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PRELIMINARY STUDY ON THE IMPACTS OF LAND USE CHANGES THROUGH SOME SOIL PROPERTIES

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ABSTRACT

When human disturbances to natural habitats are considered, filling is one of the common processes due to urbanization. The present infrastructure of the Open University of Sri Lanka (OUSL) has been established on a land fill that used to be a marshy wetland next to the Diyawanna Canal. The main objective of this study is to determine the current physical, chemical & biological characteristics of OUSL soils in comparison with a natural habitat to understand the impacts due to land use changes (filling). The studies on physical, chemical and biological properties of this soil were carried out using standard methods.

Moisture and air content of OUSL is almost equal to the undisturbed habitat. With observed high sand & air content in OUSL soils, high moisture content cannot be expected. This may be due to clay layer formed about 30 - 50 cm below the surface of OUSL soil due to erosion of lateritic soils. However, the high value for bulk density clearly proves that OUSL soil is still under compaction or with very high clay. The pH of OUSL soils (7.44) clearly shows that proper chemical processes are not happening. The low conductivity is mainly due to erosion by rainfall and low decomposition rates. High OM may be due to high clay content in the soil profile. Significantly low Cation Exchange Capacity (CEC) indicates that chemical fertility is not good. Low CEC encourages leaching and hampers the delivery of a steady, adequate supply of nutrients throughout the growing season. This could be one of the reasons why some die backs are reported in the OUSL premises. Reduced bacterial counts and microbial biomass indicate that OUSL soils are not biologically fertile and still under the effect of compaction. The results for soil fauna clearly showed that OUSL soil is still under rehabilitation after heavy compaction. No effect is recorded to indicate that habitat conversion has caused this poor quality.

INTRODUCTION

Soil has been described as our most precious non-renewable resource and is vital for productivity in terrestrial environments (Lavelle,1996). Chemical and physical properties of soils have been studied intensively for many years. Although soil organisms have a critical role in soil development (Pawluk 1985) and maintenance of soil fertility (Seastedt, 1984), the biological component of soils has been largely ignored mainly due to non availability of expertise and high cost involved. Further, the biological component of soils also plays a major role in deciding the soil stresses.

The abundance, diversity and ecological roles of soil organisms including microorganisms sites affected by human disturbances are poorly understood due to a lack of intensive studies and baseline information (Kevan,1993). Over the last twenty years, there have been regular studies on the effects of both physical and chemical disturbances of soils and of land rehabilitation. Zak *et al.*(1992) and Visser and Parkinson (1992) pointed out that diverse soil microbiological criterion may indicate changing soil quality. However, ecosystem parameters could provide the best assessment of ecosystem recovery and stability. Visser and Parkinson (1992) further suggested that ecosystem level approaches give the best chance for rapid assessment of soil quality changes.

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When human disturbances are considered, filling is one of the common land use change due to urbanization. The term "fill" includes any material that is placed in, on, or over wetlands or other surface waters/low lying areas. For example, dirt, sand, gravel, rocks, shell, pilings, mulch and concrete are all considered fill if they are placed in a wetland or other surface water/low lying areas. Construction activities often lead to significant changes in soil properties, making it difficult to determine the properties of the natural soil that existed before construction. Information about the native soil conditions may be useful with regard to site suitability and limitations. Soil compaction is one of the most critical components in building construction sites, roads, airfields, embankments, and foundations. Compaction is the process of mechanically densifying a soil. Densification is accomplished by pressing the soil particles together into a close state of contact with air being expelled from the soil mass in the process. In soil science and agronomy soil compaction is usually a combination of both engineering compaction and consolidation that may occur due to a lack of water in the soil, the applied stress induced by internal suction resulting due to water evaporation as well as passage of animal feet. Affected soils become less able to absorb rainfall, thus increasing runoff and erosion. Plants have difficulty in establishing themselves in compacted soil because the mineral grains are pressed together, leaving little space for air and water, which are essential for root growth. Burrowing animals also find it a hostile environment, because the denser soil is more difficult to penetrate. The ability of a soil to recover from this type of compaction depends on climate, mineralogy and fauna. Soils with high shrink-swell capacity, such as vertisols, recover quickly from compaction where moisture conditions are variable (dry spells shrink the soil, causing it to crack). However, clays which do not crack as they dry cannot recover from compaction on their own unless they host ground-dwelling animals such as earthworms. After earth filling, these disturbed soils are settling over time to have the basic soil characteristics of that agro-ecological zone. During this settlement, the soil will arrange in such a way to achieve suitable physical, chemical and biological characteristics (Nadian *et.al.* 2008).

