Bull. Environm. Contam. Toxicol. 23,717-724 (1979)

Sewage Sludge as Conditioner for Improving Soils Affected by Sulfur Dioxide

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Continuous emission of SO_2 from the acid manufacturing plant at Ching Lung Tau, New Territories of Hong Kong damaged most of the surrounding vegetation, leaving only a few comparatively more resistant species, e.g. Eragrostis sp., Ischaemum aristatum, Smilax glabra, etc. Erosion occured after heavy rainfall. Fine particles were washed away, leaving the non-fertile subsoil which lack nutrients (WONG 1978).

The utilization of sludge as a soil conditioner has been regarded as a method of sludge disposal which not only solves some of the pollution problems but receives benefit from the waste product. A considerable amount of literature has been concerned with improving infertile soil including the reclamation of spoiled land, e.g. coal mine spoils (PETERSON and GSCHWIND 1973), iron-ore tailings (WONG and LAI, in press).

The present investigation attempts to study the effect of applying digested sewage sludge to eroded soil using laboratory soil columns and a green house trial.

MATERIALS AND METHODS

Samples of eroded soil at Ching Lung Tau near the acid manufacturing plant were collected and transferred into the laboratory. They were then placed in self-constructed plastic soil-column containers measuring 150 cm x 12 cm x 10 cm.

The columns containing the eroded soil were divided into three groups,one without the application of sludge served as a control (column 1) and the other two applied with digested sludge (column 2: 1 cm and column 3: 2 cm on the soil surface respectively) collected from the sewage treatment plant at Shek Wu Hui, Hong Kong.

The columns were leached with 200 ml deionized water daily for a period of 60 days. Two columns for each group were removed every ten days. The soils in the columns were divided into 5 horizons, each measuring 8 cm. They were passed through a 2 mm mesh seive after being air-dried and tested for the following items: Hydraulic conductivity (constant head method; KLUTE 1965), pH (1 g soil: 20 ml distilled water and tested with a pH meter), organic carbon (WALKLEY and BLACK 1934) and SO_4 (turbidimetric method; HESSE 1971).

The leachate of each column was also collected on a ten-day basis and analysed for pH (pH meter) and SO_4 (turbidimetric method).

0007-4861/79/0023-0717 $01.60

A green house trial was also conducted simultaneously. The eroded soil was placed in culturing pots which were divided into 4 groups (5 replicates each), one without the application of sludge while the rest with 0.5 cm, 1 cm and 1.5 cm of digested sludge applied to the surface. The sixth group consisting of only garden soil (a sandy clay loam) was used for comparison.

Ten seeds of two grass species, Agropyron smithii and Buchloe dactyloides were sown separately in the pots. All the pots were placed in a green house and watered everyday. The plants were harvested after a period of 80 days.

RESULTS AND DISCUSSION

The results of the soil column study, leachate quality and the green house trial are presented in Figs. 1-4, Figs. 5-6 and Fig. 7 respectively.

Hydraulic conductivity

The constant head method is designed for measuring the hydraulic conductivity of saturated soil. When a soil is saturated, all of the interconnecting pores are available for water conduction and the reading is at a maximum.

Adding sludge to the eroded soil raised the hydraulic conductivity but it eventually returned to a lower value only slightly above the untreated soil with the sole exception of the top horizon of column 3 (Fig. 1). The obvious changes in hydraulic conductivity implied that there were changes in the soil characteristics, e.g. texture, porosity, distribution of pores, etc. in the eroded soil treated with digested sludge. The lower values of hydraulic conductivity at the later stage indicated that water movement through the sludge treatments was restricted by blocked pores which was due to the clogging of pores by microbial decomposition products (JOHNSON 1957). Continual decomposition of organic matter would cause such effect due to the formation of gases or solids as the decomposition products. Similar results were obtained by EPSTEIN (1975) in the study of the effect of sewage sludge on some physical properties.

pH

The vertical distribution of pH of the soil columns on three occasions are shown in Fig. 2. Application of the digested sludge raised the pH of the eroded soil especially that of the upper horizons. This was in line with the findings of PETERSON and GSCHWIND (1973) when applying digested sludge on coal mine spoils.

