Studies on soil properties of Tsunami affected areas in southern Sri Lanka

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Abstract

An assessment on soil quality parameters was performed along the Southern coast of Sri Lanka, to study the effect of Tsunami. The coastal belt was divided subjectively into 3 zones (0-100, 100-200 and >200 m from the coast) in order to make sure both affected and unaffected soils to be sampled. Furthermore 3 depths (0-20, 20-40 and 40-60 cm) were considered for the sampling and soils were analyzed for soil texture, pH, EC, N, P, K, organic matter (OM) contents, and heavy metals using standard methods.

Results revealed that the average N and organic matter contents of affected soils were 0.098 and 0.27% respectively with P and K contents of 98.73 and 144.4 mg/kg of soil. The N and OM (0.13 and 1.06%) contents of unaffected soils were significantly (p> 0.05) higher than that of the affected soils. However, it was hard to see considerable negative impacts of Tsunami on P and K (96.3 and 175 mg/kg of soil) contents. The average pH and EC values were 8.49 and 6.48 dS/m respectively for the affected soils. Whereas the corresponding figures for the unaffected soils were 6.78 and 1.2 dS/m. Furthermore, it showed that soil pH has increased while EC has decreased with time though both of them have decreased with increasing distance from the coast. The decreasing trend of salinity with time, possibly due to gradual washing off the salt by rainfall received following the Tsunami while gradual replacement of cation in the soil aggregates may explain the increasing trend of pH. As a consequence of high pH and EC, soil productivity could be reduced and thus appropriate rehabilitation measures should be taken before using affected soils for crop production.

Key words: pH, Rehabilitation, Salinity, Tsunami

Introduction

Agro-based livelihoods and ecosystems were severely affected by the recent Tsunami, hit across a vast area of coastal regions in Sri Lanka. The croplands in the coastal regions of East, North-east, South-east and South of Sri Lanka were severely damaged by the intrusion of large amounts of salt water, leading to built up of soil salinity. Furthermore, the evidence demonstrates that intrusion of debris and marine sediment to agricultural lands has worsened the consequences. The severity of the damage varied from place to place depending on water-borne energy received, seabed and terrestrial terrain of the area.

Salinization has direct negative impacts on soil biology and crop productivity and indirect effects leading to loss of soil stability through changes in soil structure (Szabolcs, 1996). Ultimate results would be depleting soil quality, defined as the capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality and promote plant and animal health (Doran and Parkin, 1994). While soil quality reflects a soil's ability to meet the ecosystem functions, measurement of soil quality requires identification of specific parameters, or "indicators" that can be quantitatively measured and compared to reference conditions or judged against some common standards (Seybold *et al.*, 1997). And also since most of the soil physical, chemical and biological properties in agroecosystems are variable in space, even if considering small distances (Ruehling *et al.*, 1997), soil property related crop performance (yield, water and nutrient uptake), environmental impacts etc. would also be variable in space (Sparovek and Schnug, 2001). The present investigation was done with the aim of assessing some selected soil properties of Tsunami affected soils in hard hit Southern Sri Lanka.

Materials and Methods

Soil sampling

The major soil types in the coastal belt of Matara and Hambantota districts where sampling was done are basically considered as Red Yellow Podzolic and Reddish Brown Earth respectively. Depending on the geography of the location and evidence of seawater intrusion, sampling points varied from nearby sea to 800 m inland. Random sampling was commenced two weeks after tsunami, and continued at monthly intervals for further period of 5 months. Special attention was paid on all tsunami affected land use types (i.e. paddy, home garden, plantation crops, livestock and agro-based industries) to be represented in the samples. Individual soil samples of about 1 kg were drawn from each sampling position representing three depths (0-20, 20-40 and 40-60 cm). Samples taken from neighboring unaffected fields with the same soil types were used as the reference to compare affected and non-affected soils. Soils were mixed well, air-dried, weighed and the fraction passing through a 2 mm sieve was split with a stainless steel riffle and saved for the analysis.

