# MALTING SLUDGES AS SOIL AMENDMENT

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## ABSTRACT

Residual sludge that results from the treatment of malt house effluents produced during the malting of barley in malt house (Argentina) was evaluated to determine its fertilising potential and capability for improving soil as a way to reuse or recycle this material. The Cabildo soil (Southwest of Buenos Aires Province), of the typic Argiustoll subgroup had a sandy clay-loam texture and was tested in this field experiments. This soil plots (4 $m^2$) were amended with equivalent malting sludges doses of 5, 15, and 25 Mg/ha. When biosolids, like malting sludges, are incorporated as an amendment, many micronutrients are provided. Chemical properties of the soil, particularly the pH, EC (Electrical Conductivity) and Cation Exchange Capacity (CEC), were improved. *Dactylis glomerata* L. were utilised as growing crop (forage) in this field test, productivity ( Dry matter) and quality (protein %) gave results following 0,205 kg/$m^2$ and 11.94 % at control in comparison with 0,4 kg/$m^2$ and 15.15 % of amended soil. Calcium concentration in grasses was significantly different for control (4651 mg/$kg^{-1}$) in comparison with high sludge dose (8907 mg/$kg^{-1}$), the same trend was found with micronutrients like Copper and Molybdenum. This results from field test indicate that this residual sludge constitutes a suitable amendment for agricultural soils, increassing quality and productivity of *Dactylis glomerata* L and improving several soil properties.

**KEY WORDS: MALTING SLUDGE, SOIL AMENDEMENT , FORAGE**

## INTRODUCTION

Nutrient depletion is a major form of soil degradation. The sludge from effluent treatment plants in agro-industrial processes is a potential source of organic fertilisers (Roy et al., 2003) that can be used to restore the fertility of agricultural soils with better prospects than even inorganic or conventional fertilisation. When biosolids are incorporated as an amendment, many micronutrients that are not incorporated with conventional (synthetic) fertilisation are provided. This incorporation is an advantage, given that the design of fertiliser dosages at the micro-level would be notably costly. The bioavailability of trace elements, such as micronutrients or toxic elements, is not determined by the total concentrations of the elements in question; rather, it depends directly on the chemical properties of the soil, particularly the pH and cation exchange capacity. The application of biosolids, organic (plant/animal) waste to the soil should be reconsidered as an economic practice, both from the standpoint of operating costs and from the standpoint of the environment, given the facts that matter is recycled and it can effectively compete with chemical fertilisers at lower environmental costs. All of these factors support the pursuit of an effectively sustainable agricultural-livestock production method. The use of organic waste would also be an advantage for countries with relatively low industrialisation that could more easily "close" the cycle of nutrient recycling in contrast to highly industrialised countries. Ideally, sustainable agricultural-livestock production would be stable when organic waste arising from the study area is reused within the same area (Schulz et al., 1997). This stability is possible when the surface areas of agricultural land are large, and the generation of agribusiness and domestic waste is not excessive, as is the Argentina situation. One way to improve or restore long-term soil quality is to intervene in the complex processes of agro-ecosystem biocycles.

Taking into account the limiting soil factors for growing crops in marginal zones of the Argentine Pampas, such as the southwestern regions of the province of Buenos Aires (sub-humid – semi-arid zones), a typical Mollysol soil (Argiudol suborder) was tested with the objective to propose practices, such as amendment with biosolids (organic waste), like malting sludges that would improve the soil quality and increase the sustainable productivity of cereals and fodder to prevent deterioration of the ecosystem. Sludge from waste biomass (activated sludge treatment of malting effluents), mainly organic matter had a chemical composition about 50% cellulose, hemicellulose 20%, 18% of lignin, 6% protein, 5% amino acids and sugars and other pectin, waxes, pigments, etc..