However, it must be noted that the changes of acidity of the sludge-amended soil will depend on the type of sludge added. The pH of the digested sludge from the treatment plant at Shek Wu Hui was about 7 due to the application of lime whereas the activated sludge from the treatment plant

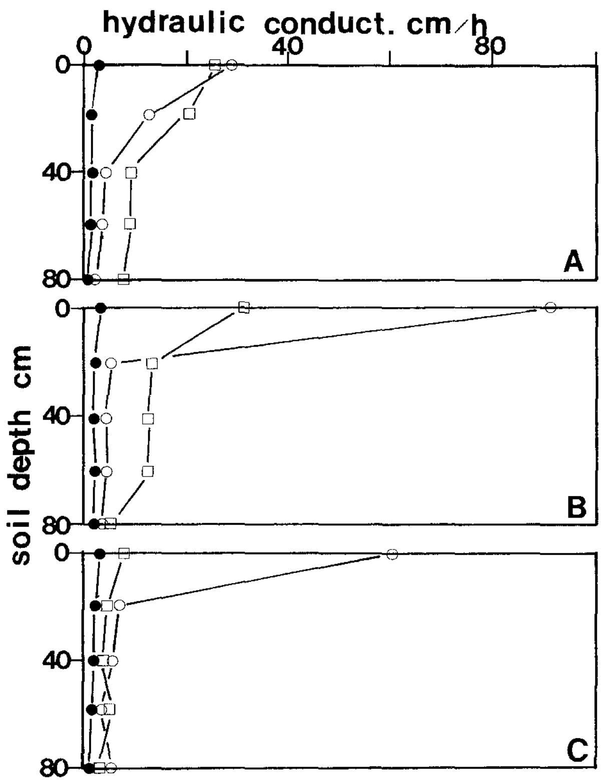


Fig. 1 Effect of digseted sludge addition on hydraulic conductivity.

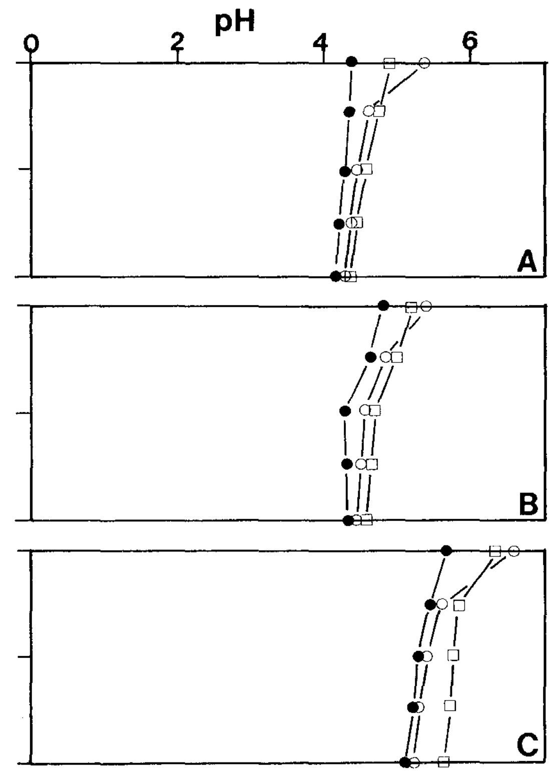
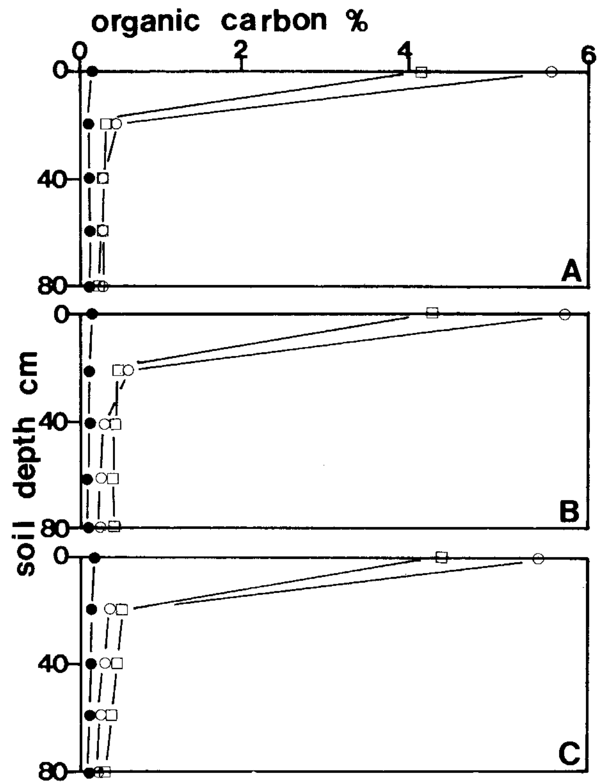


Fig. 2 Effect of digested sludge addition on soil pH.

