.6 | 44.8 | 36.4 |
| Site 15 | 39.7 | 28.5 | 43.0 | 29.9 | 30.3 | 31.3 | 31.3 |
| | 31.7 | 34.6 | 31.3 | 24.7 | 32.7 | 30.8 | 41.1 |
| Site 16 | 23.3 | 21.9 | 21.3 | 30.3 | 20.5 | 18.2 | 17.3 |
| | 25.8 | 26.6 | 33.1 | 18.7 | 27.1 | 19.6 | 22.4 |

**Table21 Analytical results for Mn (Ⅱ) (mg $kg^{-1}$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **0-10** | **10-20** | **20-30** | **30-40** | **40-60** | **60-90** | **90-120** |
| Site 1 | 12.20 | 4.01 | 4.65 | 4.55 | 3.90 | 4.97 | 4.27 |
| | 5.64 | 11.39 | 9.23 | 42.50 | 44.43 | 6.33 | 2.34 |
| Site 2 | 19.73 | 21.18 | 50.14 | 4.62 | 1.75 | 26.39 | 40.98 |
| | 7.97 | 13.81 | 34.08 | 72.28 | 77.47 | 48.38 | 30.31 |
| Site 3 | 35.03 | 10.02 | 7.24 | 8.14 | 7.57 | 5.49 | 28.00 |
| | 68.82 | 29.63 | 8.81 | 4.69 | 6.31 | 6.92 | 8.55 |
| Site 4 | 90.73 | 64.60 | 22.26 | 8.26 | 6.16 | 10.14 | 6.28 |
| | 42.90 | 62.93 | 20.41 | 6.72 | 7.11 | 6.65 | 7.38 |
| Site 5 | 9.57 | 4.56 | 0.37 | 3.23 | 1.66 | 1.90 | 2.20 |
| | 1.52 | 3.85 | 2.65 | 4.20 | 1.35 | 1.30 | 2.30 |
| Site 6 | 29.77 | 17.51 | 5.07 | 2.80 | 4.79 | 5.62 | 8.02 |
| | 6.87 | 5.16 | 1.68 | 3.05 | 2.82 | 3.68 | 2.04 |
| Site 7 | 3.53 | 10.98 | 11.73 | 8.47 | 13.31 | 6.64 | 3.92 |
| | 18.15 | 6.27 | 3.89 | 9.30 | 10.35 | 8.26 | 5.32 |
| Site 8 | 10.69 | 4.42 | 2.60 | 1.32 | 3.52 | 4.11 | 5.86 |
| | 12.71 | 6.49 | 2.31 | 3.10 | 5.01 | 5.17 | 1.30 |
| Site 9 | 92.71 | 3.63 | 6.54 | 5.51 | 5.10 | 3.56 | 3.65 |
| | 6.49 | 4.82 | 4.48 | 6.47 | 6.24 | 2.16 | 4.10 |
| Site 10 | 5.31 | 14.11 | 15.58 | 13.56 | 16.38 | 9.71 | 4.33 |
| | 2.50 | 10.45 | 12.58 | 10.52 | 7.16 | 10.82 | 10.37 |
| Site 11 | 183.60 | 65.69 | 84.54 | 7.61 | 8.31 | 5.52 | 5.26 |
| | 192.20 | 65.58 | 6.71 | 6.89 | 3.96 | 6.00 | 5.22 |
| Site 12 | 28.24 | 66.38 | 10.53 | 6.60 | 6.36 | 4.60 | 4.90 |
| | 66.51 | 41.94 | 1.99 | 1.34 | 1.32 | 4.56 | 3.20 |
| Site 13 | 31.15 | 18.35 | 6.46 | 3.66 | 2.93 | 6.20 | 4.75 |
| | 30.22 | 8.69 | 7.80 | 6.91 | 7.84 | 6.30 | 3.98 |
| Site 14 | 6.32 | 5.11 | 2.94 | 0.00 | 1.25 | 0.00 | 1.45 |
