

Portugal study site experiment 3: APPLYING URBAN SEWAGE SLUDGE TO IMPROVE SOIL HEALTH

The problem

The Baixo Mondego valley is mainly dedicated to monocultures of irrigated corn grain. Production is highly specialized and intensive, with high fertiliser usage. These practices do not promote soil quality improvement in terms of fertility, structure or biodiversity. An alternative technique to mineral fertilizer, the amendment with urban sewage sludge, is used by some farmers in the region. Nevertheless, this practice is the focus of many controversies and stakeholders identified it as a technique to be tested.

The proposed solution

Some farmers use organic amendments such as sewage urban sludge, but it is a very controversial issue. It was necessary to determine scientifically by the measurement of a clear and concise dataset, the real impact of this organic amendment on soil quality (specially in term of Soil organic matter content improvement) and crop yield and establish its interest in term of circular economy through the sewage urban sludge valorization.

The study started in April 2018 and aims to assess and to compare soil fertility parameters evolution of 2 trial fields, one field fertilized every spring since 3 years with 20 ton/ha of urban sludge's and a control field fertilized exclusively with conventional mineral amendments. The urban sludge presented about 15% of dry matter and a concentration of 60 g/kg of N; 30 g/kg of P and 4 g/kg of K. The treatment with NPK mineral amendment corresponds to 280 kg/ha of N; 140 kg/ha of P and 140 kg/ha of K.

Experimental design

Treatment	SICs?	Samples per campaign (0-30cm)
Conventional maize with urban sludge amendment	SICs	36
Conventional maize with mineral amendment	Control	36

Factors measured within the study site

Physical factors: Erodibility, existing limitation rooting, penetration resistance

Chemical factors: Available P and K, Exchangeable K, Ca, Na, Mg, total N, soil organic carbon, pH, EC, Heavy Metal

Biological factors: pest burdens, weed disease, cover crop assessment, crop yield, biodiversity

Socio-economic factors: Socio-cultural dimension



SoilCare is funded by the EU's Horizon 2020 research and innovation programme. Grant agreement No. 677407

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Results

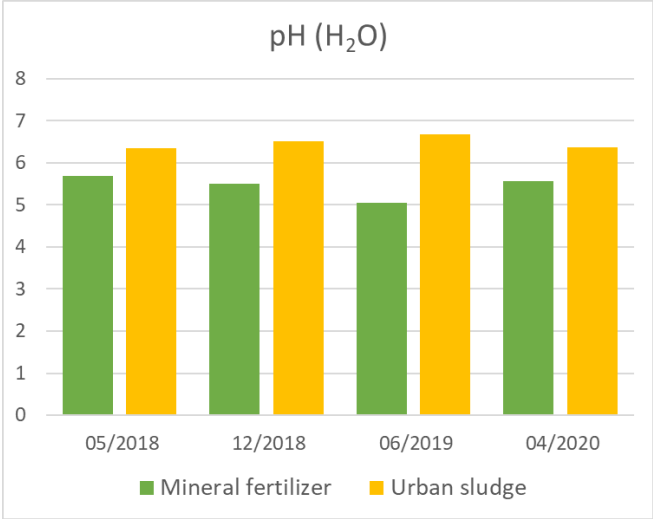
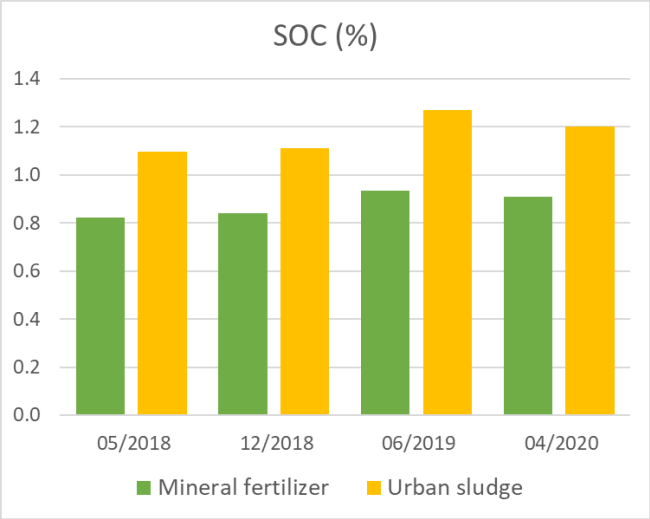


Figure 1. Soil Organic Carbon (SOC, %). Soil organic content increases significantly under urban sludge amendment, representing an improvement of 30% in relation with the initial SOC.

