The gram-negative soil-dwelling saprophytic bacterium *Burkholderia pseudomallei* causes melioidosis, a fatal disease highly endemic to Southeast Asia and northern Australia (1). Humans can be infected with *B. pseudomallei* via inoculation, inhalation, and ingestion. Rice farmers are at high risk for infection because of their frequent exposure to soil and water, but newborns, children, and older persons also are at risk (2,3). We report 3 melioidosis deaths among children in northern Vietnam.

### The Study

In November 2019, the Preventive Health Center of Soc Son district in Vietnam reported the deaths of 3 children from 1 family. The first child, a 7-year-old girl, had a high fever and abdominal pain on April 6, 2019. Two days later, she was admitted to a local hospital; after 1 day, she was transferred to St. Paul Hospital in Hanoi, where septic shock was diagnosed. She died on April 9, shortly after admission, before any diagnostic tests were performed.

On October 27, 2019, the second child, a 5-year-old boy, had a high fever and abdominal pain around the umbilicus. He was admitted to Vietnam National Children’s Hospital in Hanoi on October 28 with diagnosed septic shock. Abdominal and chest radiographs and abdominal ultrasound results were unremarkable. His blood culture grew *B. pseudomallei*, and he died on October 31.

The third child, a 13-month-old boy, had a high fever and poor appetite on November 10, 2019. According to his grandparents, he had black stool, like his sister and brother. He was admitted to Vietnam National Children’s Hospital; chest radiography results were unremarkable, but *B. pseudomallei* was cultured from his blood sample. He died on November 16.

We retrieved laboratory findings from all hospitals to which these children were admitted. Results showed leukopenia, neutropenia, thrombocytopenia, and high procalcitonin and C-reactive protein in all children’s blood. Liver dysfunction was diagnosed in all 3 children, but kidney dysfunction was recognized only in the 2 older children. We detected no identifiable risk factors (Table 1).

To trace the source of infection, on November 17, 2019, we visited the family home in the midland region of northern Vietnam (Figure 1). During our active surveillance for melioidosis cases admitted to provincial and tertiary hospitals surrounding Hanoi (4), no previous cases had been reported from this area.

We interviewed the parents and grandparents using epidemiologic questions about all the children’s daily activities inside and outside the house. The family used water supplied from 3 boreholes: 1 for bathing (borehole A), 1 for livestock (borehole B), and 1 for human consumption (borehole C). During our first environmental investigation, we collected samples of front garden soil (n = 7), borehole water (n = 9), and boiled drinking water (n = 1). We performed qualitative culture for *B. pseudomallei*, and all 3 water samples collected from borehole A tested positive (Appendix, https://wwwnc.cdc.gov/EID/article/28/8/22-0113-App1.pdf).
We revisited the home on November 23, 2019, and asked the family about the history of borehole A. In brief, the borehole was drilled in 2010. In 2015, the family reconstructed the back garden and added a new soil layer, resulting in the bore cap being ≈80 cm below the soil surface (Figure 2, panel A). At the end of 2018, the foot valve in the suction pipe of the dynamic electric pump was damaged, and the bore cap was not sealed after the damage was repaired (Figure 2, panel B). We suspected rainwater and surface soil particles contaminated with *B. pseudomallei* drained into the groundwater via the opened borehole. To test this hypothesis, we conducted a second round of environmental sampling, focusing on borehole A and the nearby surface soil. We collected 26 borehole water and 46 garden soil samples. Within a 1-km radius of the home, we also collected 39 water samples from other boreholes, 30 surface water samples from 10 ponds, and 40 soil samples from 8 rice fields (Figure 1; Appendix).

We found 26 (100%) water samples collected from borehole A and 27 (58.7%) garden soil samples from 8 (80%) sampling points near the borehole were *B. pseudomallei*-positive by qualitative culture. These findings supported our hypothesis that *B. pseudomallei* from surface soil might have contaminated the groundwater through the unsealed bore cap during the rainy season, which starts in April and coincided with the first child’s illness and death. Another 5 (12.5%) soil samples from 2 (25%) rice fields also tested *B. pseudomallei*-positive. Quantitative culture showed that the median *B. pseudomallei* count was 406 CFU/mL (range 12–746 CFU/mL) in soil (Appendix). Of 26 water samples collected from borehole A, 2 (7.7%) grew *B. pseudomallei* on the initial agar plates and had a median *B. pseudomallei* count of 2 CFU/mL (Table 2).

