Incubation study of kieselguhr (diatomite) for application as organic fertilizer and soil ameliorant

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Abstract
The goal of this study is to determine the change in soil reaction (pH) and the effect of applied kieselguhr sludge as organic nitrogen fertilizer and soil ameliorant. Rates of application of studied kieselguhr waste were 40, 60, 80, 100 $t.ha^{-1}$. During incubation of 56 days nitrogen mineralization and change of soil pH were studied. Net nitrogen mineralization for studied period was 27 - 54 mg N.kg-1 for different rates of application. Statistically proved differences exist between control and other treatments and 40 tons and 100 tons treatment. For the same period soil pH increased in average by 0,2 – from 5.6 to 5.8. Negative net N mineralization (immobilization) was observed during first 7 days of kieselguhr incubation - nitrogen mineralization decrease up to 9.67 mg N.kg-1. Waste kieselguhr material could be applied as slow-acting organic fertilizer and soil ameliorant. Kieselguhr material could supply from 18 to more than 90 kg nitrogen per hectare for breaded crops.

Introduction

Different industrial wastes could be reutilized as slow-acting organic fertilizers and soil ameliorants. In fact, beer is the fifth most consumed beverage in the world behind tea, carbonated drinks, milk and coffee [2] .The beer brewing process often generates large amounts of wastewater effluent and solid wastes that must be disposed off or treated in the least costly and safest way so as to meet the strict discharge regulations that are set by government entities to protect the environment [1].
Diatomaceous earth has various advantages for filtration in brewing process [4]. Kieselguhr sludge is generated during the filtration of beer. Currently, the most frequent disposal method is to spread the used kieselguhr over agricultural land. This is a satisfactory solution to the problem of disposal [3]. Organic wastes have been extensively used in order to improve soil quality. Indeed, organic waste can enhance plant productivity as it contains major nutrients (N, P, K).
Kieselguhr waste from brewery in Bulgaria could reach 1000 tons per year. It could be a valuable soil amendment.

Material and Methods

Soil and kieselguhr sludge

The soil in these incubation studies was classified as a Haplic Luvisol (Grey-brown forest soil) and was sampled from the top 30-cm layer of an agricultural soil in Nikolaevo (Bulgaria). Kieselguhr comes from the beer factory located in Shumen (Bulgaria), which has a capacity of 1.5 million hectoliter per year. The main characteristics of the soil and sludge are shown in Table 1, Table 2 and Table 3. Heavy metal content in the sludge was not a significant issue, since concentrations were below the limits established by EU legislation [5].

Table 1. Agrochemical characteristics of Haplic Luvisol used in experiment (0 – 30 cm)

Total N	Organic C	C:N	pH_{H_2O}	pH_{KCl}	Available P_2O_5	Available K_2O	N min
%	%				$mg.100g^{-1}$	$mg.100g^{-1}$	$mg.kg^{-1}$
0,120	1,95	9,4	5,1	3,9	5	17	30

Table 2. Chemical characterization of the kieselguhr sludge

Total N	Organic C	C:N	pH_{H_2O}	pH_{KCl}	Available P_2O_5	Available K_2O	N min
%	%				$mg.100g^{-1}$	$mg.100g^{-1}$	$mg.kg^{-1}$
0,64	4,59	7,17	5,1	5,3	98,0	186,1	63,2

Table 3. Heavy metals in kieselguhr sludge

As	Cd	Cr	Cu	Ni	Pb	Zn
$mg.kg^{-1}$	$mg.kg^{-1}$	$mg.kg^{-1}$	$mg.kg^{-1}$	$mg.kg^{-1}$	$mg.kg^{-1}$	$mg.kg^{-1}$
0,18	< 0,01	< 0,5	0,3	< 0,5	< 0,5	0,3

Incubation procedure

The kieselguhr sludge was mixed with soil at rates equivalent to 40, 60, 80 and 100 $t.ha^{-1}$ with four replicates. After completing the applications, the pots were incubated in a laboratory with active climatic control (air temperature ranged within 22°C). During the incubation soil moisture was near field capacity.