| | 6.78 | 2.96 | 1.83 | 0.00 | 0.75 | 4.45 | 2.87 |
| Site 15 | 17.62 | 11.68 | 7.32 | 10.92 | 9.54 | 4.91 | 14.17 |
| | 5.12 | 22.25 | 4.56 | 7.60 | 5.84 | 3.73 | 6.28 |
| Site 16 | 11.61 | 5.01 | 2.75 | 1.61 | 1.99 | 5.00 | 3.19 |
| | 13.13 | 13.38 | 5.75 | 6.00 | 5.22 | 5.00 | 2.42 |

**Table22 Analytical results for $SO_4^{2+}$ (g $kg^{-1}$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 1.56 | 1.50 | 1.02 | 1.80 | 1.08 | 1.32 | 1.38 |
| | 1.32 | 0.84 | 1.68 | 1.32 | 1.14 | 1.20 | 0.42 |
| Site 2 | 0.84 | 0.54 | 0.54 | 0.84 | 0.72 | 0.36 | 0.60 |
| | 0.60 | 1.08 | 0.90 | 1.20 | 0.96 | 0.54 | 1.08 |
| Site 3 | 0.96 | 0.72 | 1.38 | 1.38 | 1.02 | 1.56 | 0.48 |
| | 1.80 | 1.20 | 1.14 | 1.08 | 1.38 | 1.68 | 2.22 |
| Site 4 | 1.14 | 0.54 | 1.08 | 1.08 | 0.72 | 0.78 | 0.84 |
| | 1.08 | 1.08 | 1.32 | 1.14 | 0.36 | 0.96 | 1.80 |
| Site 5 | 1.32 | 1.14 | 1.86 | 2.94 | 2.16 | 1.62 | 1.32 |
| | 1.68 | 1.62 | 1.32 | 1.14 | 0.96 | 1.26 | 0.90 |
| Site 6 | 0.66 | 0.66 | 0.60 | 0.72 | 0.78 | 0.72 | 0.12 |
| | 0.42 | 1.80 | 0.72 | 1.08 | 0.66 | 0.48 | 0.42 |
| Site 7 | 1.56 | 1.08 | 1.32 | 2.52 | 0.72 | 1.20 | 1.56 |
| | 1.14 | 1.08 | 1.08 | 1.44 | 0.66 | 1.02 | 1.26 |
| Site 8 | 1.32 | 1.62 | 1.44 | 1.20 | 2.46 | 2.10 | 1.68 |
| | 0.06 | 1.38 | 1.14 | 1.02 | 1.50 | 0.24 | 0.78 |
| Site 9 | 0.72 | 0.54 | 0.90 | 0.36 | 0.36 | 1.14 | 0.78 |
| | 0.36 | 0.30 | 0.48 | 0.60 | 0.78 | 0.42 | 0.60 |
| Site 10 | 0.84 | 0.54 | 0.54 | 1.08 | 1.08 | 1.02 | 0.96 |
| | 0.48 | 0.72 | 0.48 | 1.02 | 0.96 | 0.72 | 1.20 |
| Site 11 | 0.84 | 1.26 | 0.84 | 1.02 | 0.90 | 1.38 | 1.50 |
| | 1.38 | 1.26 | 1.86 | 1.02 | 2.58 | 1.08 | 1.14 |
| Site 12 | 0.60 | 1.26 | 1.68 | 1.50 | 0.54 | 0.42 | 1.74 |
| | 1.38 | 1.86 | 2.94 | 1.92 | 1.44 | 1.14 | 1.20 |
| Site 13 | 1.32 | 1.20 | 1.92 | 1.74 | 1.50 | 1.08 | 0.78 |
| | 1.44 | 0.72 | 0.72 | 0.78 | 2.04 | 1.56 | 0.90 |
| Site 14 | 1.50 | 0.84 | 1.02 | 0.78 | 0.78 | 1.32 | 0.90 |
| | 1.08 | 0.30 | 0.60 | 0.66 | 0.60 | 1.44 | 0.96 |