Analysis

Soil samples were analyzed for electrical conductivity and pH, in order to depict the salinity levels and soil reaction in the medium. Furthermore soil organic matter and main macronutrients (N, P and K) contents were determined along with some physical parameters such as soil texture. A digital pH meter (model 868) was used in measuring soil pH and EC readings were preformed using EC meter. Micro Kjeldhal method (McGill and Figueiredo, 1990) was applied to measure total nitrogen content and soil P was extracted according to borax method (Dick and Tabatabai, 1977) and determined using a spectrophotometer (UV - 2102). Exchangeable K (Blackmore et al., 1987) was determined using an atomic absorption spectrophotometer (PGENERAL, TAS-986) and wet oxidation method (Tiessen and Moir, 1993) was applied to determine soil organic matter content. Soil texture was determined with the Bouyoucos densimeter method (FAO, 1984). All the chemicals were analytically graded and used without further purification. De-ionized water taken from a Millipore Milli-Q system was used throughout the experiments. All measurements of weight were performed with a digital balance (Sartorins, BS 210 S).

Results and Discussion

pH

The average pH of unaffected soils was 6.48 while in affected soils it has increased up to 8.49 (Figure 1). Results further revealed that more than 50 % samples collected from affected soils had pH higher than 8.13. With time it could be seen that an increasing trend of pH for almost all the sample locations, in particular, Hambanthota shelter belt. However, from 4[th] to 5[th] month, the pH values of all the samples were slightly stable.

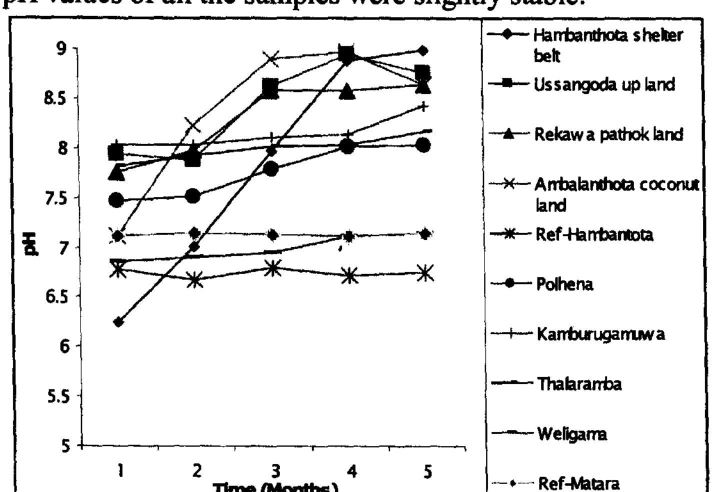

Figure 1. Changes in pH of affected soils. Values are means of five replicates.

There was a significant decrease of pH value with increasing of distance from the coast. The average pH values were 8.00, 7.74 and 7.54 respectively for 0-100, 100-200 and >200 m. However, no significant pH differences were found among the samples taken from different depths.

Electrical Conductivity

The average EC values of unaffected and affected soils were 1.2 and 6.78 dS/m respectively (Figure 2). It was seen a gradient of EC from sea to inland and furthermore EC declined as time progressed. As shown in pH distribution, EC significantly varied with distance from the sea but not at different soil depths. The reduction was steep in Ussangoda area. However, it was notable that even after five months Rekawa and Ambalanthota area contained a considerably high level of salinity.