After 0, 7, 14, 28 and 56 days of incubation a portion of each soil was taken for analysis of soil pH and mineralized nitrogen.

Soils analysis

Soil pH was measured in a 1:2 (soil: water) suspension. Mineralised nitrogen determination was according Bremner-Keeney method for inorganic nitrogen assessment [7]. P and K were determined by acetate-lactate method for assessment of plant available forms of phosphorus and potassium [6].

Statistical analysis

For each parameter data were submitted to an analysis of variance (ANOVA) by Statgraphics Centurion XV software. The variance was related to the main effects and interaction between amendment type on soil and nitrogen mineralization.

Results

A multiple comparison procedure was applied to determine which means are significantly different from which others. At the top part of the table 4, three homogenous groups are identified using columns of X's (Control – 4t, 4t-6t-8t and 8t-10t). The bottom part of the table shows the estimated difference between each pair of means. An asterisk has been placed next to 5 pairs, indicating that these pairs show statistically significant differences at the 95.0% confidence level (10t – 4t, 10t – Control,4t – 8t, 6t – Control , 8t – Control). The method currently being used to discriminate among the means is Fisher's least significant difference (LSD) procedure.

Table 4. Multiple Range Tests for Net N mineralisation Days 56 by Treatments

Treatments	*Count*	*Mean*	*Homogeneous Groups*
Control	2	27.035	X
4t	2	33.075	XX
6t	2	44.5	XX
8t	2	53.115	X
10t	2	54.29	X

Contrast	*Sig.*	*Difference*	*+/- Limits*
10t - 4t	*	21.215	13.139
10t - 6t		9.79	13.139
10t - 8t		1.175	13.139
10t - Control	*	27.255	13.139
4t - 6t		-11.425	13.139
4t - 8t	*	-20.04	13.139

4t - Control		6.04	13.139
6t - 8t		-8.615	13.139
6t - Control	*	17.465	13.139
8t - Control	*	26.08	13.139

* denotes a statistically significant difference.

During the short incubation of 56 days nitrogen mineralization and change of soil pH were studied. Net nitrogen mineralization for studied period was 33 - 54 mg $N.kg^{-1}$ for different rates of application. For the same period soil pH increased in average by 0,2 – from 5.6 to 5.8. Negative net N mineralization (immobilization) was observed during first 7 days of kieselguhr incubation - nitrogen mineralization decrease up to 9.67 mg $N.kg^{-1}$ (Fig. 1).