The premise of the Open University of Sri Lanka (OUSL) was a marshy wetland next to the Diyawanna Canal before it was reclaimed. With the decision to construct the Open University, this premise was filled resulting a change of land use and the present infra-structure was built. According to the present corporate plan (2011-2016), one of the main goals is to develop a green environment in the Open University. Therefore, it is important to investigate the present status of soil after 30 years of succession through filling a natural ecosystem and human intervention by change of land use. This will be done through the investigation of changes in physical, chemical and biological parameters of soil and through some soil micro faunal studies.

OBJECTIVES OF THIS STUDY

- To determine physical, chemical & biological characteristics of OUSL soils in comparison with a natural terrestrial habitat
- To obtain a baseline data set on the species diversity and abundance of both soil micro fauna and soil micro flora (bacteria and fungi) of OUSL premises
- To gain an understanding on the recovery status of OUSL soils after disturbance (filling)

METHODOLOGY

Sampling plots (10 plots to cover the Narahenpita area) were marked based on Fully Randomised Block Design (RBD) to obtain representative samples from OUSL premises and a home garden (HG). Four samplings (each sampling with 10 samples from OUSL and three samples from HG) were done within a period of 6 months from the same plots.

Soil samples were collected from first 30cm of the soil profile from the plots marked to cover impacts of all possible levels of succession during land use change. These samples were collected in polythene bags and tied with sufficient air. To avoid any further growth, the soil samples were kept in the refrigerator at $4^{0}C$. Soil samples were tested for % air & moisture content, permeability, bulk density, % sand content, pH, conductivity, % organic matter, Cation Exchange Capacity(CEC) (Head, 1986) and microbial biomass (Jenkinson and Powlson,1976) using standard test methods.

Samples of litter and soil were collected from the respective sites of OUSL premise using standard quadrate method. (20cm x 20cm x 10cm quadrate, bottomless square stainless steel box). Eight samples were collected in each plot in stratified random manner using metal quadrates. All the litter was collected from within the quadrate and then the quadrate was pressed into the soil up to a depth of 10cm. The soil and litter samples were collected into separate polythene bags and sealed. The collected samples were transported to the laboratory for faunal extraction, preservation and identification.

RESULTS AND DISCUSSION

Moisture and Air content of OUSL is almost equal to HG. With observed high sand & air content, high moisture content cannot be expected. This may be due to clay layer formed about 30-50cm below the surface due to erosion on lateritic soils (Personal communication with Civil Eng.). Even though the air content and water content is almost similar to the HG soil, low permeability & very high bulk density reported for OUSL soil should be given a deep thought. As reported by Yavuzcana *et al.* (2005), this clearly indicates the presence of impervious layer which is the clay layer formed with gravitational water. However, the high value for Bulk Density clearly proves that OUSL soil is still under compaction or with very high clay as found by Carter (1990). The high sand content may be due to erosion on lateritic filled soil which is liable for easy removal of clay with runoff water. Gupta *et al.*(2002) reported that compaction can be defined in terms of an increase of the bulk density (g/cm-3) of a soil as compared to its natural uncompacted state.