Figure 2. pH (H₂O). Soil pH was significantly higher under urban sludge amendment (pH between 6 and 7) that for the Control soil with pH more acidic (from 5.0 to 5.5).

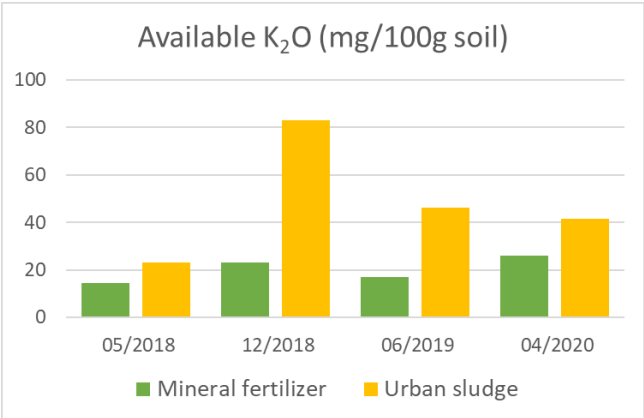
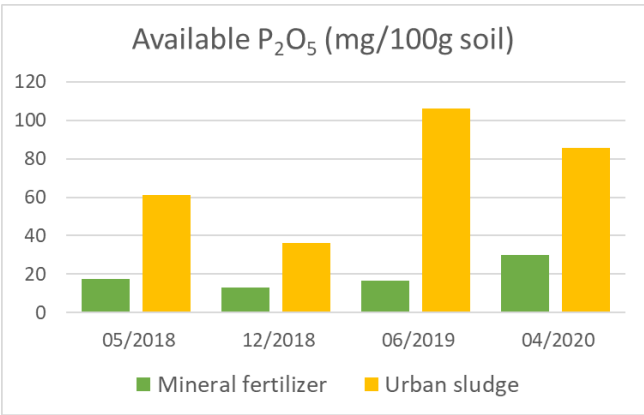
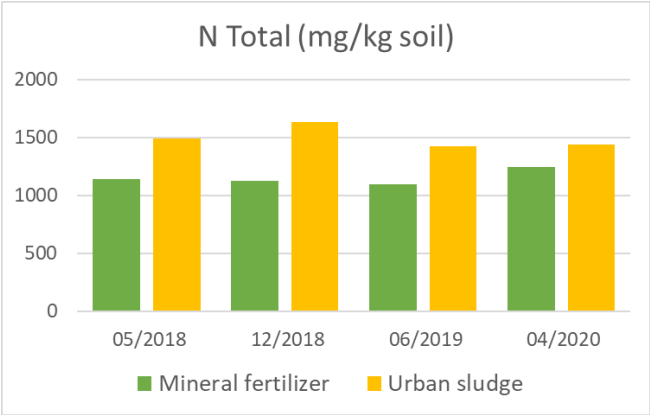


Figure 3. Total Nitrogen, Available phosphorus and Potassium. Urban sludge amendment consistently results in much higher levels of macro nutrients as Total Nitrogen, Available Phosphorus (P₂O₅) and Available Potassium (K₂O) that for Control with mineral fertilizer amendment.



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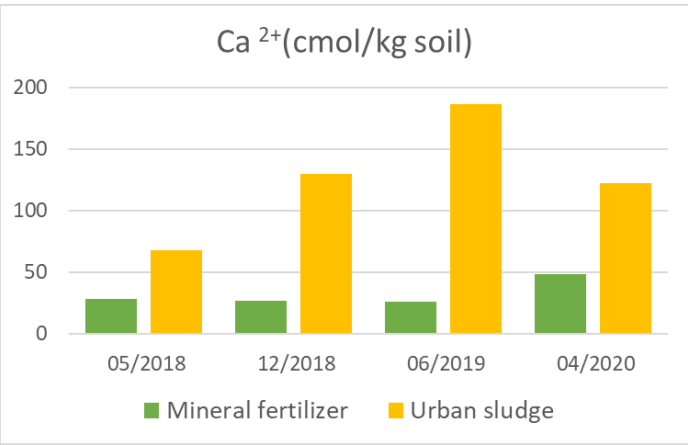


Figure 4. Exchangeable cations Ca²⁺
Ca²⁺ exchangeable cations soil concentration under urban sludge amendment presents a high concentration, 2 to 10 times higher than under control with mineral fertilizer amendment.

