Ecological Engineering 37 (2011) 1700–1708

Contents lists available at ScienceDirect

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

The development of soil physical properties and vegetation establishment on brownfield sites using manufactured soils

Shaun Sparke[a,*], Philip Putwain[b], Jennifer Jones[a]

[a] School of Natural Sciences and Psychology, Liverpool John Moores University, Byrom Street, Liverpool L3 3AF, UK
[b] The University of Liverpool, Ness Botanic Gardens, Ness, Neston, Cheshire, L64 4AY, UK

ARTICLE INFO

Article history:
Received 1 February 2011
Received in revised form 18 June 2011
Accepted 29 June 2011
Available online 12 August 2011

Keywords:
Green waste compost
Bulk density
Soil physical properties
Meadow grassland
Porosity
Organic matter

ABSTRACT

The physical properties of natural soils have been researched extensively. However, there is a paucity of information on the short and longer term effects on a manufactured soil after the addition of municipal green waste compost as an organic component. Two field trials were set up using different soil forming materials. Trial 1 (Chorley), added compost to degraded subsoil, whilst trial 2 (Bidston) utilised compost added to a mixture of sand and silt. The trials were established to determine what effect the addition of municipal greenwaste compost had on the development of soil physical properties, and the soils subsequent ability to support vegetation establishment. The compost was introduced as a blend and mulch at varying ratios in an attempt to establish the most appropriate mix to support the establishment of grassland vegetation. It was found that the addition of compost reduced the bulk density proportionally across the majority of the blends at both trial sites which in turn had a positive effect on porosity and infiltration rates. At trial 1 there was evidence of a good suite of meadow plants present in many plots with reasonable similarity to the Natural Vegetation Classification MG5/5a except for the treatment with 33% compost mulch. At trial 2 the soil mixture treatments that supported vegetation most similar to the Natural Vegetation Classification MG5 suite of sown species were the mixes with 15% and 30% compost. The compost mulch treatment and the mix with 45% compost content were probably too fertile as they became dominant with ruderal weed species due to natural succession and inhibited the growth of the meadow plants. Overall, the initial findings of the two trials suggest that adding green waste compost at specific rates could be used as a successful strategy in the early stages of establishing and managing controlled vegetation growth on a manufactured soil.

1. Introduction

The physical properties of natural soils have been researched extensively and are well understood (Birkeland, 1999; Brady and Weil, 2002; Bronick and Lal, 2005). This contrasts with a paucity of information regarding the properties of manufactured soils. The use of green waste compost (hereafter referred to as GWC) to manufacture soils for brownfield remediation for the long-term establishment of urban greenspace is a recent development (Foot and Sinnett, 2006; Ouki et al., 2007), and offers an alternative method to applying biosolids for supplying an accessible supply of organic matter and nutrients. Applications of biosolids have previously been used in the reclamation of degraded areas (Sort and Alcaniz, 1996; Fuentes et al., 2007). However, Fuentes et al. (2007) recognises that detailed information on the effects of biosolids on ecosystems is needed to maximize the benefits and minimize the environmental risks of biosolid use in ecological restoration. Little is known of the short or longer-term effects of organic amendments such as GWC on manufactured soils. Clearly there is a need to understand the dynamics of these properties in such soils given their relevance to land remediation.

In urban areas in many parts of the developed world, municipal green waste originating from domestic gardens and civic parks is regularly collected separately from other wastes, composted and utilised for the creation of "manufactured" or otherwise named anthropogenic soil. Natural soil differs considerably from green waste derived, manufactured soil, as natural topsoils typically comprise 95% mineral matter derived from parent material and only about 5% organic matter (Brady and Weil, 2002). The addition of GWC with its acknowledged organic content of approximately 20–30% (Van Der Gaag et al., 2007) will inevitably increase the organic matter content of a soil.

* Corresponding author. Tel.: +44 151 231 2224.
E-mail addresses: s.p.sparke@2007.ljmu.ac.uk, spsparke@blueyonder.co.uk (S. Sparke).

0925-8574/$ – see front matter
doi:10.1016/j.ecoleng.2011.06.041

Traditionally, municipal organic waste was disposed to landfill. The current target for European Union countries is to decrease the quantity of organic waste going to landfill sites by 50% before 2050 (EC/Directive, 1999). This legislation has given considerable impetus to the production of soil improvement composts derived from GWC and it is therefore necessary that opportunities for an alternative use for the green waste component of organic waste should be explored. Composting the green waste and utilising it as an end product could provide an important component of a newly created anthropogenic soil, with this method for landscape improvement and creation viewed as a possible long term objective (Petersen et al., 2003).