| Site 15 | 0.36 | 1.14 | 0.72 | 1.14 | 1.14 | 0.66 | 1.08 |
| | 2.22 | 1.56 | 1.68 | 0.96 | 1.92 | 1.86 | 0.78 |
| Site 16 | 0.42 | 1.32 | 1.68 | 0.84 | 1.44 | 0.84 | 0.48 |
| | 0.54 | 1.08 | 1.32 | 0.90 | 1.32 | 1.08 | 0.90 |

**Table23 Analytical results for $Mg^{2+}$ (mg $kg^{-1}$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 19.8 | 28.8 | 27.0 | 29.4 | 37.3 | 87.7 | 15.6 |
| | 37.9 | 39.1 | 39.5 | 15.0 | 18.3 | 12.5 | 12.0 |
| Site 2 | 22.9 | 25.6 | 50.2 | 46.3 | 16.8 | 9.6 | 16.8 |
| | 56.2 | 33.3 | 62.5 | 45.3 | 16.5 | 17.4 | 86.5 |
| Site 3 | 15.4 | 20.2 | 15.6 | 13.2 | 8.4 | 21.6 | 21.6 |
| | 10.8 | 30.0 | 24.0 | 16.7 | 25.2 | 20.4 | 12.0 |
| Site 4 | 6.0 | 31.2 | 30.0 | 12.0 | 58.9 | 31.2 | 18.0 |
| | 10.7 | 10.8 | 19.2 | 24.0 | 16.0 | 25.6 | 24.1 |
| Site 5 | 16.0 | 27.6 | 24.6 | 37.9 | 43.9 | 12.4 | 16.8 |
| | 33.6 | 47.5 | 42.1 | 73.3 | 34.2 | 34.9 | 33.6 |
| Site 6 | 66.1 | 30.0 | 13.2 | 35.5 | 33.0 | 19.2 | 7.8 |
| | 21.6 | 37.9 | 24.6 | 36.1 | 45.7 | 31.8 | 7.2 |
| Site 7 | 22.8 | 52.9 | 66.1 | 74.5 | 68.5 | 61.3 | 40.9 |
| | 128.6 | 38.5 | 55.3 | 32.4 | 103.3 | 57.7 | 84.1 |
| Site 8 | 30.0 | 22.8 | 13.2 | 8.4 | 9.0 | 20.9 | 15.9 |
| | 24.6 | 67.9 | 13.8 | 15.6 | 22.2 | 28.2 | 25.2 |
| Site 9 | 5.4 | 19.2 | 16.8 | 15.6 | 21.6 | 25.8 | 10.2 |
| | 12.8 | 15.0 | 20.6 | 25.8 | 20.3 | 16.2 | 15.2 |
| Site 10 | 15.7 | 31.2 | 21.6 | 10.8 | 16.2 | 12.6 | 18.6 |
| | 12.6 | 15.0 | 22.6 | 13.2 | 21.0 | 31.8 | 19.8 |
| Site 11 | 34.2 | 55.3 | 61.3 | 36.7 | 73.3 | 24.0 | 42.7 |
| | 45.7 | 88.9 | 69.7 | 27.6 | 47.5 | 56.5 | 68.5 |
| Site 12 | 18.0 | 40.9 | 61.9 | 10.8 | 25.2 | 18.2 | 60.7 |
| | 54.7 | 25.2 | 25.2 | 10.2 | 20.4 | 12.6 | 20.4 |
| Site 13 | 22.8 | 29.4 | 51.1 | 54.7 | 81.1 | 55.9 | 59.5 |
| | 7.8 | 13.8 | 8.4 | 42.7 | 27.6 | 22.8 | 9.6 |
| Site 14 | 69.7 | 79.3 | 18.0 | 23.6 | 16.5 | 24.0 | 43.3 |
| | 28.8 | 92.5 | 57.7 | 56.2 | 43.1 | 50.5 | 28.8 |
| Site 15 | 7.8 | 48.7 | 23.4 | 36.7 | 30.2 | 31.2 | 11.2 |
| | 42.1 | 25.2 | 17.4 | 30.0 | 48.1 | 25.2 | 12.6 |
