INVENTORY OF SOIL HEAVY METAL CONCENTRATIONS IN GALICIA

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1 INTRODUCTION

European Union 91/271/CEE Directive established that Member States shall ensure that all agglomerations with a population equivalent of more than 2000 inhabitants should be provided with collecting systems for urban waste water, at the latest by 31 December 2005. This Directive has increased the production of the Municipal Sewage Sludge which causes environmental problems if it is not adequately disposed of. Sewage sludge fertiliser use is one of the most promoted ways of recycling this residue in the EU. The use of sewage sludge as fertiliser is an adequate way of disposal of this residue due to the high nitrogen and organic matter content which could enhance nutrient recycling and benefit crop production (Smith, 1996). One of the most important aspects related to the use of sewage sludge utilisation as fertiliser is the composition of the sludge. Sludge nitrogen concentration and its mineralization rate is the main factor driving sludge fertiliser (EPA, 1994) supply of crop nutrients. However, phosphorous and potassium inputs into the soil are also made when the sludge is applied. The fertiliser value of the sewage sludge processed in different ways of 45 plants within Spain has been recently described (Mosquera-Losada et al., 2010) indicating that the quality of the sludge is good enough to be used in agriculture.

Higher heavy metal concentrations of sewage sludge than in soil is one of the main concerns regarding the use of sewage sludge as fertiliser. For this reason, the use of the sewage sludge as fertiliser is regulated by the Spanish Directive 1310/90 coming from the 86/278/CEE Directive. Both Directives regulate the maximum quantity of heavy metal concentrations in the sewage sludge to be used as fertiliser. Mosquera-Losada et al. (2010) have recently evaluated the levels of the main heavy metals of different sludge within the Spanish territory and indicated that most of the samples evaluated did not exceeded the limits provided by the regulations. Once the levels of the sewage sludge are evaluated, the use of the sewage sludge as fertiliser depends on the levels of soil heavy metals in such a way that even if the sewage sludge has low levels of heavy metals it cannot be used as fertiliser if the soil heavy metal concentrations are above the soil limits also described by the Spanish Directive 1310/90 and the European 86/278/CEE Directive. Regulated heavy metal are copper, zinc, chromium, cadmium, mercury, lead and nickel. This study aimed to evaluate the potential use of sewage sludge as fertiliser based on the levels of the seven heavy metal concentrations in Galician region soils regulated by Spanish and European directive.

2 MATERIALS AND METHODS

The experiment was carried out in Galicia, a region in the North-West of Spain at the North of Portugal. Galicia is located in the south part of the European Union Atlantic Biogeographic region, which is characterised by high precipitations and warm temperatures. AGROAMB PRODALT is a Company which manages more than the 50% of the sewage sludge production in Galicia. This company manages the sewage sludge from the municipal plant to the soil where it is used as fertiliser. Soil analysis are performed in all soils before sewage sludge is applied at a depth of 25 cm, as indicated by Spanish RD 1310/90 (BOE, 1990). Around 2500 soils were used in this experiment from areas where grassland is extensively used to feed livestock and which can be seen in Figure 1. Soils were transported to laboratory, air dried, sieved and ground in an agate mortar. Nitric acid digestion was performed in a CEM microwave (CEM, 1994). Copper, cadmium, lead, chromium, zinc and nickel concentrations were determined using atomic absorption spectrophotometry and mercury in a hydride vapour generator. Mean values of the samples were estimated and the proportion of plots which did not fulfil the Spanish 1310/90 regulation evaluated and placed in a map using a GIS program.