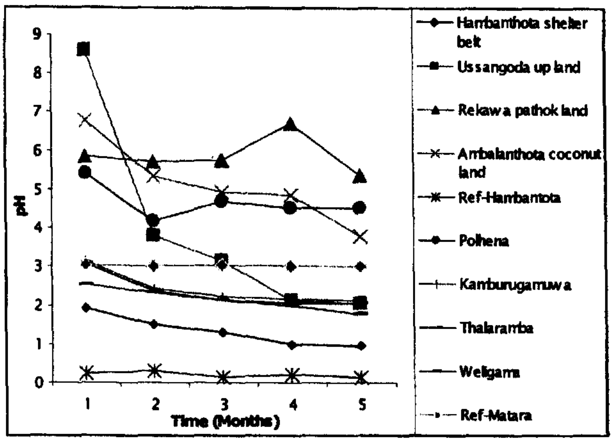

Figure 2. Changes in Electrical Conductivity (EC) in affected soils. Values are means of five replicates.

Soil nutrients

No significant differences were found between affected and non affected soils for major nutrients (N and P) and for organic matter contents (Figure 3). However, results revealed a slight reduction of major nutrients and organic matter contents of affected areas which may be due to washed out of top soil and/or sand deposition as a consequence of Tsunami. Furthermore, it is believed that the major soil types (Reddish brown and Red yellow podzolic) of the area are generally poor in soil nitrogen and phosphorus. The total phosphorus content of the soil is in the range of 0.02-0.15 %. Major nutrients and organic matter contents decreased with increasing depth and the reason may be due to the activities of microorganisms in top layers of the soil. However, no differences were found as the distance from the sea increased. Average N and organic matter contents in tsunami affected soils were 0.098 and 0.27% respectively with P and K contents of 98.73 and 144.4 mg/kg of soil. The corresponding figures for the unaffected soils were 0.13 and 1.06% (N and OM) and 96.3 and 175 mg/kg of soil (P and K) indicated a considerable reduction of N and OM as consequences of Tsunami (Figure 3). Results further revealed that the N and P contents of more than 50 % samples collected from affected soils were well below the average value which indicates a high variability of nutrient status in tsunami affected areas.

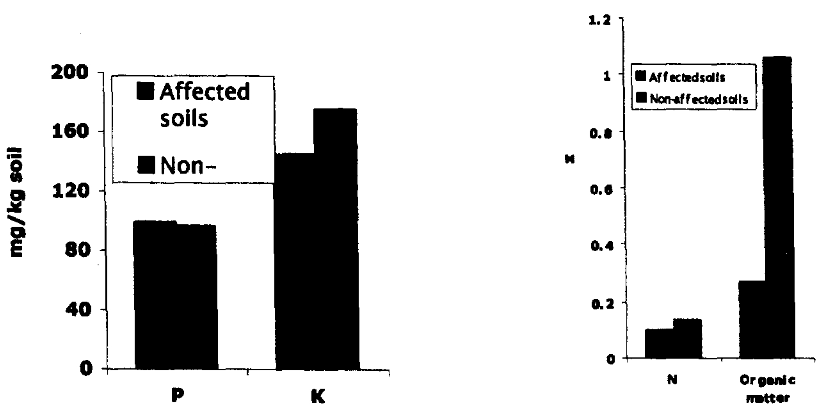

Figure 3. Changes in P, K and N, Organic Matter (OM) contents in Tsunami affected soils. Values are means of five replicates.

Soil texture

Table1. shows the results of soil texture, which varied sand to loamy sand and as expected, most of the sampling locations contained sandy soil.

Table 1. Soil texture variation in Tsunami affected and non-affected soils.

Location	Soil Texture
Ussangoda	sand
Kirinda	sandy loam
Ambalanthota	loamy sand
Hambanthota-east	sand
Hambanthota (ref)*	loamy sand
Polhena	loam
Kamburugamuwa	sand
Thalaramba	sand
Weligama	sand
Devinuwara (ref)*	sand