We selected 20 *B. pseudomallei* isolates for multilocus sequence typing (MLST) (5): 7 from borehole A, 6 from back garden soil, 5 from rice field soil,

### Table 1. Demographic and clinical characteristics and corresponding isolates from 3 children who died of melioidosis caused by *Burkholderia pseudomallei*-contaminated borehole water, Vietnam, 2019*

| Characteristics | Case 1 | Case 2 | Case 3 |
|-----------------|--------|--------|--------|
| Age, y/sex      | 7/F    | 5/M    | 1/M    |
| Date            | Apr 6  | Oct 27 | Nov 10 |
| Hospital admission | Apr 9  | Oct 28 | Nov 11 |
| Death           | Apr 9  | Oct 31 | Nov 16 |
| Signs and symptoms | High fever, abdominal pain, vomiting, diarrhea with mucus, tachycardia, and cyanosis | High fever, abdominal pain, vomiting, tachyplea, and tachycardia | High fever, poor appetite, mild pitting edema in the feet and hands, tachyplea, and tachycardia |
| Underlying disease | Not detectable | Not detectable | Not detectable |
| Microbiology    |        |        |        |
| Blood culture   | ND     | B. pseudomallei–positive | B. pseudomallei–positive |
| Sequence type   | ND     | 541    | 541    |
| Other sample cultures | ND | ND | ND |
| Antimicrobial drug treatment | Cefoperazone in the first day; then eflora and amikacin on subsequent days | Ceftriaxone, tobramycin, and metronidazole in the first day; then meropenem and levofloxacin on subsequent days | Ceftazidime in the first 2 days; meropenem in the last 3 days |
| Imaging at admission | No abnormalities noted | No abnormalities noted | No abnormalities noted |
| Chest radiograph | NA | NA | NA |
| Abdominal radiograph | NA | NA | NA |
| Abdominal ultrasound | NA | NA | NA |
| Laboratory findings | | | |
| WBC, × 10⁹ cells/L | Day 1 | Day 2 | Day 1 | Day 2 | Day 1 | Day 2 | Day 1 | Day 2 | Day 1 | Day 3 | Day 4 | Day 5 |
| 0.6 | 0.7 | 25.2 | 0.35 | 10.8 | 7.5 | 1.35 | 1.06 |
| Neutrophils, × 10⁸ cells/L | NA | 0.12 | 22.8 | 0.05 | 8.4 | 4.0 | 0.76 | 0.38 |
| Lymphocytes, × 10⁸ cells/L | NA | 0.48 | 1.07 | 0.29 | 1.52 | 3.07 | 0.50 | 0.55 |
| Platelets, × 10⁹ cells/L | 47 | 36 | 272 | 29 | 264 | 72 | 67 | 32 |
| Urea, mmol/L | 8.9 | 9.9 | NA | 9.8 | 2.2 | 1.4 | 3.7 | 4.1 |
| Creatinine, µmol/L | 91 | 123 | NA | 124 | 45 | 33 | 55 | 71 |
| AST, U/L | 571 | 713 | NA | 602 | 23 | 59 | 185 | 269 |
| ALT, U/L | 226 | 258 | NA | 166 | 10 | 40 | 94 | 73 |
| CRP, mg/L | 124 | NA | 26 | 148 | 57 | NA | 209 | 158 |
| PCT, ng/mL | NA | >100 | NA | >100 | 9 | 43 | NA | NA |

*Data were collected from the St. Paul Hospital and Vietnam National Children’s Hospital, except for the laboratory findings for case 1, which were retrieved from the child’s local hospital. ALT, alanine aminotransferase; AST, aspartate aminotransferase; CRP, C-reactive protein; NA, not available; ND, not done; PCT, procalcitonin; WBC, white blood cell count.*
B. pseudomallei – Contaminated Borehole Water

and 2 from blood samples from cases 2 and 3. MLST showed an identical sequence type (ST), 541, among all samples (Table 2).

Conclusions

B. pseudomallei is ubiquitously distributed in soil and surface water throughout the tropics, including in Asia, the Pacific Islands, sub-Saharan Africa, and Latin America, where boreholes are the most common water supply in the rural areas (1,6,7). In addition to other waterborne infections (7), untreated water supplies have been implicated in previous human B. pseudomallei infections (8–10). B. pseudomallei also was isolated from the compacted earth floor under the bathing tub of a woman who died from septicemic melioidosis in Brazil (11).