## MATERIALS AND METHODS

Soil plots were established in Rucalen-Cabildo (Buenos Aires, Province) as soil C (Torres Carbonell et al., 2012). Malting sludges were from a malt house nearby Bahia Blanca- Argentina (Campaña D.H. et al., 2014). 15 plots were laid out square, 4 m2 each, with ploughing and raking up soil, and, after 8 days, biosolids were applied superficial. 4 trials were conducted with three replicates each, adding doses equivalent to 5, 15 and 25 Mg. per há. Control plots (soil without sludge), also was tested. Once added, sludge was mixed with the topsoil (15 - 20 cm), then raking to prepare the seedbed. Five weeks later (36 days), it was taked the first soil sample from each plot and was seeded, orchard grass (*Dactylis glomerata L*). The seeding rate was 1.25 grams of seed per m2 each plot (equivalent to the rate typically used forage cropping). Any irrigation was not performed, so that the water intake was only by rainfall during the experimental period. After fourteen weeks, the grass was cutted, immediately was maked the second sampling of soil and finally the third sample was collected after completion of the final collection of grass, which was made by hand with scissors cutting leaving a minimum of grass remaining in the plot (less than 2 cm in height). The harvest included , orchard grass and the other species growed togheter. The pH, electrical conductivity, , exchange cations and the effective exchange capacity , were measured for soil samples. For vegetables, after performing acid digestion (nitric / perchloric acid) samples were determined total contents of P, Ca, Mg, K, Cu, Zn, Mo atomic emission spectrometer inductively coupled plasma (ICP-AES). To estimate the crude protein, the determination was made on a dry sample of plant total N measured by the Kjeldahl method, multiplied by the factor 6.25, assuming that the average content of N is 16% crude protein. Statistical validation was by analysis of variance (ANOVA) to test significant differences of measured variables, all cases were determined properties by triplicate samples. As an alternative nonparametric analysis of variance (ANOVA) were used: in some cases the Kruskal-Wallis, or the Wilcoxon test.

## RESULTS AND DISCUSSION

Eight months crop growing (forage) using orchardgrass (*Dactylis glomerata L.*) in soil C, sub-humid climatic conditions (Cabildo- Buenos Aires-Argentina) was performed. At the experimental plots were determined soil pH, electrical conductivity (EC), cation exchange capacity (CEC). For *Dacylis glomerata L.* (Orchard grass), dry matter production, and quality, including protein, Ca, Mg, K, P, Zn, Cu and Mo were measured. The micronutrients evolution and forage production were evaluated, beginningMarch and ending mid-November. The maximum and minimum average temperatures were similar initial and finally(26 º C and 13.2 ° C in March and 25.8 ° C and 10.6 ° C in November). The lowest temperature happend at July, with an average maximum of 11.6 T º C and average minimum of 1.5 ° C. The rainfall for the period was 469 mm, the distribution was: 132 mm at 1st sampling, 124 mm at second one and 213 mm at final sampling. Intermediate sampling results were not showed (space limitation), pH, electrical conductivity, cation exchange capacity and exchangeable cátions are presented in Table 1 . Finally plant production (dry matter), protein and micronutrients contents were determined and showed in Table 2.

The soil pH of plots with biosolids amendment, remained at the upper limit of ideal 7 to 7.5 since in the soils of pH> 7 , 5 the enzimatic activity decreases (Schomberg et al., 1994). The initial EC of soil amended was significantly increased all doses, due to the surface application of sludge , which have increased salt concentration. Anyway was of lesser magnitude than that found by other researchers using different biosolids (dairy) (López Mosquera et al., 2000) or from poultry industry (Punshon et al., 2002) . The final EC was greater with all doses of malting sludge, similar to soil amended with organic residues (Jiménez et al., 2004). The small variation of the Cation Exchange Capacity, of the soil amended with high doses of malting sludge could be due to a decrease in negative charges (organic matter). The final values of the CEC all plots were slightly lower than the initials, coinciding with the results obtained by other researchers in soil amendments with organic wastes (Rivero, 1998).