| Site 16 | 26.4 | 68.5 | 53.5 | 60.7 | 25.2 | 13.6 | 8.4 |
| | 13.2 | 13.8 | 9.0 | 14.4 | 12.6 | 17.4 | 16.8 |

**Table24 Analytical results for $Ca^{2+}$ (mg $kg^{-1}$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 84.1 | 34.0 | 36.1 | 71.1 | 75.1 | 44.1 | 73.1 |
| | 71.1 | 40.1 | 37.1 | 41.1 | 40.1 | 55.1 | 32.0 |
| Site 2 | 25.6 | 33.1 | 25.6 | 44.1 | 55.1 | 32.0 | 30.0 |
| | 26.8 | 55.6 | 28.6 | 42.2 | 48.3 | 45.1 | 27.0 |
| Site 3 | 50.1 | 42.1 | 44.1 | 26.0 | 34.0 | 18.0 | 28.0 |
| | 34.0 | 16.0 | 44.1 | 36.1 | 20.0 | 22.0 | 32.0 |
| Site 4 | 42.1 | 20.0 | 20.0 | 24.0 | 30.0 | 38.1 | 32.0 |
| | 44.1 | 36.1 | 20.0 | 26.0 | 34.0 | 32.0 | 52.1 |
| Site 5 | 35.1 | 51.1 | 42.1 | 27.0 | 20.0 | 40.1 | 17.0 |
| | 49.1 | 61.1 | 60.1 | 48.1 | 40.1 | 56.1 | 39.1 |
| Site 6 | 30.0 | 22.0 | 30.0 | 24.0 | 18.0 | 22.0 | 26.0 |
| | 30.0 | 31.0 | 29.0 | 26.0 | 19.0 | 15.0 | 42.1 |
| Site 7 | 50.1 | 112.2 | 170.2 | 50.1 | 28.0 | 44.1 | 20.0 |
| | 66.1 | 32.0 | 20.0 | 42.1 | 34.0 | 36.1 | 80.1 |
| Site 8 | 60.1 | 45.1 | 50.1 | 36.1 | 45.1 | 37.1 | 35.2 |
| | 74.1 | 52.1 | 50.1 | 89.1 | 36.1 | 35.1 | 31.0 |
| Site 9 | 31.0 | 19.0 | 21.0 | 15.0 | 22.0 | 18.0 | 24.0 |
| | 19.0 | 15.0 | 20.0 | 16.0 | 24.0 | 17.0 | 23.0 |
| Site 10 | 12.6 | 22.6 | 22.0 | 24.0 | 24.0 | 20.0 | 18.0 |
| | 18.0 | 24.0 | 46.1 | 27.0 | 18.0 | 23.0 | 28.0 |
| Site 11 | 30.0 | 24.0 | 21.0 | 20.0 | 12.0 | 21.0 | 15.0 |
| | 21.0 | 23.0 | 17.0 | 29.0 | 23.0 | 20.0 | 27.0 |
| Site 12 | 35.1 | 19.0 | 16.0 | 52.1 | 32.0 | 46.1 | 25.0 |
| | 25.0 | 28.0 | 30.0 | 26.0 | 21.0 | 25.0 | 35.1 |
| Site 13 | 39.1 | 31.0 | 25.0 | 29.0 | 35.1 | 27.0 | 31.0 |
| | 28.0 | 22.0 | 31.0 | 17.0 | 16.0 | 16.0 | 28.0 |
| Site 14 | 56.1 | 42.1 | 38.1 | 68.1 | 36.1 | 30.0 | 32.0 |
| | 50.1 | 38.1 | 40.1 | 22.0 | 46.1 | 36.1 | 48.1 |
| Site 15 | 176.2 | 79.1 | 51.1 | 32.0 | 36.3 | 35.1 | 122.2 |
| | 120.2 | 38.1 | 49.1 | 49.1 | 45.1 | 40.1 | 45.1 |
| Site 16 | 45.1 | 32.0 | 22.0 | 16.0 | 18.0 | 42.1 | 16.0 |
| | 23.0 | 44.1 | 24.0 | 27.0 | 21.0 | 13.0 | 24.0 |

