THE pH AND NUTRIENT CONTENT OF SEWAGE SLUDGE TREATED WITH LIMESTONE BY-PRODUCTS AND DESTINED FOR AGRICULTURAL USE

F. Quiroga-Lago, Y. Pousada-Ferradás, A. Núñez-Delgado
Dept. of Soil Science and Agricultural Chemistry. Escuela Politécnica Superior. Campus de Lugo, 27002. University of Santiago de Compostela, Spain

ABSTRACT

The disposal or recycling of sewage sludge produced in Waste Water Treatment Plants (WWTP) is of growing concern. In view of some potentially useful characteristics of sewage sludge, such as its organic matter and nutrient contents (especially that of nitrogen), its use on agricultural and forest land has been suggested. However, continuous use of these residues may lead to soil acidification and increases in heavy metal contents and populations of pathogenic microorganisms. The treatment of sewage sludge with by-products of limestone processing is proposed as a method of minimizing these risks. The resulting mixture should have a more suitable pH, the heavy metals bound into unavailable forms and the populations of pathogenic microorganisms drastically reduced. The changes in pH and nutrient content of several samples of sewage sludge treated with different concentrations of lime and dolomite were monitored in an attempt to determine the most appropriate proportions of sewage sludge and liming agent. In light of the results, the most appropriate mixture appears to that composed of 30 % liming agent and 70% sewage sludge.
Keywords: *sewage sludge, quicklime, charred dolomite, mixtures.*

INTRODUCTION

Sewage sludge is the residue generated during the treatment of waste water. The production of sewage sludge is increasing significantly in EU countries as a consequence of current guidelines that demand a more thorough treatment of waste water than previously required (European Guidelines 91/271).

Management of the sludge produced creates generally complex and costly technical problems. Unauthorized dumping of sewage sludge is banned by law, and land filling or incineration are expensive and potentially hazardous methods of disposal from an environmental viewpoint.

In light of the high content of organic matter and of some nutrients essential for plants, application of the sludge on agricultural lands as a fertilizer has been suggested as an alternative to land filling and incineration (Kelley et al*.,* 1984; Mosquera et al., 2001).

However, there are several difficulties associated with the application of sewage sludge on land, such as soil acidification and the incorporation of heavy metals and pathogenic microorganisms in the receiving soil (Alloway and Jackson, 1991).

The stabilization of sludge by mixing it with alkaline products (quicklime, dolomite, etc.) is proposed as a solution to these problems. This practice raises the pH of the soil, thereby promoting the immobilization of many heavy metals and the reduction of pathogenic microorganisms (Abbott et al*.,* 2001), while at the same time enriching the soil with nutrients such as Ca or Mg.

The aim of this study was to prepare and assess mixtures made of sewage sludge from WWTP (Waste Water Treatment Plants) and an alkaline material - quicklime (QL) or charred dolomite (CD) - to find the optimal proportions for its use as fertilizer and amending agent for agricultural land.

MATERIAL AND METHODS

- Sewage sludge. The sludge samples used in this study were obtained from five WWTP situated in the following municipalities in Galicia (NW Spain): Betanzos, Carballo, Pontedeume, Santiago de Compostela and Lugo. Most of the sludge samples had undergone stabilization treatment and, in some cases, they had had been subject to digestion, denitrification, or anaerobic processes.

Samples were collected in the WWTP in wide-mouthed plastic containers of 20 L of capacity, which were hermetically sealed and labelled appropriately.

- Alkaline agents. The alkaline materials were provided by CEDIE, S.A., an electrochemical and limestone processing company. The products tested were: QL (0-4) = quicklime of particle size between 0 and 4 mm, QL (1-5) = quicklime of particle size between 1 and 5 mm, CD (0-1) = charred dolomite of particle size between 0 and 1 mm, CD (0-4) = charred dolomite of particle size between 0 and 4 mm and CD (1-5) = charred dolomite of particle size between 1 and 5 mm.

- Mixing procedure. Three mixtures were prepared with 10, 20 and 30 % (w/w) of alkaline agents and 90, 80 and 70 % of sewage sludge, respectively (using the sludge with the original moisture levels registered during the sampling).