Dry matter production obtained in this study were slightly higher than those reported by other authors in field trials where biosolids were applied with similar doses (Zebarth et al., 2000). The protein content of harvested grass was not significantly different. As other investigators found, the lack of water can limit the absorption of N by the crop (Cáceres et al., 2005). However, the concentration of N in plants is slightly higher than the range suggested by other researchers (Zebarth et al., 2000). The contents of P, Ca, Mg and K in the harvested plants were similar to those obtained in other species such as ryegrass (*Lolium perenne* subsp. Multiflorum (Lam.) Husn). P concentrations in orchardgrass (*Dactylis glomerata* L.) .The increase in Ca content might be related to prevailing pH in the root zone, but mainly due to the increased availability of this element ( Ca / Mg in the exchange complex greater than 6). Mg which is part of the chlorophyll molecule and is intimately involved in photosynthesis was measured at normal levels.The concentrations founded were at the limit mentioned by some researchers to prevent the development of diseases such as tetanus grass in ruminants. The increase in Cu content, agrees with that shown by other researchers found significativly increases of Cu in stems and leaves of wheat, using sewage sludge as organic amendment (Frost et al., 2000).

## CONCLUSIONS

The soil C slightly alkaline, amended with biosolids (malting sludge) have decreased pH, which is a positive change in quality (at the begining) and have showed an slow increasing trend throughout the test period because growing of grasses and nitrate absorption of those.

Malting Sludge amendement have increased significativally available P, Zn and Cu.

The nutricional quality of *Dactylis glomerata* L. was significantly increased with the malting sludges amendment (Ca and Cu contents).

Finally this results from field test indicate that this biosolids constitutes a suitable amendment for agricultural soils, increassing quality and productivity of forage.

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**Table 1. pH EC and CEC of soil amended with malting sludge (0 , 120 and 240 days)** *

| soil properties | low dose | medium dose | high dose | Control |
|---|---|---|---|---|
| Initial pH | 7.26a | 6.73a | 7.12 b | 7.59[a] |
| Initial EC ($mS/cm^{-1}$) | 0.48b | 0.47b | 1.04b | 0.23 a |
| Initial CEC($cmol(+)kg^{-1}$) | 24.58a | 25.17a | 29.48b | 23.65[a] |
| Mid pH ) | 7.78a | 7.12a | 7.16a | 7.90[a] |
| Mid EC ($mS/cm^{-1}$) | 7.26 a | 6.73 a | 7.12 b | 7.59[a] |
| Mid CEC($cmol(+)kg^{-1}$) | 19.98a | 19.35a | 23.3a | 17.91[a] |
| Final pH | 7.58a | 6.93 a | 7.50a | 7.77[a] |
| Final EC ($mS/cm^{-1}$) | 0.19b | 0.21b | 0.23b | 0.09[a] |
| Final CEC($cmol(+)kg^{-1}$) | 22.08a | 18.10a | 23.27a | 18.52[a] |

*Average values of three plots same dose
In each row values followed by the same letter are not significatly differnt ($p>0.05$).

**Table 2. Dactylis glomerata L. production (DM -dry matter), protein content (%), macro and micronutrients from soil amended with malting sludge** *

| | low dose | medium dose | high dose | Control |
|---|---|---|---|---|
| Grass DM ($kg/m^2$) | 0.4 a | 0.346 a | 0.261a | 0.205[a] |
| Proteins (%) | 12.59a | 13.58 a | 15.15a | 11.94[a] |
| K (mg/kg-1) | 26512a | 26729a | 31080a | 27628[a] |
| Ca ($mg/kg^{-1}$) | 5666b | 6601b | 8907b | 4651[a] |
| Mg ($mg/kg^{-1}$) | 2018a | 2187a | 2469a | 2461[a] |
| P ($mg/kg^{-1}$) | 2792a | 2767a | 2917a | 2558[a] |
| Zn ($mg/kg^{-1}$) | 18.30a | 21.47a | 21.37a | 20.87[a] |
| Cu ($mg/kg^{-1}$) | 3.07a | 3.93b | 4.37b | 2.87[a] |
| Mo ($mg/kg^{-1}$) | 2.13b | 0.93a | 2.33b | 0.93 a |

*Average values of three plots same dose
In each row values followed by the same letter are not significatly differnt ($p>0.05$).