It is known that increasing the organic matter content can assist in improving degraded or nutrient deficient soils by significantly altering and improving soil physical properties (Gallardo-Lara and Nogales, 1987; Aggelides and Londra, 2000; Ros et al., 2003). It is also generally accepted that soil structure dominates soil physical properties and their functions (Dexter, 1997). Improvement in structure usually implies an increase in total porosity thus having a positive effect on soil aeration and hydraulic properties (Berger and Hager, 2000). Additionally, the application of composted plant residues to soil is considered good management practice as it stimulates soil microbial activity, resulting in the mineralization of plant nutrients (Amlinger et al., 2003; Tejada et al., 2009). The microbial by-products foster the enhancement of the soil structure through the bonding of soil particles (Bronick and Lal, 2005) and play an important role in nutrient cycling which has obvious benefits for the healthy growth of plants. Tejada and Gonzalez (2008) demonstrated that the application of composted plant residues had a positive effect on soil physical, chemical and biological properties and plant colonisation, which can protect the soil against erosion and will contribute to its long term restoration.

Physical and chemical properties of soil change slowly over time and it is not always easy to quantify any significant changes over a short time period. Understanding soil responses to the addition of materials is important for the success and sustainability of remediation projects. The aim of the current study was to monitor and assess the short term effects on several key physical soil properties of a degraded soil after the addition of GWC, which had been seeded with various wildflower species and grasses. Additionally, the assessment of the establishment of grassland vegetation at two separate experimental sites was to provide evidence regarding the efficacy of industry standard compost (BSI PAS 100), as a component of manufactured soils to achieve a generalised sustainable vegetation growth. Soil physical properties were assessed by analysing several parameters including bulk density, water stable aggregates (WSA), soil water retention and movement, and soil texture over a period of 12 months.

2. Materials and methods

2.1. Study sites and experimental setup

The study was conducted at two experimental plots situated in a temperate climate zone in the Northwest of England. Trial 1 at Bidston (SJ288916) which is 9 m above sea level, is on a former municipal landfill site used for disposal of predominantly domestic waste during the period 1963–1978. The geology of this area is classed as Wimslow sandstone formation. This 14.4 ha site was poorly restored with a 0.1–0.3 m subsoil capping layer above the landfill contents. The original restoration was deemed unsatisfactory by modern standards and subsequent site investigations revealed soil cover was unsuitable for successful community woodland establishment without importation of suitable additional soil (WRAP, 2008).

Fig. 1. Experimental setup at Bidston demonstrating the incorporation of compost with the other soil forming materials.

The second experimental plot was located at the former Royal Ordnance Factory site at Euxton, Chorley (SJ561206) at an altitude of 72 m above sea level. This area was owned by BAE Systems Ltd. The bedrock geology of this area is classed as the Sherwood Sandstone Group. The Royal Ordnance Factory produced munitions between 1936 and 1990. Approximately 40% of this 265 ha site has been set aside for soft end uses including public open spaces, new habitats and development landscaping. The contaminated topsoil was stripped leaving heavy clay subsoil on the surface that restricted natural vegetation establishment. Topsoil was created using a mix of various soil forming materials blended with GWC at a range of volume ratios. At both experimental plots the soil treatments were placed on top of the existing surface to a depth of 30 cm (Figs. 1 and 2). This is consistent with previous experimental research in which a new or replacement topsoil was created (Liebrand and Sykora, 1996; Saebo and Ferrini, 2006). The blends used are shown in Table 1.

The experimental area comprised three blocks, with five treatments and three (5 m × 5 m) replicate plots, located within an area identified as suitable for species rich meadow grassland. Baseline data for the physicochemical properties of each treatment were obtained during the setting up phase prior to the seeding of the plots. A seed mix was created which simulated wildflower meadow grassland with the characteristics of National Vegetation Classification (NVC) MG5 (Table 2). The sowing rate was 4.0 g per m^2. The plots at the former Royal Ordnance facility were sown (seed broadcast by hand and surface raked) on 1st May 2007 and at Bidston landfill on 4th May 2007 using the same procedure (Figs. 3 and 4).

Fig. 2. Experimental setup at Chorley showing the preparation and setup of the randomized plots.