Impact of human intervention on soil degradation in the Nilwala Project

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Abstract

The present investigation was carried out in order to assess the soil development of a human impacted site located near Kamburupitiya in the Matara district. The site previously under cinnamon cultivation was severely affected by the Nilwala Ganga Flood Protection Scheme in 1987. The soil has been cut down to the bed rock and removed from the site in order to construct dams. Representative soil samples (from 0-15 cm depth) were drawn randomly from the disturbed site and analyzed for pH, EC, bulk density, N, P, K and organic matter contents using standard methods. A neighboring site with the same soil type was used as the reference in order to compare the disturbed and undisturbed soils. Results revealed that the average bulk density, pH and EC of the disturbed soil were 1.25 g/cm^3, 5.35 and 36.25 μ mhos/cm respectively. Whereas the corresponding values for the undisturbed soil were 0.87 g/cm^3, 5.23 and 56.2 μ mhos/cm. The values of major nutrients (N, P and K) were 0.0088 %, 10.5 and 72.66 mg/kg for the disturbed soil and 0.095 %, 44 and 82.8 mg/kg for the undisturbed soil. The average organic matter contents of the disturbed and the undisturbed soil were 0.24 and 1.09 % respectively. The observation made during the study revealed that the soil surface had been totally exposed due to severe erosion and therefore, the major reason for the significantly lower values of nutrients (organic matter, N, P and K) recorded in disturbed soil would be removal of the bulk of nutritive soil byerosion. Furthermore, the present findings indicate that even 18 years after the disturbance the development of soil was quite poor and thus it may take some considerable period of time to improve the soil for crop production.

Key words: Nilwala Ganga Flood Protection Scheme, bed rock, human impacted land

Introduction

Agro ecosystems are constantly undergoing disturbance in the form of cultivation, soil preparation etc. The ecological concepts of disturbance and recovery through succession have important applications in agro ecology. A long-standing tenet of ecology is that following a disturbance, an ecosystem immediately begins a process of recovery from that disturbance. Recovery takes place through the relatively orderly process of succession. In the broadest sense, ecological succession is the process of ecosystem development, whereby distinct changes in community structure and function occur over time. Depending on the intensity, frequency, and duration of the disturbance, the impact on the structure and function of the ecosystem will vary, as will the time required for recovery from the disturbance.

Soil is a dynamic, living matrix that is an essential part of the terrestrial ecosystem. It is a critical resource not only to agricultural production and food security but also to the maintenance of most life processes. In early times modification of the soil by man seemed to be mostly unintentional, induced largely by vegetation changes. Human interventions were either direct - through ploughing, liming etc. or indirect through changing natural soil forming factors, changing the parent material through transport, dumping or exploitation of peat and rocks, through erosion and sedimentation. Some lands previously under agro-forestry were completely destroyed; their soil was removed to construct dams under the Nilwala project carried out in the Matara district in 1987.

The present study was aimed to assess the soil development of an imacted land following the Nilwala Project.

Materials and methods

Site selection: The selected site situated near Kamburupitiya in the Matara district, was severely affected by the Nilwala Ganga Flood Protection Scheme in 1987. The soil has been cut down to the bed rock and removed from the site in order to construct dams.

Soil classification: The soil used in this study belongs to Red Yellow Podzolic great soil group and is classified as Hapludults according to the USDA soil taxonomy (Mapa *et al.*, 1999).

Soil sampling: Individual soil samples (40 samples) of about 1 kg were collected from each sampling position at a depth of 0-15 cm after removing the surface litter of the soil. Samples were mixed well, air-dried, weighed and carefully sieved through a 2 mm screen. A representative sample taken from a neighboring undisturbed site with the same soil type was used as the reference to compare disturbed and undisturbed soils.

Soil analysis: Soil samples were analyzed for electrical conductivity (EC) and pH. Furthermore soil organic matter and main macronutrients (N, P and K) contents were determined along with some physical parameters such as bulk density. A digital pH meter was used in measuring soil pH and EC readings were preformed using an EC meter. Micro Kjeldhal method (McGill and Figueiredo, 1993) was applied to measure total nitrogen content. Soil P was extracted according to the borax method (Dick and Tabatabai, 1977) and determined using a spectrophotometer. Exchangeable K was determined using a flame photometer (Blackmore *et al.*, 1987) and the Wet Oxidation method (Tiessen and Moir, 1993) was applied to determine soil organic matter content.

Results and discussion

Results revealed that the average bulk density, pH and EC of the disturbed soil were 1.25 g/cm^3, 5.35 and 36.25 μ mhos/cm respectively, whereas the corresponding values for the undisturbed soil were 0.87 g/cm^3, 5.23 and 56.2 μ mhos/cm.