● Column 1: eroded soil alone, □ Column 2: eroded soil treated with digested sludge, 1cm
○ Column 3: eroded soil treated with digested sludge, 2 cm. A=20th day, B=40th day, c=60th dः



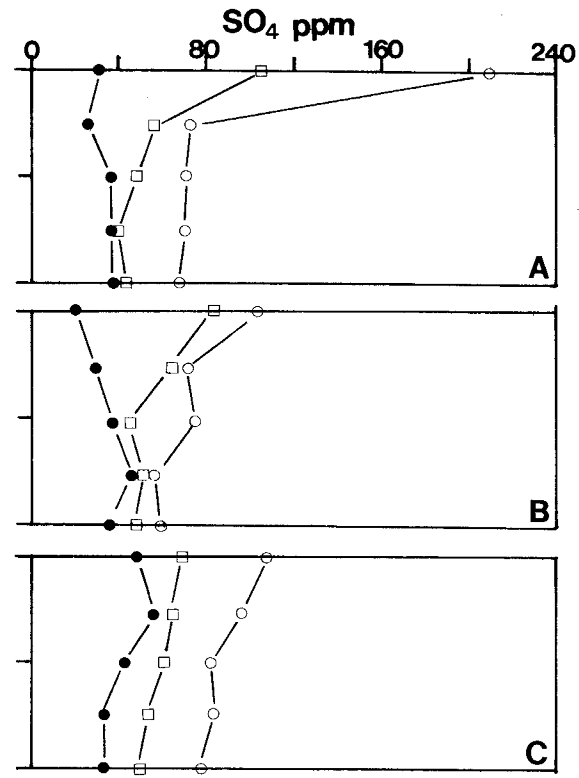


Fig. 3 Effect of digested sludge addition on soil organic matter.

Fig. 4 Effect of digested sludge addition on on SO_4.

● Column 1: eroded soil alone, □ Column 2: eroded soil treated with digested sludge, 1 cm.
○ Column 3: eroded soil treated with digested sludge, 2 cm. A=20th day, B=40th day, C=60th da

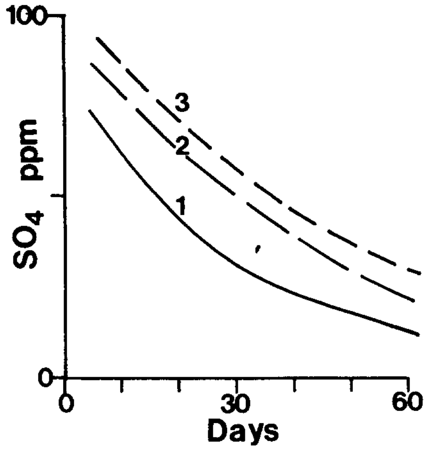


Fig. 5 SO_4 of the leachates from treated soil (Column 1) and digested sludge treated soil (Column 2:1cm, Column3:2cm)

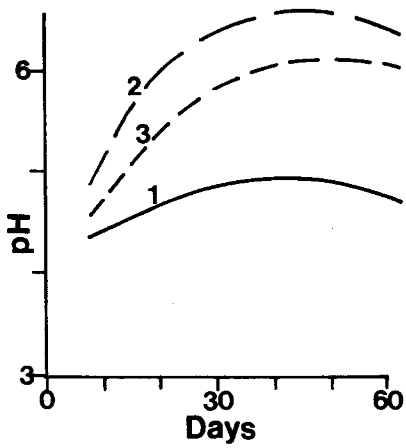


Fig. 6 pH values of the leachates (symbols refer to Fig. 5).

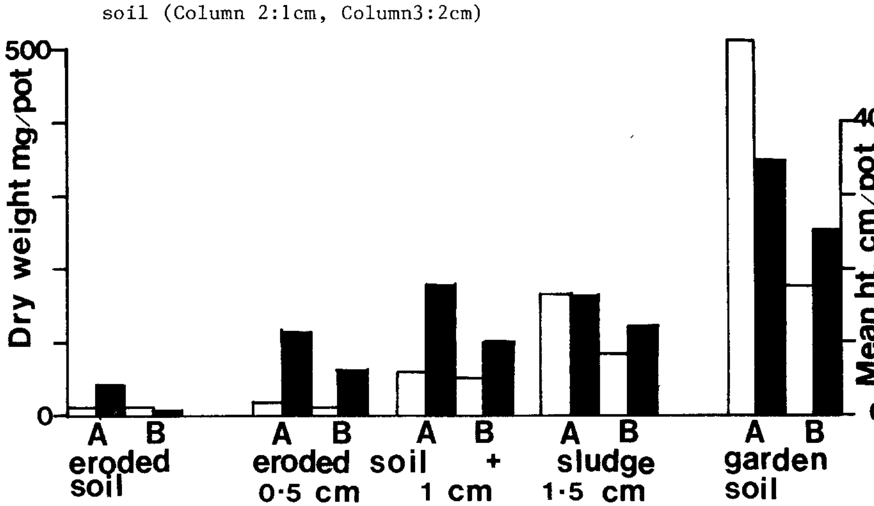


Fig. 7 The results of the green house trial of the two grass species treated with digested sludge (A=*Agropyron smithii*, B=*Buchloe dactyloides*, empty bars indicate dry weight, solid bars indicate mean height).

at the Chinese University was more acidic with an average pH of 5.

