Major and Trace Element Composition of Bottom Sediments of the Malagane Tank: Relationship with Sources

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Introduction

Sri Lanka has one of the oldest traditions of irrigation in the world, dating back as far as 300 BC. It was the basis of the Dry Zone prosperity in ancient Sri Lanka. An interconnected series of tanks within a small watershed is called a Tank Cascade System (TCS). In TCS, water from one tank flows to the downstream tank, while it is utilized for agriculture and other domestic purposes. A tank has three basic components; the bund, tank body (*wewa*) and the upper periphery which is a gently sloping land locally termed *Thaulla.*

Since tank sediments are formed mainly from material supplied from the terrestrial surroundings of the tank, the chemistry of sediment is a function of characteristics of the catchment including events of pollution. The composition of tank sediments reflects the chemical inputs from the surrounding environments and the anthropogenic influence within a particular ecosystem. Therefore, our main intention was to study the geochemical composition of tank bottom sediments in Sri Lanka and to determine whether the sediments represent average continental crust values or polluted material.

Methodology

The Malagane tank in the Deduru Oya river basin located in the Intermediate Climatic Zone of Sri Lanka was selected for the study. Thirteen sediment samples were collected using a stainless steal auger at pre-defined locations. The pH of sediments was measured using 1:1 w/v sediment/water extractions. The percentage of organic matter in the sediments was determined as percentage loss on ignition (LOI) after drying the sediments at 550 °C. Available fraction of nitrogen and phosphorous in sediments was extracted using 1 mol dm^{-3} KCl and 0.5 mol dm^{-3} $NaHCO_3$ (pH = 8.5), respectively. The available metals are extracted using 0.5 mol dm^{-3} CH_3COOH and measured using atomic absorption spectrophotometry. The total elemental contents of sediment samples were determined with Phillips PW-2400 X-ray fluorescence spectrometer. The recoveries of international reference samples were within ±5% RSD for major elements.

Results and discussion

The spatial distribution of mean grain sizes of the Malagane tank shows the deposition of medium to coarse sand in *Thaulla,* where the inflow stream water enters the lake. Fine sand and sandy clay have been deposited one after the other and silty clay is predominant in the middle of the tank. Rate of water flow most probably controls the grain size in bottom sediments of tanks. However, a gradational variation has been observed from the middle of the tank towards the lake bund. Coarser sand layers are observed closer to the tank bund which may be due to scouring effects associated with hydraulic conditions caused by water released to the downstream paddy fields.

The pH of the sediment of Malagane tank varies from 4.87 to 6.55 with the mean value of 5.50. Sediments may become slightly acidic due to intense leaching of base forming cations. The LOI of the tank sediments varies from 4.8% to 16.9%. The organic matter concentrates at the centre of the tank with the clay layers. The *Thaulla* contains low amounts of organic matter (5.9%), which may be due to low retention of organics in sandy soils.

The mean P concentration of the sediment of Malagane tank is 1.44 mg/kg. The lowest value occurs closer to *Thaulla* and high contents occur associated with the clay sediments in the middle of the tank and closer to the tank bund area, which could be due to anthropogenic inputs. The mean nitrogen content of sediments of the Malagane tank is 51.8 mg/kg. The highest leachable N values were obtained closer to the tank bund and the content does not depend on the grain size. In *Thaulla,* where the biological activities are prominent, the denitrifying bacteria could convert the sediment nitrates into gaseous nitrogen and escape from the system or allow the plants to take up nitrates for their metabolism.

The available metals considered are Na, K, Ca, Mg, Fe, Mn, Ni, Zn, Pb and Cr, and their mean concentrations, in mg/kg, are 122, 170, 671, 2078, 1723, 240, 3.2, 5.2, 7.5 and 3.5, respectively. All the available metals show a general distribution pattern which is an association with clay sediments. The total content of elements of bottom sediments was compared with that of the Upper Continental Crust (UCC) values in order to determine the anthropogenic influence to the tank sediment. Since the average elemental levels of the terrain were not available, the bulk chemical composition of the sediments of Malagane tank was compared with the UCC values proposed by Rudnick and Gao (2003) (Figure 1). With few exceptions, the major and trace element compositions of Malagane tank sediments are either similar or slightly depleted (alkali and alkaline earth elements, P, Mn and Cu) to that of the UCC composition. As and V are enriched in sediments in the main tank body and sediments close to the bund. The Zr and Ce contents are enriched in the *Thaulla* and in the tank body, whereas Hf, Pb and Th are enriched throughout the tank compared with that of the UCC values. Since the *Thaulla* of the tanks acts as a sediment trap, heavy minerals supplied from the watershed are deposited mainly at *Thaulla* and only fine grains including organic particles are flushed into the tank body.

Conclusions

The analysis of sediments in the Malagane tank emphasizes that the sediments are comparable to the upper continental crust composition and therefore mainly derived from the upper catchment of the tank. Apart from the terrestrial materials, geochemical processes associated within the sediments also play a major role. The total metal concentrations and distribution indicates though extensive paddy cultivations are practiced in the tank watershed, the anthropogenic heavy metal pollution levels are not significant in the study area.

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References

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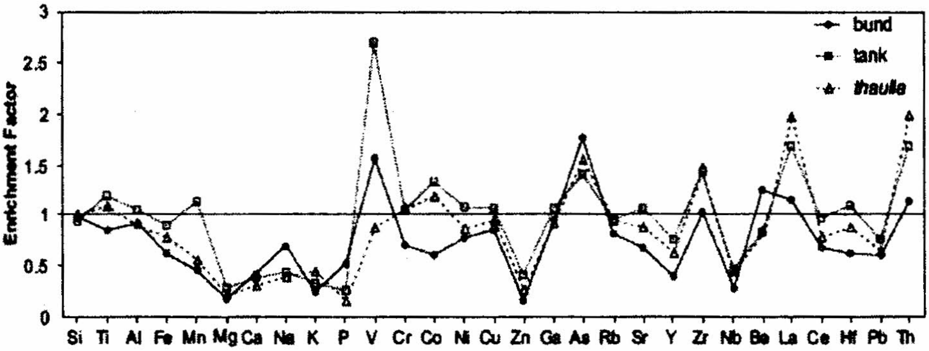

Figure 1. Average upper continental crust normalized elements from the Malagane tank