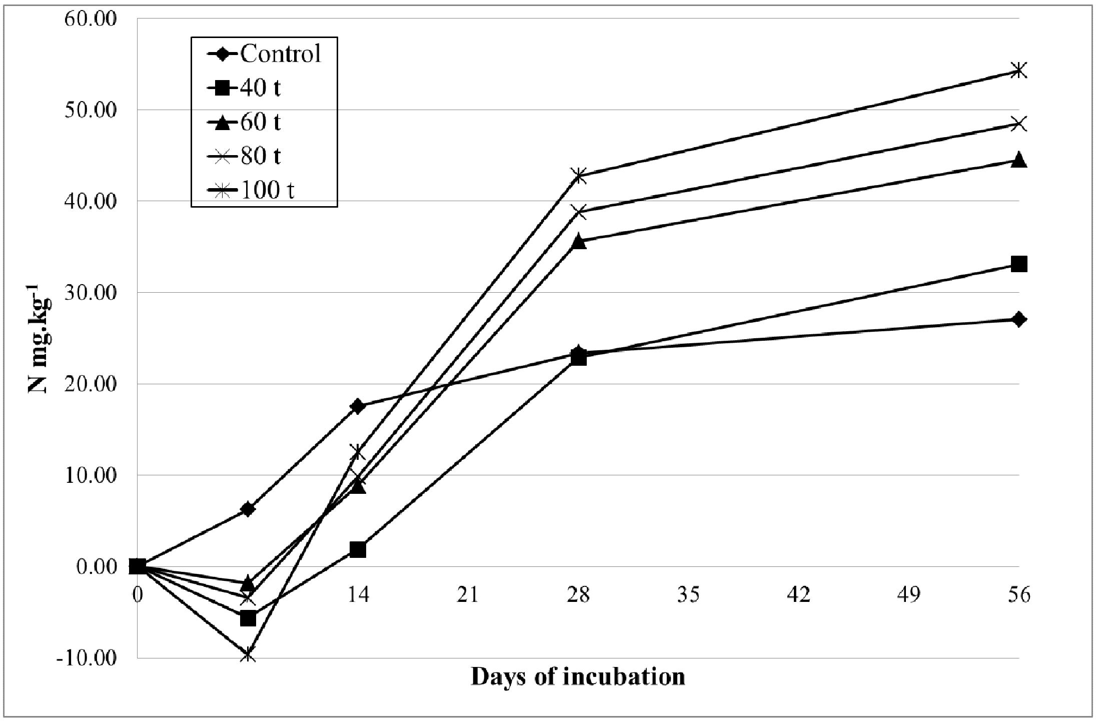

Figure1. Net nitrogen mineralization for 56 days of incubation

Linear data relation exists between kieselguhr application rates and mineralized nitrogen (Fig. 2). The correlation is strong – r^2=0.95. It is obvious that larger amounts of kieselguhr could be applied in filed than that in our experiment. Nitrogen mineralization from kieselguhr for studied period was between 6 - 27 mg $N.kg^{-1}$. It represents nitrogen quantities from 18 to 82 kg per hectare. Larger sludge amount could replace industrial fertilizers application in some cases. For example, the highest rate for sunflower is 80-90 kg nitrogen per hectare. Average nitrogen fertilizers rates for 2011 in Bulgaria were 94 kg per hectare, which is close to the mineralized nitrogen from highest rate (100 t) of kieselguhr.

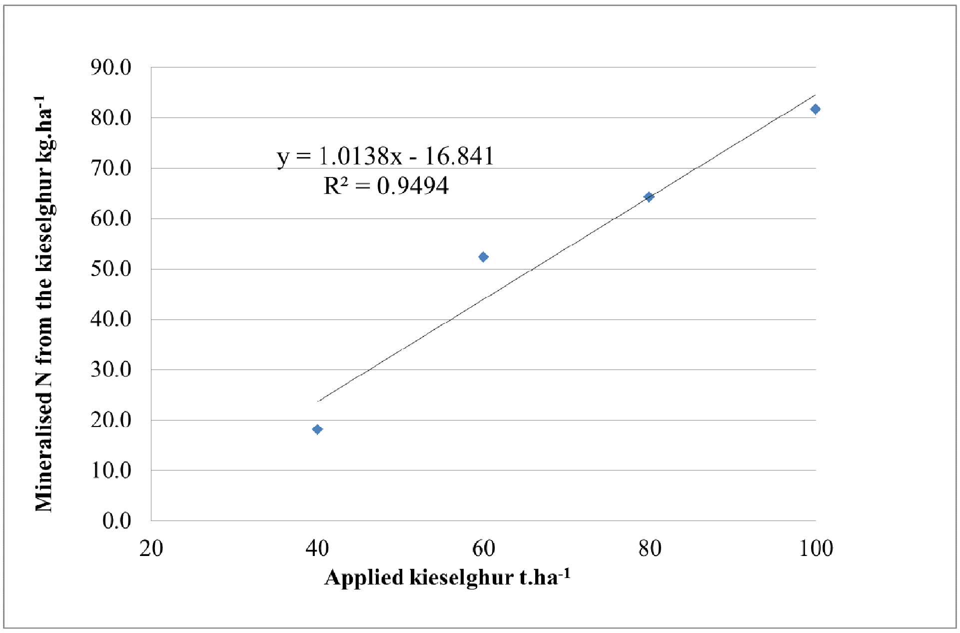

Figure 2. Correlation between applied kieselguhr rates and mineralised N from it

Conclusion and perspectives

The application of kieselguhr sludge can supply nitrogen and other nutrients to crops, although mineralization could take some months to increase their availability for plants. Waste kieselguhr material could be applied as slow-acting organic fertilizer and soil ameliorant. Storage capacities for this waste could decrease significantly which will diminish odors in the environment around breweries.

References

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