Studies in Australia and Thailand detected diverse STs among B. pseudomallei isolates from an unchlorinated bore water site and a single soil sample (12,13), but our analysis revealed a single ST in the borehole, nearby garden, and surrounding rice fields. Because all 3 infections occurred in children, we believe B. pseudomallei transmission likely occurred through ingestion of contaminated water during bathing, especially considering that the 13-month-old boy was not in contact with garden or rice field soil. Ingestion also could explain the gastrointestinal symptoms the children exhibited.

Figure 1. Environmental sampling sites in an investigation of 3 child deaths from melioidosis caused by Burkholderia pseudomallei–contaminated borehole water, Vietnam, 2019. The satellite map was created using QGIS software version 3.22.1 (https://www.qgis.org). Red outline indicates the family property where the children lived; red circle is borehole A from which B. pseudomallei was isolated. Yellow outlines are rice fields from which soil samples were collected; red stars indicate rice fields that tested positive for B. pseudomallei. Yellow circles indicate neighbors’ boreholes and yellow squares indicate neighbors’ ponds from which water samples were collected. Inset map shows Vietnam; red square indicates sampling area.

Figure 2. Borehole involved in 3 child melioidosis deaths caused by Burkholderia pseudomallei–contaminated borehole water, Vietnam, 2019. A) View of area around borehole. The bore cap is ≈80 cm below the soil surface inside the masonry area. Red arrow indicates cracks in the masonry construction that might enable rainwater and soil particles to drain into the borehole area. B) View from above the borehole. Red arrow indicates the unsealed, opened gap around the borehole, which likely enabled rainwater and soil particles to drain into the groundwater during the rainy season.


**Table 2. Culture results and genotype data from environmental samples in a study of 3 child melioidosis deaths caused by *Burkholderia pseudomallei*-contaminated borehole water, Vietnam, 2019***

| Sample type, date | No. samples | No. (%) positive samples | No. (%) positive sampling points | Qualitative culture | Median quantitative count, CFU (range) | No. isolates selected for MLST† | ST
|------------------|-------------|--------------------------|---------------------------------|---------------------|--------------------------------------|--------------------------------|------
| Sampling 1, 2019 Nov 17 |             |                          |                                 |                     |                                      |                                |      
| Front garden soil | 7           | 0                        | 0                               | NP                  | NA                                   | NA                             |      
| Water from borehole A | 3           | 1                        | 3 (100)                         | 1 (100)             | NP                                   | 2§                              | 541  
| Water from borehole B | 3           | 1                        | 0                               | NP                  | NA                                   | NA                             |      
| Water from borehole C | 3           | 1                        | 0                               | NP                  | NA                                   | NA                             |      
| Boiled drinking water | 1           | 1                        | 0                               | NP                  | NA                                   | NA                             |      
| Sampling 2, 2019 Nov 23 |             |                          |                                 |                     |                                      |                                |      
| Back garden soil near borehole A | 46          | 10                       | 27 (58.7)                       | 8 (80)              | 406 (12–746)§                        | 6                               | 541  
| Rice field soil | 40          | 8                        | 5 (12.5)                        | 2 (25)              | ND                                   | 5                               | 541  
| Water from borehole A | 26          | 1                        | 26 (100)                        | 1 (100)             | ND                                   | 4                               | 541  
| Water from borehole B | 3           | 1                        | 0                               | 0                   | NP                                   | NA                             |      
| Water from borehole C | 3           | 1                        | 0                               | 0                   | NP                                   | NA                             |      
| Water from neighbors’ borehole | 33         | 11                       | 0                               | 0                   | NP                                   | NA                             |      
| Water from ponds | 30          | 10                       | 0                               | 0                   | NP                                   | NA                             |      

*CFU, colony forming unit; MLST, multilocus sequence typing; NA, not applicable; ND, not detected; NP, not performed; ST, sequence type.
†Sampling points refer to garden, borehole, field, and pond sites.
‡We selected 20 *B. pseudomallei* isolates for sampling; 2 patient isolates are not shown here.
§*B. pseudomallei* colonies were countable only in 2 borehole water samples and 5 garden soil samples (Appendix, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC740113-App1.pdf). In water samples CFU/mL; in soil samples CFU/g.