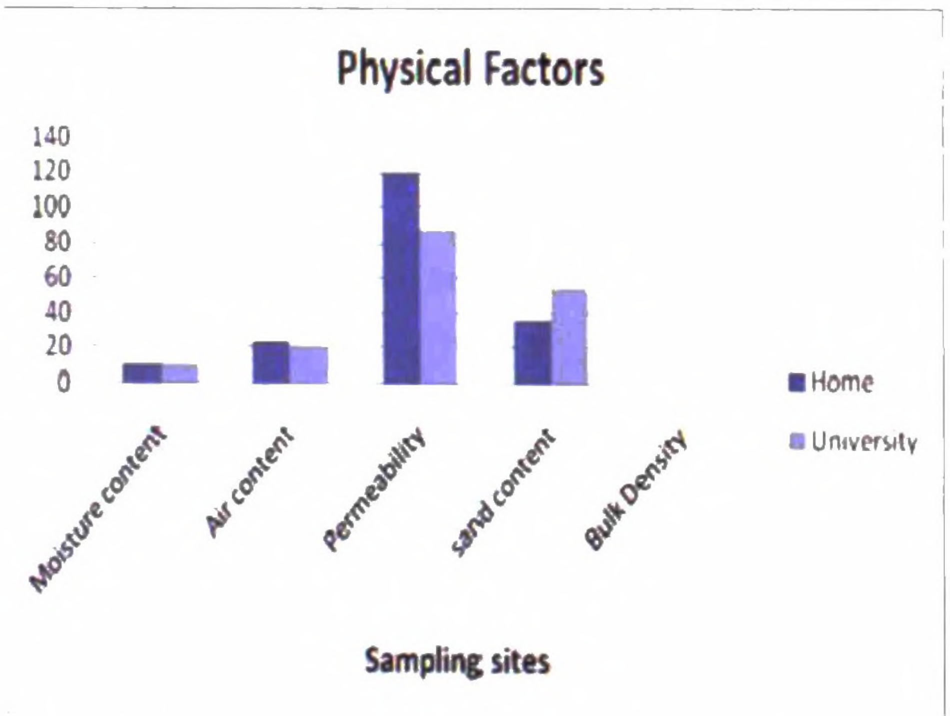

Fig.1 Physical properties of the samples studied

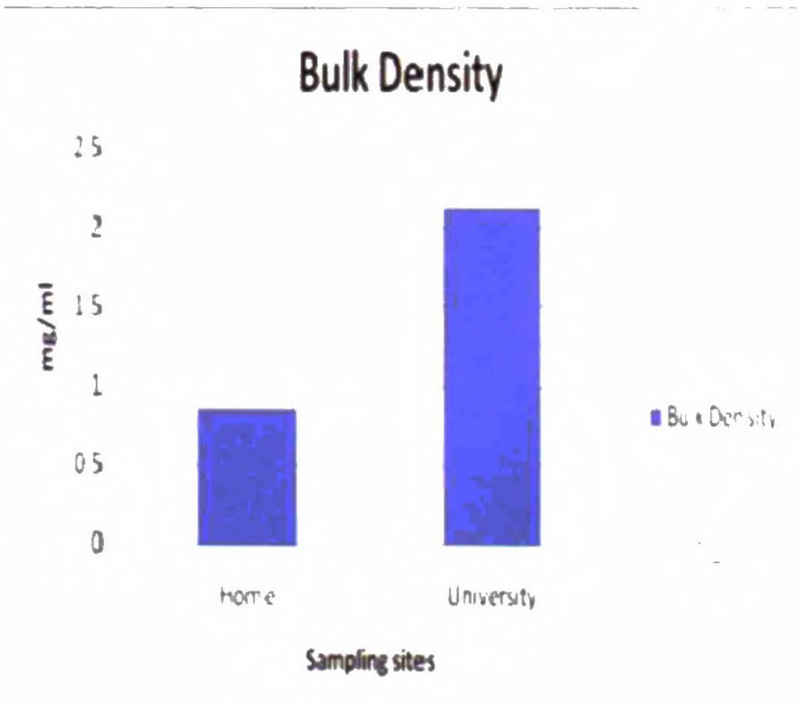

Fig. 2 Bulk density of the samples studied

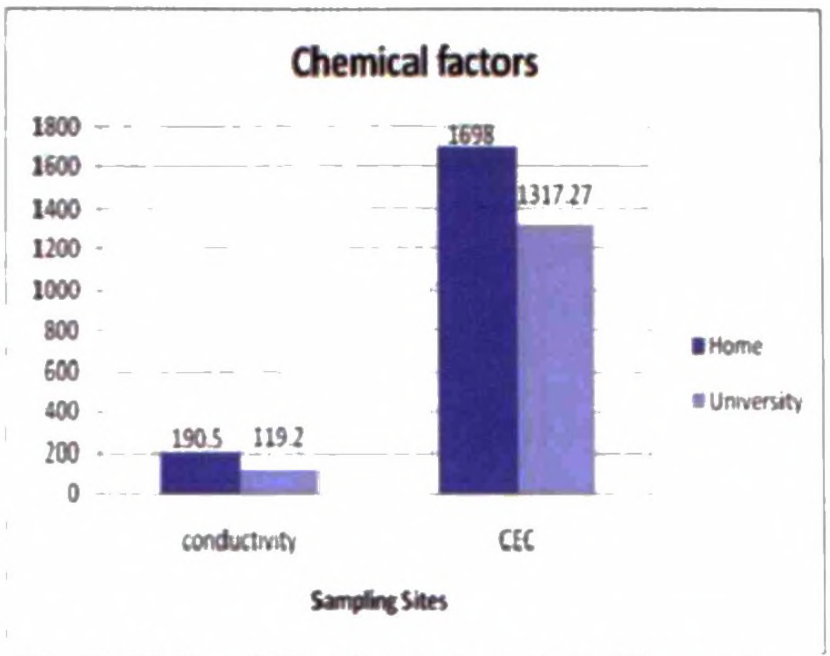

Fig. 3 CEC and Conductivity (micro Siemens) soils sampled

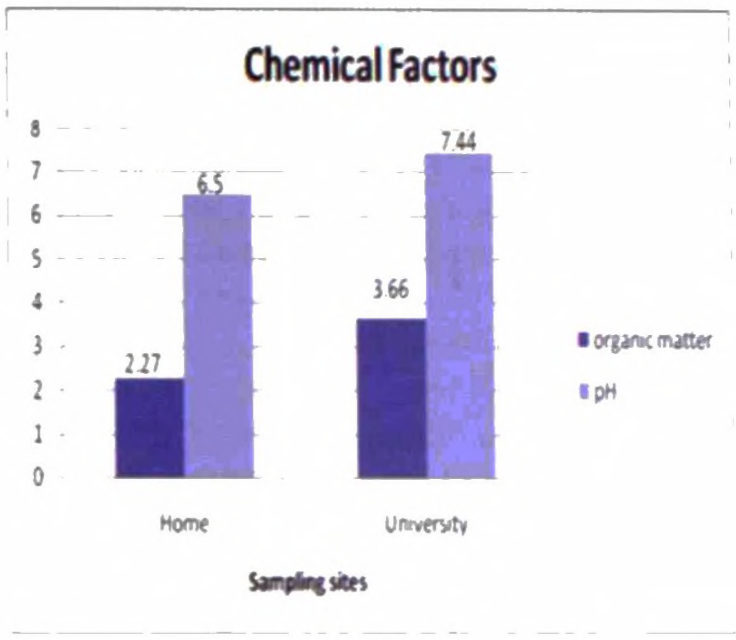

Fig. 4 pH and OM% of soils sampled

The pH of OUSL soils falls in the neutral range compared to the characteristic values expected for the soil in the agro climatic zone within which OUSL is located indicating that proper chemical processes are not taking place even after 30 years of human disturbances. The pH of the OUSL is slightly alkaline (Fig 4) and therefore, better decomposition cannot be expected. Further low chargeable ion content also indicates a low decomposition rate. The low conductivity observed in the OUSL soil can be attributed to erosion due to rainfall. Soil organic matter tends to increase as the clay content increases. Soils with higher clay content increase the potential for aggregate formation. Macro aggregates physically protect organic matter molecules from further mineralization caused by microbial attack (Rice, 2002). Therefore, high OM content observed may be due to the high clay content in the soil profile. The CEC levels are significantly low indicating poor chemical fertility (Fig 3).

As reported by Rice (2002), low Cation Exchange Capacity (CEC) encourages leaching and hampers the delivery of a steady, adequate supply of nutrients throughout the growing season. This could be one of the reasons why some die backs are reported in the OUSL premises and is also another very important finding that supports the hypothesis that the OUSL soil is still not reached the level of good quality after 30 years. Both bacterial counts and microbial biomass indicate that OUSL soils are not biologically fertile as compared to HG (Fig 5 & 6). When compared with both chemical and physical data, it is clear that OUSL soil is still under the effects of compaction due to earth filling.