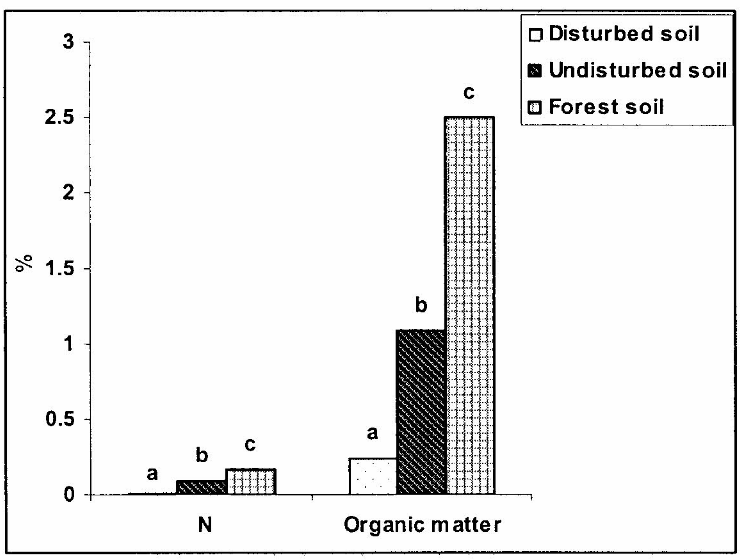

Fig. 1 N and organic matter contents in disturbed, undisturbed and forest soil

The average organic matter contents of the disturbed and the undisturbed soil were 0.24 and 1.09 % respectively (Figure 1). A 77% reduction is observed in human impacted soil (compared to the adjoining undisturbed soil) even 18 years after the disturbance. It has been documented that losses of organic matter are influenced by soil texture (Bauer and Black, 1981; Campbell and Souster, 1982), furthermore, there is a positive relationship between percentage of clay and soil organic matter (Coote and Ramsey, 1983; Nichols, 1984). The carbon reduction of the disturbed soil might be caused by decreased organic matter inputs, increased decomposition and erosion associated with the disturbance. Decomposition increases because of a change in aggregate structure of the soil (Coote and Ramsey, 1983) which influences the physical protection of soil organic matter and increases soil temperatures. This in turn influences the soil water holding capacity, oxygenation and activity of extra cellular enzymes. These factors have led to an increase in mineralization of soil organic matter and consequent losses of soil organic carbon could be seen as described by Wilson (1978).

The main effect of human disturbance is the removal of aboveground organic matter, which usually leads to long term or permanent impacts on floral structure and composition. The reasons for the higher organic matter content under undisturbed soils are probably due to factors such as leaf fall, high soil moisture and the presence of a rich soil fauna which help in litter decomposition. It is observed that organic matter contents of these disturbed and undisturbed soils are much lower (2.5%) than those of the forest soils in this area. Different lands show statistically significant differences ($P \geq 0.05$) in their organic matter contents.

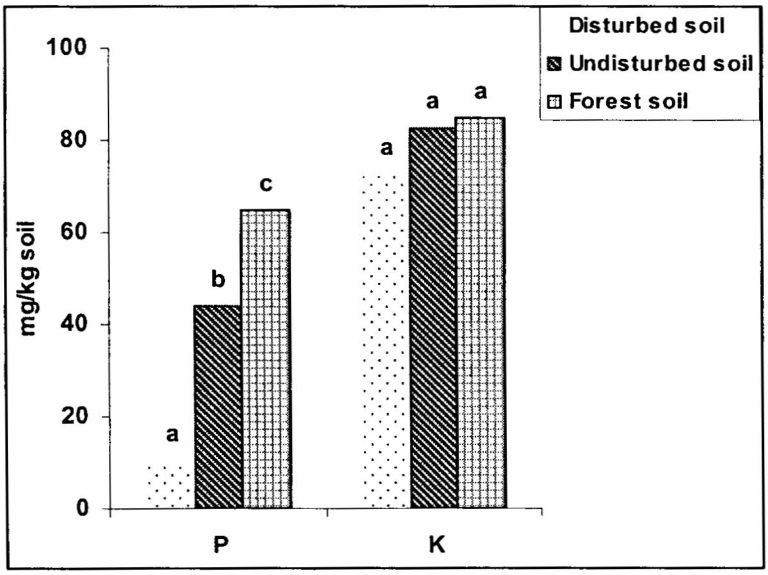

Fig. 2 P and K contents in disturbed, undisturbed and forest soil

The values of major nutrients such as N, P and K were 0.0088 %, 10.5 and 72.66 mg/kg soil for the disturbed soil, 0.095 %, 44, 82.8 mg/kg soil for the undisturbed soil and 0.17%, 65 and 85 mg/kg soil for the forest soil respectively (Figures 1 and 2). Trends in this average N, P and K contents follow the order forest soil > undisturbed soil > disturbed soil. The differences between these average N and P values are statistically significant ($P \geq 0.05$). Disturbed soils show a significant lowering of N and P contents compared to forest and undisturbed soils. As described for soil organic matter, the probable reasons for lowering N content in the disturbed soil may be associated with increased mineralization of soil organic matter (Reinhorn and Avnimelech, 1974) and severe erosion, since the human impacted soil is subjected to greater exposure to sunlight as well as heavy rain too. Therefore, the loss of major soil nutrients from soils by means of volatilization, leaching is much greater in disturbed soils compared to undisturbed soils.

The notable feature of the present results of K contents was that no significant ($P \geq 0.05$) differences were found between disturbed and undisturbed soils. It seemed that disturbance did not necessarily cause a loss of soil K. In fact, forest soils may have more or less K contents compared to disturbed and undisturbed soils. That is possibly due to the fact that the forests with their larger biomass utilize K to a greater extent.

Soil disturbances are ubiquitous, but generalizations about their ecological functions are difficult to make (Goldberg and Gross, 1988). In some studies, soil disturbances are favorable for establishment of a suite of species (McIntyre et al, 1995). Whereas other work indicates that soil disturbances are unfavorable for seedlings (Rapp & Rabinowitz, 1985). Integrated studies of multiple disturbances have sometimes revealed emergent plant responses that could not be predicted by studying the individual disturbances in isolation (Gibson, 1989; Collins et al., 1998).

Conclusions

Organic matter content of the soil has decreased drastically as a consequence of disturbance. Disturbed soils have much lower soil N and P contents compared to undisturbed soils. The loss of K is apparently negligible in contrast to the other major nutrients. Cultivating sun loving trees for a few seasons, preventing soil erosion and adding crop residues, organic manures, green manures etc. could be considered as the most appropriate measures that can be adopted to enhance the rehabilitation of these human impacted lands.

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