B. *pseudomallei* ST541 has been reported from hu-
man melioidosis cases in northern Vietnam (3) and has only been described from southeast Asia thus far. During previous surveillance (4), we found other ST541 isolates in clinical and environmental samples from north and north-central Vietnam. An ST541 iso-
late available in a public MLST database (https://
pubmlst.org/organisms/burkholderia-pseudomal-
lei; accessed 2021 Dec 8) was from a human case in Hanoi, China, which is close to the area of Vietnam where these 3 melioidosis deaths occurred. From our clinical data retrieval (3,4), 5 of 8 patients infected with *B. pseudomallei* ST541 died, which could mean ST541 is more virulent than other STs, but further data are needed.

From the epidemiologic investigation and field study at the family home, we became aware of the construction and maintenance of the borehole, which had an unsealed cap and an open borehole below the soil surface. The unsealed borehole probably enabled *B. pseudomallei* from surface soil to contaminate groundwater during rainfall. Other studies have re-
ported higher rates of gastrointestinal pathogens in water from boreholes with unsealed annuli (14,15). Therefore, persons using boreholes in countries where melioidosis is endemic should ensure proper construction and maintenance to avoid contamination with *B. pseudomallei* and other pathogens from surface soil.

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**References**

1. Limmathurosakul D, Golding N, Dance DA, Messina JP, Pigott DM, Moyes CL, et al. Predicted global distribution of *Burkholderia pseudomallei* and burden of melioidosis. Nat Microbiol. 2016;1:15008. PubMed https://doi.org/10.1038/nmicrobiol.2015.8

2. Limmathurosakul D, Kanoksil M, Wuthiekanun V, Kitphati R, deStavola B, Day NP, et al. Activities of daily living associated with acquisition of melioidosis in northeast Thailand: a matched case-control study. PLoS Negl Trop Dis. 2013;7:e2072. https://doi.org/10.1371/journal.pntd.0002072

3. Phuong DM, Trung TT, Breitbach K, Tuan NV, Nübel U, Flintner G, et al. Clinical and microbiological features of melioidosis in northern Vietnam. Trans R Soc Trop Med Hyg. 2008;102(Suppl 1):S50–6. https://doi.org/10.1016/S0035-9203(08)70069-9

4. Trinh TT, Nguyen LDN, Nguyen TV, Tran CX, Le AV, Nguyen HV, et al. Melioidosis in Vietnam: recently improved recognition but still an uncertain disease burden after almost a century of reporting. Trop Med Infect Dis. 2018;3:39. https://doi.org/10.3390/tropicalmed3020039

5. Godoy D, Randle G, Simpson AJ, Aanensen DM, Pitt TL, Kinoshita R, et al. Multilocus sequence typing and evolutionary relationships among the causative agents of...
melioidosis and glanders, *Burkholderia pseudomallei* and *Burkholderia mallei*. J Clin Microbiol. 2003;41:2068–79. https://doi.org/10.1128/JCM.41.5.2068-2079.2003

6. Foster T, Priadi C, Kotra KK, Odagiri M, Rand EC, Willetts J. Self-supplied drinking water in low- and middle-income countries in the Asia-Pacific. npj Clean Water. 2021;4:37. https://doi.org/10.1038/s41545-021-00121-6

7. Odiyo JO, Mathoni MM, Makungo R. Health risks and potential sources of contamination of groundwater used by public schools in Vhuronga 1, Limpopo Province, South Africa. Int J Environ Res Public Health. 2020;17:6912. https://doi.org/10.3390/ijerph17186912

8. Limmathurosakul D, Wongsupan G, Aanensen D, Ngamwilai S, Saiprom N, Rongkard P, et al. Melioidosis caused by *Burkholderia pseudomallei* in drinking water, Thailand, 2012. Emerg Infect Dis. 2014;20:265–8. https://doi.org/10.3201/eid2002.121891

9. Inglis TJ, Garrow SC, Henderson M, Clair A, Sampson J, O'Reilly L, et al. *Burkholderia pseudomallei* traced to water treatment plant in Australia. Emerg Infect Dis. 2000;6:56–9.