Therefore, it is very difficult to have biologically high quality soil at the premises of OUSL. Since the decomposition rates are very slow as indicated by low CEC and high OM content, high microbial biomass (activity) cannot be expected. As reported by Xiao *et al.* (2001), Microbial biomass (activity) is reduced with soil compaction due to high water content, low available OM, less permeability & low decomposition rates.

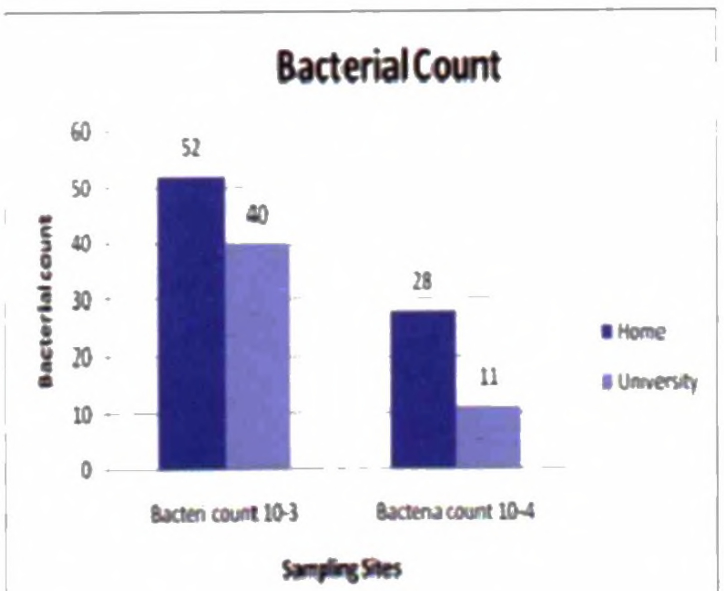

Fig. 5 Biological properties of soils sampled

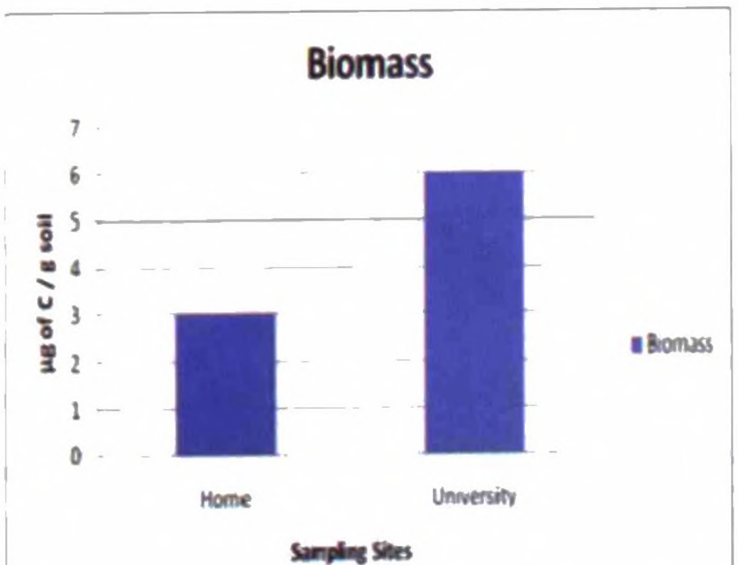

Fig.6 Microbial Biomass of soils sampled

No effect is recorded to indicate that habitat conversion (land use change) has caused this poor quality. Even though there are no significant differences, data clearly shows that microbial counts of soil have not yet reached the values of home garden. The reasons for this low microbial activity too could be reduced physical and chemical fertility of OUSL soils as reported earlier. The results for soil fauna clearly show that the home garden (HG) soil has a high faunal density than the OUSL soil. It clearly shows that OUSL soil is still under rehabilitation after heavy compaction. As reported by Saetre *et al*,(1999), low faunal density recorded may also be due to poor vegetation cover, lack of plant litter covering, lack of direct sun light (high temperature) and low moisture content.