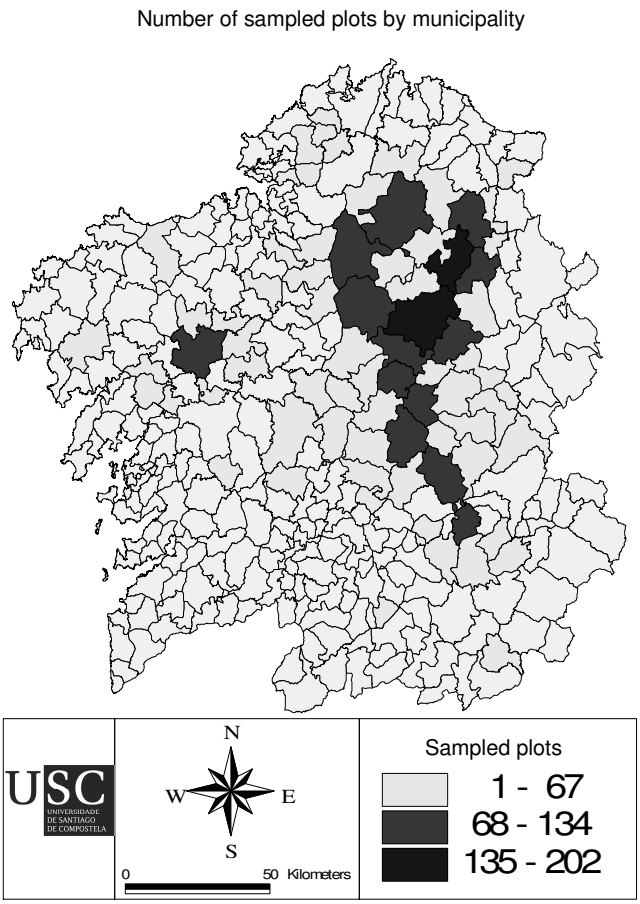

FIGURE 1 **Sampling area distribution in Galicia per municipality.** Light grey colour represents no sampled municipalities.

3 RESULTS AND DISCUSSION

Heavy metal mean concentrations of the 2500 samples were within the low part of the range provided for these heavy metals in the literature (Table 1), with the values of Ni and Cd closer to the Spanish RD 1310/90 limits than the others heavy metals. Galician soils are usually very acid which cause bioavailability of these heavy metals and leaching, reducing the levels in soils.

TABLE 1 **Heavy metal concentrations in soil of Galicia (Galicia mean),** mean soil range provided by literature ([a]:Kabata and Pendias, 1988 and [b]: Carter 1993 and the maximum values provided by the RD 1310/90 for acid soils (water pH below 7) to receive sewage sludge. All units are in mg per kg of soil, with the exception of Hg which is expressed in micrograms per kilogram of soil

	Cu	Cr	Zn	Ni	Cd	Pb	Hg
Galicia mean	16.38	10.03	45.33	12.2	0.05	10.21	0.05
Mean soil range	6-60[a]	1.4-1389[a]	10-105[a]	1-100[b]	0.07-1.1[a]	3-189[a]	0.01-0.5[a]
RD 1310/90	50	100	150	30	1	50	1