10. Currie BJ, Mayo M, Anstey NM, Donohoe P, Haase A, Kemp DJ. A cluster of melioidosis cases from an endemic region is clonal and is linked to the water supply using molecular typing of *Burkholderia pseudomallei* isolates. Am J Trop Med Hyg. 2001;65:177–9. https://doi.org/10.4269/ajtmh.2001.65.177

11. Rolim DB, Vilar DC, Sousa AQ, Miralles IS, Almeida de Oliveira DC, Harnett G, et al. Melioidosis, northeastern Brazil. Emerg Infect Dis. 2005;11:1458–60. https://doi.org/10.3201/eid1109.050493

12. Mayo M, Kaesti M, Harrington G, Cheng AC, Ward L, Karp D, et al. *Burkholderia pseudomallei* in unchlorinated domestic bore water, tropical northern Australia. Emerg Infect Dis. 2011;17:1282–3. https://doi.org/10.3201/eid1707.100614

13. Wuthiekanun V, Limmathurosakul D, Chantratita N, Feil EJ, Day NP, Peacock SJ. *Burkholderia pseudomallei* is genetically diverse in agricultural land in northeast Thailand. PLoS Negl Trop Dis. 2009;3:e496. https://doi.org/10.1371/journal.pntd.0000496

14. Knappett PS, McKay LD, Layton A, Williams DE, Alam MJ, Mailloux BJ, et al. Unsealed tubewells lead to increased fecal contamination of drinking water. J WaterHealth. 2012;10:565–78. https://doi.org/10.2166/wh.2012.102

15. MacDonald AM, Calow RC. Developing groundwater for secure rural water supplies in Africa. Desalination. 2009;248:546–56. https://doi.org/10.1016/j.desal.2008.05.100

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Child Melioidosis Deaths Caused by *Burkholderia pseudomallei*—Contaminated Borehole Water, Vietnam, 2019

Appendix

**Materials and Methods**

**Soil Sampling**

A primary environmental investigation was conducted at the family property on November 17, 2019. Seven soil samples at a depth of 10 cm were collected at different sampling points of the front garden. Nine borehole water (3 samples from each borehole) and one boiled drinking water samples were also collected.

A secondary environmental sampling was conducted on November 23, 2019. At borehole A, the electric pump was turned on, and 26 bore water samples were collected every five minutes (from 0 to 120 minutes) and at 240 minutes. Forty-six soil samples from 10 sampling points near borehole A in the back garden were also collected, and the distance between each sampling point was ≈10 m. At each point, the soil samples were collected at depths of 10, 20, 30, 40, and 50 cm, except for 2 points where only soil samples at depths of 10, 20, and 30 cm were collected. Additionally, 39 bore water samples were collected from the other two boreholes on the family property and 11 boreholes in the neighborhood (3 samples from each borehole). Thirty surface water samples from 10 surrounding ponds (3 samples from each pond) were collected. Forty soil samples from eight rice fields were collected at a depth of 30 cm (5 samples from each rice field) (Figure 1).

**Qualitative Culture of *B. pseudomallei***

Detection of *B. pseudomallei* from water and soil samples was performed using a two-step enrichment approach (1). In brief, a 10-gram soil sample was added to 50 mL tubes containing 20 mL of TBSS-C50 broth. After vigorous vortexing, the tubes were statically
incubated at 40°C for 2 days. Subsequently, 1 mL of the culture supernatants were transferred to new tubes containing 9 mL of MB broth. After static incubation at 40°C for 4 days, the enriched culture supernatants were streaked out on Ashdown agar plates. The plates were then incubated at 40°C for 4 days and examined every day. Based on morphological characteristics, suspected colonies of *B. pseudomallei* were picked up, and the bacterial identification was confirmed using the *B. pseudomallei*-specific real-time PCR assay targeting the TTSS1 gene (2). The bacterial isolates were stored at –70°C in Luria-Bertani broth containing 20% glycerol for further genotype experiment.

For water samples, 100 mL of water sample was centrifuged at 5,000 rpm for 30 min, and the supernatants were decanted to obtain the water sediments. Then, 20 mL TBSS-C50 broth was added to the tubes, and the culture approach for *B. pseudomallei* was performed, as described above.

**Quantitative Culture of *B. pseudomallei***

The bacterial count was only performed on water or soil samples positive for *B. pseudomallei* by the quantitative culture. In brief, a 10-gram soil sample was added to a 250-mL Erlenmeyer flasks containing 20 mL of distilled water. The soil was dispersed by shaking at 160 rpm for 2 h at room temperature. The flasks were left for 30 min to allow the soil particles settle. Then 100 µL of the upper layer suspension and its serial 10-fold dilutions were plated out on the Ashdown agar plates. After incubation at 40°C for 4 days, the suspected *B. pseudomallei* colonies were counted, and the CFU/g of soil was calculated, as previously described (3).