- Methods of analysis. The original materials (sewage sludge and alkaline agents) and the mixtures were analysed following standard procedures (Guitián and Carballas, 1976; APHA, 1998). The following parameters were determined: pH, Total Kjeldahl Nitrogen (TKN, %) and total contents of P, K, Ca and Mg (g Kg^{-1}).

RESULTS AND DISCUSSION

The main objective of the mixing was to attain a pH higher than 12 in the final product. This pH value is considered as the threshold above which the precipitation of most heavy metals and a drastic reduction of pathogenic microorganisms occur (although the pH level must be maintained for at least 1 hour). Figure 1 shows the average pH of the five sludge samples tested, with the different proportions of liming agents.

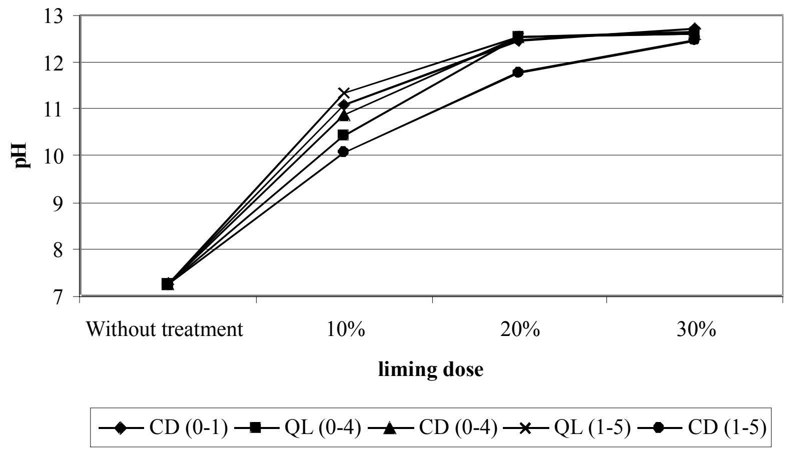

Figure 1*. Average pH attained for the five sludge samples mixed with the different proportions of the liming agents.*

Figure 1 shows the increase in pH of the mixtures as more liming agent was added. The increase was less marked at between 20 and 30 % liming agent. However, only a proportion of 30 % guaranteed a pH > 12 in all cases, e.g. with 20 % of charred dolomite (1-5 mm), the average pH value for the five sludge samples under study was below 12.

The average contents of N, P and K of sewage sludge, as well as their corresponding mixtures, are shown in Table 1.

***Table 1**. Average contents of TKN (%), Total P (g Kg^{-1}) and Total K (g Kg^{-1}) in the sewage sludge alone and mixed with different proportions of the liming agents.*

Sewage sludge				Proportion of liming agent								
			Limin g agent	10 %			20 %			30 %		
N	P	K		N	P	K	N	P	K	N	P	K
3.21	44.52	3.97	CD (0-1)	3.10	46.09	3.82	2.60	46.33	3.53	2.31	41.99	3.49
			QL (0 -4)	2.03	41.86	4.19	2.75	45.84	3.85	2.15	46.07	3.42
			CD (0-1)	2.37	55.64	3.46	2.60	46.88	3.55	2.29	49.39	3.18
			QL (0 -4)	3.29	56.57	3.87	2.42	53.33	4.92	2.39	52.50	3.13
			CL (0 -1)	2.66	49.61	3.70	3.58	55.27	4.92	2.69	42.42	3.20

The amounts of N, P and K in the sewage sludge samples were similar to those reported in similar studies (Kelley et al*.,* 1984; Jackson et al*.,* 1999). Abbot et al*.* (2001) reported amounts of different elements in a lime-stabilized biosolid, e.g. 4 g Kg^{-1} of K, which is very similar to our results, and 4.7 g Kg^{-1} of P, which is very different from the concentration that we obtained, indicating the high variability in sewage sludge composition.