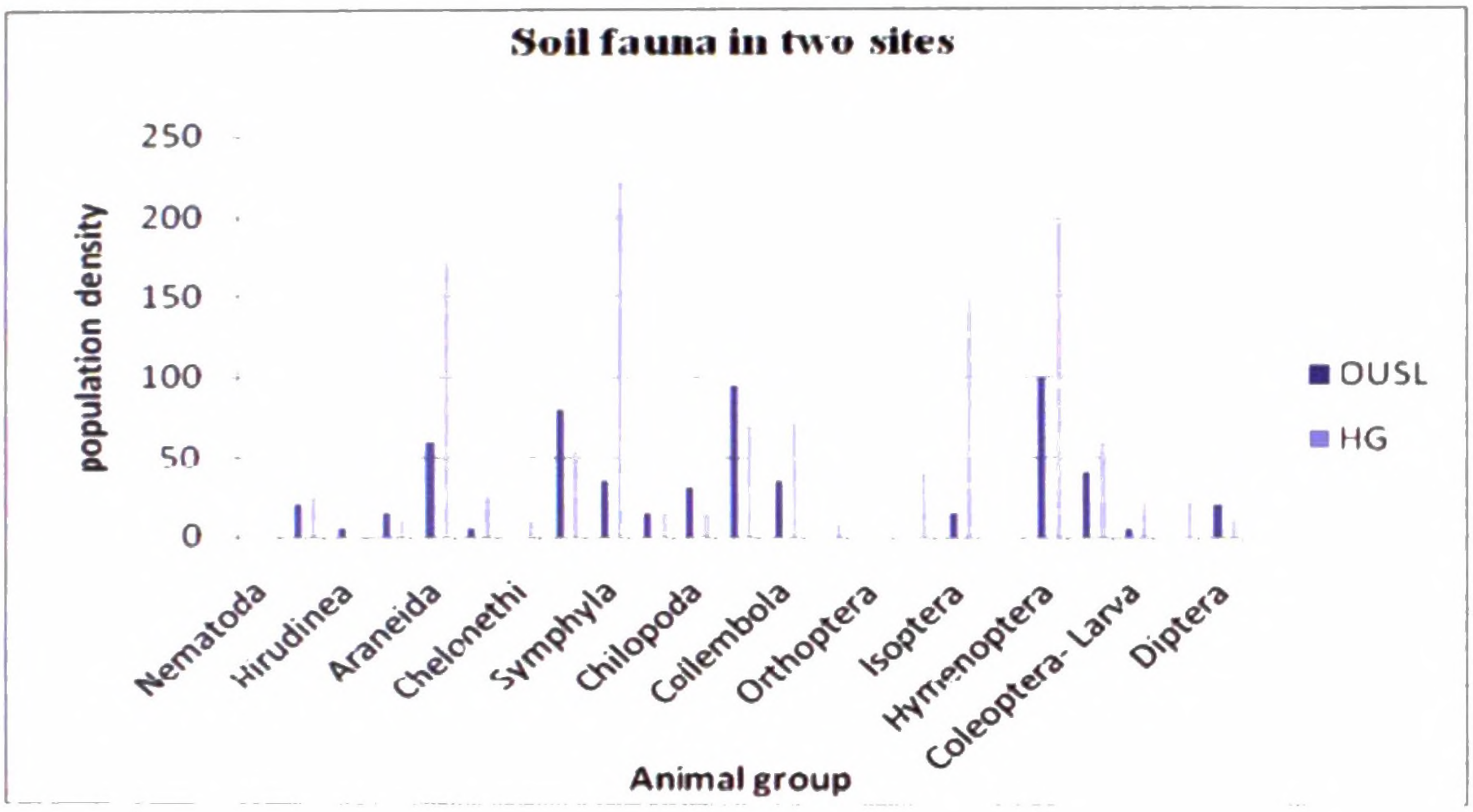

Fig. 7 Soil faunal density in soils of OUSL and home garden (HG).

CONCLUSIONS AND RECOMMENDATIONS

This research clearly indicates the formation of impervious clay layer over the time with erosion on compacted and filled soil. Further, obviously low soil quality based on selected physical, chemical and biological properties of OUSL soils clearly justifies the impacts of filling. Further studies are needed to explain these results with more numbers of sampling.

Findings do not indicate the actual scenario of the soil profile and give a set of unexplainable data mainly for physical properties. This could be due to not enough depth of sampling.

Chemical and biological data clearly indicates that filled earth of OUSL premises is not yet settled up to near natural status.

Some mitigation measures such as soil amelioration with suitable amendments (inorganic fertilizers) is suggested during planting. Only possible reason for die backs could be retarded root growth.

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