**Table25 Analytical results for Mn (g $kg^{-1}$)**

| Sampling sites | Soil layer (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-10 | 10-20 | 20-30 | 30-40 | 40-60 | 60-90 | 90-120 |
| Site 1 | 0.04 | 0.02 | 0.04 | 0.04 | 0.02 | 0.10 | 0.05 |
| | 0.06 | 0.03 | 0.04 | 0.08 | 0.06 | 0.14 | 0.05 |
| Site 2 | 0.10 | 0.06 | 0.09 | 0.05 | 0.08 | 0.06 | 0.05 |
| | 0.12 | 0.09 | 0.08 | 0.17 | 0.09 | 0.12 | 0.13 |
| Site 3 | 0.16 | 0.14 | 0.12 | 0.12 | 0.32 | 0.45 | 0.18 |
| | 0.11 | 0.57 | 0.65 | 0.54 | 0.36 | 0.33 | 0.52 |
| Site 4 | 0.25 | 0.27 | 0.20 | 0.09 | 0.09 | 0.11 | 0.15 |
| | 0.21 | 0.26 | 0.13 | 0.07 | 0.07 | 0.14 | 0.10 |
| Site 5 | 0.19 | 0.21 | 0.16 | 0.14 | 0.22 | 0.10 | 0.09 |
| | 0.25 | 0.17 | 0.29 | 0.21 | 0.13 | 0.17 | 0.11 |
| Site 6 | 1.06 | 1.05 | 1.38 | 0.57 | 0.40 | 0.42 | 0.45 |
| | 1.08 | 1.10 | 1.76 | 1.07 | 0.74 | 0.41 | 0.38 |
| Site 7 | 0.17 | 0.18 | 0.27 | 0.18 | 0.04 | 0.03 | 0.04 |
| | 0.04 | 0.06 | 0.04 | 0.05 | 0.04 | 0.05 | 0.02 |
| Site 8 | 0.17 | 0.19 | 0.12 | 0.12 | 0.11 | 0.08 | 0.05 |
| | 0.17 | 0.19 | 0.15 | 0.12 | 0.13 | 0.10 | 0.10 |
| Site 9 | 0.24 | 0.19 | 0.19 | 0.04 | 0.03 | 0.03 | 0.03 |
| | 0.14 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| Site 10 | 0.06 | 0.03 | 0.02 | 0.03 | 0.16 | 0.25 | 0.28 |
| | 0.12 | 0.14 | 0.15 | 0.15 | 0.15 | 0.17 | 0.23 |
| Site 11 | 1.21 | 1.49 | 0.95 | 0.94 | 0.29 | 0.18 | 0.55 |
| | 1.25 | 1.47 | 1.02 | 0.53 | 0.46 | 0.42 | 0.48 |
| Site 12 | 0.58 | 0.46 | 0.75 | 0.27 | 0.17 | 0.22 | 0.25 |
| | 1.17 | 1.06 | 0.33 | 0.29 | 0.19 | 0.33 | 0.22 |
| Site 13 | 0.33 | 0.42 | 0.45 | 0.56 | 0.15 | 0.2 | 0.22 |
| | 0.48 | 0.4 | 0.27 | 0.26 | 0.18 | 0.33 | 0.08 |
| Site 14 | 0.4 | 0.43 | 0.49 | 0.19 | 0.1 | 0.12 | 0.23 |
| | 0.24 | 0.29 | 0.09 | 0.12 | 0.42 | 0.61 | 0.58 |
| Site 15 | 0.21 | 0.18 | 0.18 | 0.21 | 0.2 | 0.29 | 0.6 |
| | 0.23 | 0.25 | 0.26 | 0.52 | 0.41 | 0.28 | 0.35 |
| Site 16 | 1.16 | 1.5 | 0.59 | 0.82 | 0.75 | 0.49 | 0.23 |
| | 1.75 | 1.14 | 0.33 | 0.35 | 0.33 | 0.29 | 0.35 |