On the other hand, the amounts of these essential nutrients in the mixtures and in the original sludge were similar (Table 1). There were only slight decreases in N after the addition of liming agents, which may be a result of the dilution effect caused by the inclusion in the mixtures of materials lacking this element, and/or volatilization of ammonia.

he concentrations of P and K were very similar in the sewage sludge and the mixtures. In some mixtures the concentrations were even higher, which was unlikely to have been caused by the addition of liming agents because of the lack of both elements in quicklime and dolomite. The increases in P and/or K are therefore attributed to the inherent variability of sewage sludge.

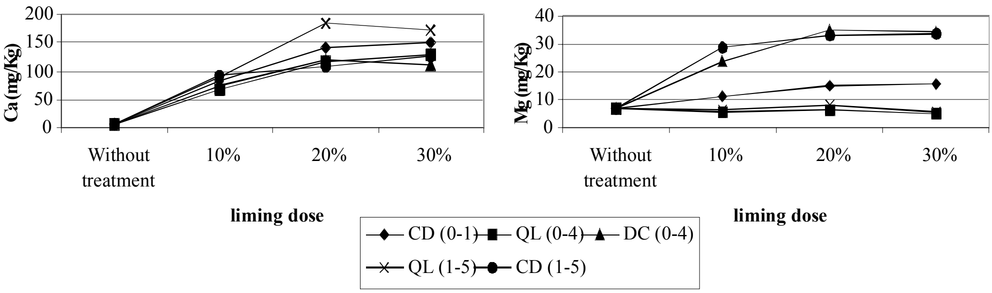

***Figure 2**. Average contents of total Ca (Mg Kg^{-1}) and total Mg (mg Kg^{-1}) in the five sewage sludge samples without liming and with the different proportions of liming agents added.*

Figure 2 shows the results corresponding to Ca and Mg. There were large increases in concentrations of Ca with increasing proportions of alkaline material up to 20 %, above which the values became stabilized or were even slightly reduced. Mixtures including quicklime (1-5 mm) showed the highest concentrations of Ca.

Increases in the concentration of Mg were observed in the mixtures including charred dolomite in their composition -the increase was less pronounced in the case of CD (0-4)-. This was not surprising as dolomite contains Mg. There were no increases in the concentration of Mg in mixtures containing quicklime.

CONCLUSIONS

The alkaline agents used in this study showed their potential to raise the pH level of sewage sludge, with the aim of achieving the precipitation of heavy metals and the reduction of pathogenic microorganisms.

These materials constitute a potentially useful source of calcium and in the case of charred dolomite, also of magnesium, therefore improving on the fertilizing capacity of the sewage sludge.

The results showed that only the mixtures containing 30 % of liming agents attained the desired level of pH 12, and this was therefore considered to be the most suitable proportion.

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REFERENCES

Abbott, D. E., Essington, M. E., Mullen, M. D., Ammons, J. T. 2001. Fly ash and lime-stabilized biosolid mixtures in mine spoil reclamation: simulated weathering. J. Environ. Qual., 30: 608-616.

Alloway, B. J., Jackson, A. P. 1991. The behaviour of heavy metals in sewage sludge-amended soils. Sci. Total Environment., 100: 151-176.

APHA. 1998. Standard methods for the examination of water and wastewater. American Public Health Association, Washington, DC.

European Guidelines. 1991. 91/271/EU of May 21st, 1991 on urban waste water treatment.

Guitián, F., Carballas, T. 1976. Técnicas de análisis de suelos. Ed. Pico Sacro, Santiago de Compostela.

Jackson, B. P., Miller, W. P., Schumann, A. W., Sumner, M. E. 1999. Trace element solubility from land application of fly ash/organic waste mixtures. J. Environ. Qual., 28: 639-647.

Kelley, W. D., Martens, D. C., Reneau, Jr., Simpson, T. W. 1984. Agricultural use of sewage sludge: a literature review. Virginia Polytechnic Institute and State University. Department of Agronomy. Bulletin 143.

Mosquera-Losada, M. R., López-Díaz, L., Rigueiro-Rodríguez, A. 2001. Sewage sludge fertilisation of a silvopastoral system with pines in northwestern Spain. Agroforestry Syst., 53: 1-10.