*Reference soil collected from non-affected fields

Heavy metals

Results revealed that the concentrations of Cadmium, Chromium and Lead in affected soils were well below the detectable level and thus it could be mentioned here that no heavy metal contamination occurred as a consequence of sea water intrusion. Soil pH plays a crucial role in nutrient availability of plants and thus the major nutrients (N, P, and K) could only exert a significant influence on crop yields if soil pH is correct. Furthermore, the solubility of trace elements such as Mn, Zn, Cu, and Fe increases as soil pH getting reduced. Phytotoxicity may be resulted for Mn, Zn and Al if the pH decreases less than approximately 5.5. The present findings ensure that such consequences would not be expected in affected soils as the pH values were well above the critical limit. It could also be explained that the steady increment of pH in current results may be due to the replacement of cation in soil aggregates. The excessive exchangeable sodium and high pH decrease the soil permeability and infiltration capacity through swelling and dispersion of clays as well as slaking of aggregates (Lauchli and Epstein, 1990). The lower N and organic matter contents recorded for tsunami affected soils than those of unaffected soils could be due to removal of bulk of nutritive soil by erosion and/or deposition of large amounts of sand dunes. Loss of soil organic matter would reduce root penetration, soil moisture and permeability, which in turn increases the risk of erosion and runoff and reduces biological activity of the soils (EEA, 1995). The microbial functions, which ensure maintaining a soil system with available nutrients aggregate stability, moreover reduce erosion and maintain water holding capacity (Kennedy and Gewin, 1997) would be severely affected in those agro-ecosystems hit by the tsunami. Negative impacts of elevated levels of soluble salts in soil solution (>4 dS/m) generally related to physiological functions of plants and thus inhibit the germination and growth of most commercial crops, reducing biomass production, and economic yields could be resulted along with low plant survival. Soil and water salinity is directly correlated with salt accumulation in plant cells/tissue and decreased shoot/leaf production, resulting in lower rates of photosynthesis and water consumption. Furthermore competition effects among different anions (Bar *et al.*, 1997; Feigin *et al.*, 1987; Kafkafi *et al.*, 1982) and different cations (Subbarao *et al.*, 1990; Izzo *et al.*, 1991; Pérez-Alfocea *et al.*, 1996) are known to occur in saline environment and they may result deleterious for normal plant growth (Grattan and Grieve, 1999). Salts tend to accumulate in the upper soil profile, especially when an intense evapotranspiration is associated to an insufficient leaching (Rhoades *et al.*, 1992; De Pascale and Barbieri, 1997). The addition of salts to the soil alters its physical and chemical properties, including soil structure and hydraulic conductivity. These modifications may further compromise the yield of crops. Haq *et al,* (1997) reported that about 25% reduction in the yield of major crops is attributed to soil salinity only. If not properly managed, Letey *et al,* (1985) also stressed that it could affect crop production when soil moisture contains a large concentration of soluble salts. Beltrao and Ben-Asher, (1997) have documented that the water content at wilting point is higher than at low salinity is a possible mechanism reducing crop yield under high saline condition. Maintenance of adequate soil physical properties in a situation similar to this, is of prime importance and it would be achieved by using water and soil amendments and proper cultural practices (Grattan and Oster, 2003). In addition, right selection of crop combination may be critical until sufficient rehabilitation is achieved. Although rainfall mitigates the deleterious effects of salinity on crop yield by leaching the excess of salts from the root zone, croplands exposed to seawater intrusion may need some sort of anthropogenic interventions to minimize salt-induced permanent modifications of the soil physical–chemical properties which may badly affect on productivity in long run. It is therefore the single highest priority is to implement various combinations of measures in various locations as the problem identified and also the location varies in terms of utilization, natural ecosystems, and human pressures, thus there will be no one solution that can be applied in all places.

Conclusions

It could be concluded that though most of the croplands investigated seemed to have affected by the seawater, some kind of natural rehabilitation, which is already in place could dilute the long-term effects. However, for the short term, some sort of physical manipulation is needed before the crop is established.

Recommendations

Adopting following measures would ensure immediate short-term benefits while, at the same time, exacerbate the underlying causes of salt imbalances.

- Use soil amendments such as gypsum, sulfur and pyrite
- Cultivate salt tolerant plant species
- Apply organic matter rice husk charcoal to develop soil structure for better drainage

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