For the water samples, 500 µL of borehole A water was plated out on the Ashdown agar plates. After incubation at 40°C for 4 days, the suspected *B. pseudomallei* colonies were counted, and the CFU/mL of water was calculated.

**Physiochemical Parameters of Soil and Water Samples**

Compared with *B. pseudomallei*–negative borehole water samples, physicochemical parameters showed water samples from borehole A had low pH and high nitrate, iron, total suspended solids, and total organic carbon (Appendix Table 1). *B. pseudomallei*–positive soil collected in the garden near borehole A had much lower electrical conductivity but much higher total potassium oxide and aluminum levels than *B. pseudomallei*–negative soil samples (Appendix Table 2).
References

1. Trinh TT, Assig K, Tran QTL, Goehler A, Bui LNH, Wiede C, et al. Erythritol as a single carbon source improves cultural isolation of *Burkholderia pseudomallei* from rice paddy soils. PLoS Negl Trop Dis. 2019;13:e0007821. PubMed https://doi.org/10.1371/journal.pntd.0007821

2. Novak RT, Glass MB, Gee JE, Gal D, Mayo MJ, Currie BJ, et al. Development and evaluation of a real-time PCR assay targeting the type III secretion system of *Burkholderia pseudomallei*. J Clin Microbiol. 2006;44:85–90. PubMed https://doi.org/10.1128/JCM.44.1.85-90.2006

3. Trung TT, Hetzer A, Topfstedt E, Göhler A, Limmathurotsakul D, Wuthiekanun V, et al. Improved culture-based detection and quantification of *Burkholderia pseudomallei* from soil. Trans R Soc Trop Med Hyg. 2011;105:346–51. PubMed https://doi.org/10.1016/j.trstmh.2011.03.004

Appendix Table 1. Physicochemical parameters of water samples from 1 *Burkholderia pseudomallei*–contaminated borehole and 13 other boreholes investigated in the deaths of 3 children from melioidosis, Vietnam, 2019*

| Physicochemical parameters, mg/mL | Contaminated borehole | Other boreholes |
|----------------------------------|-----------------------|-----------------|
| pH                               | 3.91                  | 6.13 (3.98–7.19) |
| Total suspended solids           | 2.47                  | 1.35 (0.85–2.67) |
| Ammonium                         | ND                    | 0.14 (ND–0.4) |
| Nitrate                          | 4.80                  | 3.08 (0.22–4.54) |
| Phosphate                        | ND                    | 0.21 (ND–0.23) |
| Iron                             | 0.34                  | 0.19 (0.11–0.30) |
| Total organic carbon             | 4.70                  | 3.31 (2.50–4.20) |
| Chemical oxygen demand           | 6.00                  | 5.50 (4.00–8.00) |
| Biologic oxygen demand           | 1.00                  | 0.75 (0.00–2.00) |

*Data represent mean (range); ND, not detected.

Appendix Table 2. Physicochemical parameters of soils collected from the garden and rice fields investigated for *Burkholderia pseudomallei* contamination in the deaths of 3 children from melioidosis, Vietnam, 2019*

| Physicochemical parameters | Garden soil | Rice field soil |
|----------------------------|-------------|-----------------|
| pH, KCl                    | 3.73 ± 0.16 | 4.08 ± 0.24     |
| Moisture content, %        | 14.30 ± 2.07| 18.10 ± 0.15    |
| Electrical conductivity, µS/cm | 75.48 ± 25.93 | 105.50 ± 53.17 |
| Organic carbon, %          | 0.99 ± 0.19 | 0.76 ± 0.40     |
| Total nitrogen, %          | 0.06 ± 0.01 | 0.05 ± 0.02     |
| Total P<sub>2</sub>O<sub>5</sub>, % | 0.05 ± 0.01 | 0.07 ± 0.03    |
| Iron, g/Kg                 | 2.18 ± 0.52 | 2.15 ± 1.31     |
| Total K<sub>2</sub>O, %    | 1.48 ± 0.49 | 0.96 ± 0.17     |
| Aluminum, g/Kg             | 4.75 ± 0.59 | 2.27 ± 1.35     |

*Data represent mean ± SD; p values were obtained from t-test. K<sub>2</sub>O, potassium oxide; KCl, potassium chloride; P<sub>2</sub>O<sub>5</sub>, phosphorus pentoxide; S, siemens.