10. Sewage sludge organic matter and soil properties.

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10.1. Introduction

Organic matter from sewage sludge can exert significant influence on the physical, chemical and biological properties of soils. Organic matter in general contributes greatly to soil's productive capacity. Organic matter incorporated into the soil surface can affect its structure, as denoted by porosity, aggregation, and bulk density, as well as causing an impact as expressed in terms of content and transmission of water, air and heat, and of soil strength. Nutrients are mineralized during organic matter decomposition; C, N, and cation exchange capacity increase following organic matter additions. Other soil chemical properties such as pH, electrical conductivity, and redox potential are changed. The soil biosystem can be altered by addition of new energy sources for organisms, reflected by changes in micro- and macro-biological populations, which in turn influence synthesis and decomposition of microbially-produced soil humic substances, nutrient availability, interactions with soil inorganic components, and other exchanges with soil physical and biochemical properties.

Sewage sludges and other municipal wastes can benefit soil organic matter relationships in the overall soil-plant-water biosphere. Large quantities of these waste materials have traditionally been incinerated, dumped in oceans, or deposited in landfills. With the recent interest in decreasing air and water pollution, agricultural scientists are advocating utilization of these wastes on cropped land rather than just disposal of them. The composition of waste materials must be determined prior to land application, though, to avoid potentially hazardous high levels of trace metals and toxic organic compounds. In general, for any organic waste such as sewage sludges, soil and crop management practices (53) will largely control the nature of the chemical and physical changes which occur.

While it is commonly recognized that organic matter imparts a desirable physical condition to soils, as well as altering chemical and biological relationships, the mechanisms by which it reacts have not been well documented. Likewise, the impact of organic matter on desirable soil physical, chemical and biological properties is not well understood.

It is the purpose of this paper to summarize and discuss the influences of organic matter from sewage sludge on the physical, chemical and biological properties of soils.

10.2. Effect of sewage sludge organic matter on soil physical properties

Literature reviews investigating changes in soil physical properties due to sewage sludge addition are available (24, 25). For the most part, these reviews have discussed changes in soil physical properties in a general sense. The objective of this review is to provide more of the specific details from studies available in the literature. Information is provided from experiments conducted in countries around the world, including the United States (19, 20, 28, 35, 37, 50, 54, 58), Norway (92), Switzerland (22), Hong Kong (97), Italy (26, 27, 67, 68, 69), France (65), Great Britain (29), and Canada (94).

10.2.1. Bulk density

Bulk density (BD), defined as the weight of oven-dry soil per unit volume, is an indicator of the soil's physical condition. BD is usually related to a soil's porosity, texture, hydraulic conductivity, aggregation, compaction, and organic matter content.

Several researchers have investigated the effect of sewage sludge addition on changes in BD of mineral soils (Table 10.1). In general, soil BD values decreased as the rate of sewage sludge application increased. The reduction in soil BD may last for as long as 48 months, if relatively high applications of sludge are used (29).

Soil BD values were reduced by sludge addition regardless of soil texture or sludge type used. The reduction of soil BD appeared to be influenced primarily by the rate of sewage sludge organic matter addition. Based on data from 23 sources, utilizing 7 waste types, 21 soil types ranging from coarse sand to clay loam, and study periods ranging from 1 to 85 years, the following highly significant ($r^2 = 0.69$) relationship between soil BD and organic-C addition was found (43):

$$\Delta BD = 3.99 + 6.62 (\Delta C),$$  \[1\]

where $\Delta BD$ (%) = the waste-treated soil BD minus the control soil BD, divided by the control soil BD times 100, and $\Delta C$ (%) = treated soil organic-C content minus the control soil C content. Reduction in soil BD was probably due not only to the dilutional effect of adding less dense organic matter to the more dense mineral matter, but also to increased soil aggregation.