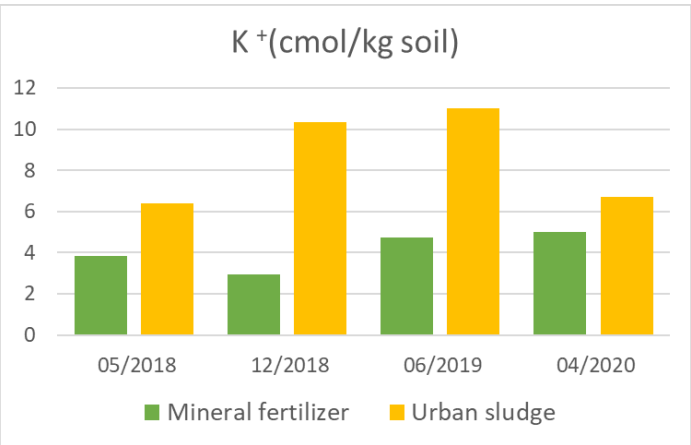


Figure 5. Exchangeable cation K⁺
K⁺ exchangeable cations soil concentration under urban sludge amendment presents a high concentration, 2 to 3 times higher than under control with mineral fertilizer amendment.

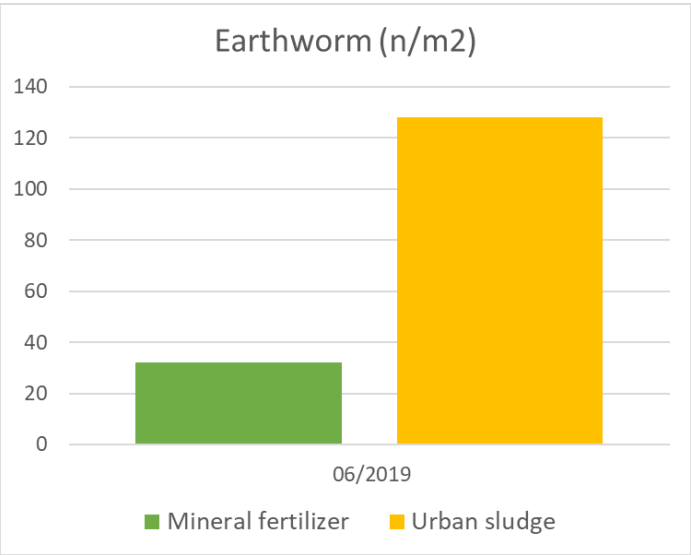


Figure 6. Earthworm counts
There were 4 times more earthworms present under urban sludge amendment than under mineral fertilizer amendment .