A slightly different picture was revealed in the changes of pH in the leachates (Fig. 5). Both columns 2 and 3 showed an immediate increase in pH at the earlier stage of the experiment, and a slight decline throughout the rest of the period but remained rather high (about 6) when compared with the untreated soil (column 1). The pH of the latter only increased slightly but declined more abruptly towards the end of the experiment after it had reached the maximum of 5.3 on the 40th day. The drop in pH in the later period possibly resulted from nitrification and oxidation of sulfides (KING and MORRIS 1972).

Organic carbon

Fig. 3 shows a considerable increase of organic carbon of the treated soil especially in the top horizons. The contents of the organic carbon decreased slightly towards the end of the experiment as shown in Fig. 3c indicating the organic material had been decomposed into simple compounds. These simple compounds probably accounted for the clogging of pores described above. EPSTEIN (1973) also reported a similar phenomena concerning the total carbon content of the soil-sludge mixture.

The proportion of organic carbon is a good indicator of fertility of the sludge which would serve as a source of nutrient when disposed onto soil surface. This is especially important for reclaiming the eroded area as the top soil which contained a comparatively higher content of organic matter had been washed away due to the lack of vegetation.

SO_4

The SO_4 contents of the top horizons of columns 2 and 3 were raised considerably at the early stage (Fig. 4a) but declined at the later stages (Figs. 4b and c). The changes of SO_4 contents were further confirmed by the similar results obtained in the leachates where all the three columns dropped about 4-fold on the 55th day compared with those on the 5th day.

It has been recognized that sulfur can be lost from soils under conditions of heavy rainfall. The relation between the amount of percolating water and the downward movement of sulfate determined with radioactive S^{35} by CHAO et al. (1962) showed the greater the amount of added water, the greater the leaching of the sulfate.

The continuous emission of SO_2 from the acid manufacturing plant accounted for the rather high contents of SO_4 in the eroded soil although the content was rather low when compared with the content in the sludge (2291 ppm). However, no reference has been cited as to the toxic effect caused by the high sulfur content in the sludge when applied to agricultural land. It may be possible that the high content of sulfur of the eroded soil is not a controlling factor in determining plant growth but other factors, e.g. coarse texture, lack of organic matter and nutrients are more important. Besides, it is expected that the availability of sulfur will be less in such low pH (4.7) in the eroded area.

Yield

The green house trial substantiated the column study where a positive growth of the vegetation responded to the application of digested sludge although they were inferior in terms of dry weight and mean height when compared with those growing in the garden soil (Fig. 7). The plants growing on the eroded soil alone were small, short and lacked a green colour. All the plants were immature with the sole exception of those growing in the garden soil where vigorous growth of seeds was formed. Nevertheless, there is no doubt that the application of digested sludge improved the plant growth due to the improvement of the soil characteristics, both physically as well as chemically as demonstrated in the above sections. The nutritive value of the leachate of the sludge has been revealed (WONG 1977, WONG et al. 1977) where *Chlorella pyrenoidosa* growing in the sludge extracts were similar to those growing in the Kuhl medium designed for cultivating a fast growing type of unicellular green algae such as *Chlorella*.

From the above data, it can be concluded that the eroded soil can be improved by applying digested sludge. However, further investigation should be concentrated on the amount of sludge added to the eroded soil, and plant tissue analysis may be conducted in order to verify that plants are receiving enough nutrients. Colonization of the existing species found in the eroded area, e.g. *Eragrostis* spp., *Ischaemum aristatum* should be enhanced due to their resistant nature.

Incorportion of the sludge instead of application to the soil surface may also obtain a better result as crusts were formed on the surface and retained higher organic matter and nutrients which would be less available to the lower horizons as deomonstrated in the early sections.

ACKNOWLEDGEMENTS

The author would like to thank Miss. S.W. YIP and Mr. C.F. MO for their technical assistance in part of the investigation. The provision of seeds by Mr. S.P. LAU, Research Officer of the Agriculture and Fisheries Department of Hong Kong is also gratefully acknowledged.

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