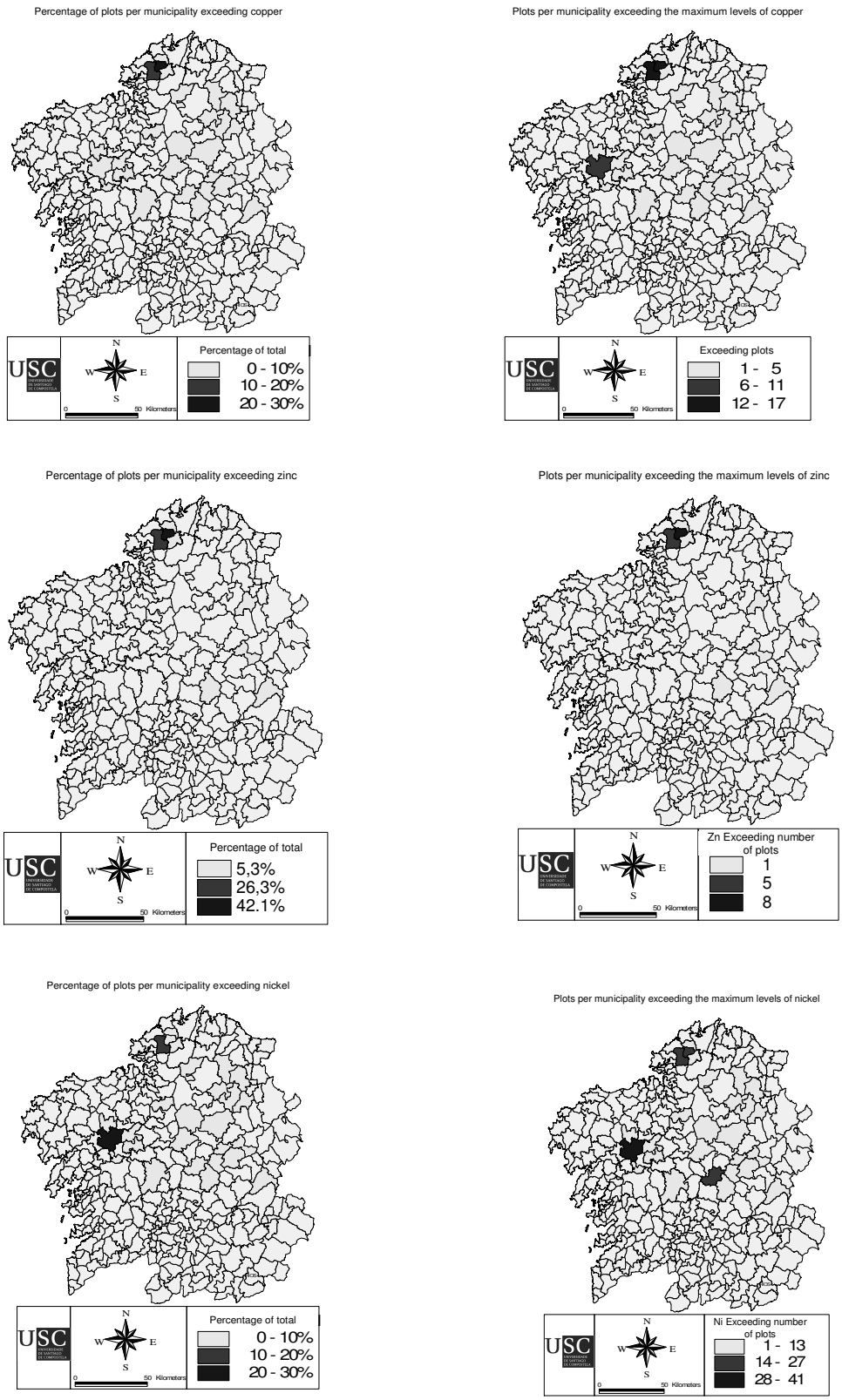

FIGURE 2 **Placement of the number of sampled plots and its percentage over total, where soil samples exceeded the levels of copper, zinc and nickel.** Light grey colour represents no sampled municipalities.

Around 93.3% of the total samples taken are allowed to receive sewage sludge following the RD 1310/90, and therefore around 6.7% were over the values provided by the RD 1310/90, which indicates that most of the soils are suitable to receive sewage sludge as fertiliser.

Although most of the sampled plots were located in the part of the region allocated to milk dairy production (north part) and to beef production (south part) (Figure 1), the plots which did not fulfil the Directive requirements were places out of these areas (Figure 2). Therefore the most sampled areas has less soil restrictions to receive sewage sludge. Copper and zinc are the two heavy metals with highest concentration in the soil compared with the regulatory values, (table 1), Nickel was the most restrictive heavy metal to apply sewage sludge, taking into account the soil parameters. Soils which were over directive limits for Ni were located in the north west part of Galicia where soils come from metamorfic rocks like gneis, anfibolites and schists, which are mainly richer in Ni. Nickel and copper are also high closer to the city of Santiago de Compostela. There are also a higher number of municipalities exceeding Cu and Ni values than Zn. All these soils are not allowed to receive sewage sludge, whatever the quality of sludge is. Moreover, sewage sludge from areas with soils over directive limits for Ni, Zn and Cu has to be transported to areas with soils fulfilling the directive related to sewage sludge use as fertilizer (RD 1310/90).

4 CONCLUSIONS

Most of the Galician soils are suitable to receive sewage sludge as fertilizer following the Spanish and European Directives, with Cu, Ni and Zn soil concentrations the most restrictive heavy metals when applying sewage sludge. Soil heavy metal concentrations depended on soil parent material. Therefore sewage sludge produced in those areas with soils which not fulfill RD 1310/90 Spanish Directive should be transported to elsewhere or eliminated through dumping or incineration.

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