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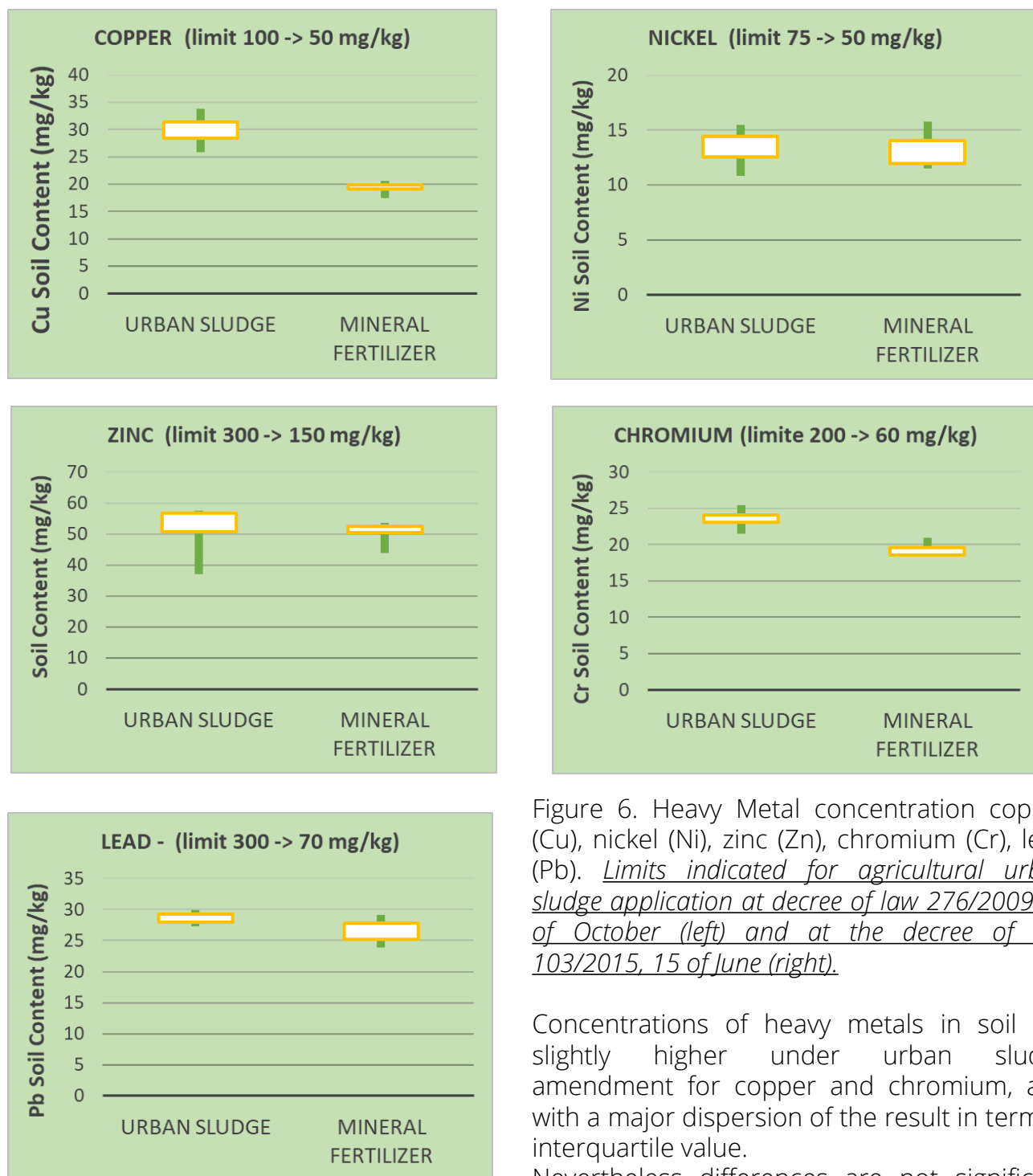


Figure 6. Heavy Metal concentration copper (Cu), nickel (Ni), zinc (Zn), chromium (Cr), lead (Pb). Limits indicated for agricultural urban sludge application at decree of law 276/2009, 2 of October (left) and at the decree of law 103/2015, 15 of June (right).

Concentrations of heavy metals in soil are slightly higher under urban sludge amendment for copper and chromium, and with a major dispersion of the result in term of interquartile value.

Nevertheless differences are not significant and the levels of heavy metal concentration maintains always very distant from the limits imposed by the law.

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Key findings

- After 3 consecutive years of urban sludge application in the agricultural field, soil fertility was significantly improved. Almost all the parameters analyses in this study show a positive impact of the urban sludge application. It improved pH, SOC content, Total Nitrogen, Available Phosphorus and Potassium, exchangeable cations (Ca^{2+} and K^{+}) and also Earthworms density.
- Under urban sludge application is highlight values extremely high of Phosphorus and Potassium, specially Phosphorus.
- Under urban sludge application, any relevant increase of heavy metal concentration in the soil was put in light. The concentrations maintained much lower that the limits defined by the national law for sludge application or fertilizer application in general.



Conclusions

- The application of urban sludge in agricultural field is suitable to improve quickly and significantly soil fertility .
- A special attention has to be pay to the adjustment of the mineral fertilization in function of the nutrients contained in the sludge in order to mitigate the risk of the nutrient excess leaching the avoid the groundwater pollution.
- Heavy metal concentration progression must be monitor carefully in the long term, but didn't showed in the short term any alarming increase of soil contamination risk by heavy metal.
- In term of perceived risks and farmer reputation, the agricultural valorization of sludge is perceived very badly by the population in general and also by the farmers constituting a great barrier to its implementation and acceptance.
- It is important to disseminate the study results on the environmental impact of sludge in seminars or dissemination to the general public in order to demystify the use of sludge, explaining that risks are controlled through the sludge management plan.

Contact information

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SoilCare is funded by the EU's Horizon 2020 research and innovation programme.
Grant agreement No. 677407