



***Brachiaria brizantha* GROWTH IN AMENDED SOIL BY EFFLUENTS FROM THE MILK INDUSTRY**

DOI: 10.7904/2068-4738-VI(11)-13

Alexandre Sylvio Vieira da Costa¹, Adolf Heinrich Horn², Essaid Bilal³, Aguiar Amando de Pinho⁴, Guilherme Kangussú Donagema⁵, Regynaldo Arruda Sampaio⁶

¹Federal University of Jequitinhonha e Mucuri Vallays (UFJMV)–Diamantina, Minas Gerais, BRAZIL.

²Institute Geosciences of UFMG–Belo Horizonte, Minas Gerais, BRAZIL

³Ecole Nationale Supérieure des Mines de Saint Etienne, GSE, CNRS UMR 5600, F42023 Saint Etienne FRANCE; e-mail: bilalessaid@gmail.com

⁴Institute Geosciences of UFMG–Belo Horizonte, Minas Gerais, BRAZIL,

⁵UNIVALE–Governador Valadares, Minas Gerais, BRAZIL

⁶Instituto de Ciências Agrárias, Universidade Federal de Minas Gerais, Caixa Postal 135, CEP 39404-006, Montes Claros, MG, BRASIL.

Abstract. The present work had as objective the verification of the effects of the incorporation of organic residues originating from ETE of the milk factory products in the soil and the effects in the development of the *Brachiaria brizantha* plants. The organic material was collected in the discard area of the factory, and been evaporated, triturated and separated in three granule size: powder, medium particles (with 2.0 mm diameter) and grains (medium particles with 6.0 mm diameter) and incorporate in soil by quantity of 0, 5, 10, 15 and 20 t. ha⁻¹ followed by the planting of the forage. During the development of the plants, three cuts were appraised the dry weight and number of tillers. At the end, analysis of the fertility of soil was executing. The used experimental design was representing by randomized blocks with four repetitions. The application of organic material originating from ETE residual of dairies was have shown highly promising results vin the development of the forage plants, mainly when they are used in the powder form or attached and in higher amounts. Also considering some absorption by the plants during the experiment, the level of the nutrients and available minerals in the soil increased, except for the magnesium.

Keyword: Agriculture Industry Residue, Soil Chemistry, Forage Production, *Brachiaria brizantha*, milk factory waste.

Introduction

All dead organic material is a substrate for soil organisms that decompose it by converting elements from organic bounding to an inorganic form, a process known as mineralization.

One part of these mineralized nutrients is absorbing by plants and another part is immobilizing by microorganisms and become part of its constitution [CORREIA, 1986].

In plants, organic materials occur predominantly as cellulose, lignin [SAMFIRA et al., 2013], proteins, amino acids and some other minor constituents, which can undergo various biochemical transformations due to microorganisms and their enzymes activities.

The intensity with which organic waste is processed depends on the environmental–chemical conditions.

Waste rich in lignin and aromatic compounds is difficult to decompose, unlike the compounds having high amounts of soluble carbohydrates [SIQUEIRA and FRANCO, 1988, BUTNARIU et al., 2012].

The agricultural use of urban and industrial bio–solids seems to have a great potential and offers the opportunity to be using as fertilizer and soil builder [SILVA et al., 2002].

Bio solids are usually using to improve forested areas, to recover degraded areas, as fertilizer on crops and as physical soil conditioner [SILVA et al., 1997; SLOAN et al., 1997].

Several authors found that the use of intense addition of bio–solids



decreases the density of soils and increases the soil water retention [AGGELIDES and LONDRA, 2000; DEBOSZ *et al.*, 2002]

Increasing demands for improvements in corporate environmental conditions has required of public and private companies a definition of environmental politics.

The proper disposal of waste is a proceeding that was recognizing in the Agenda 21 (World Conference as an Instrument for the Environment; Rio 92) which included the topic "Environmentally correct treatment of solid waste".

In function of these, were defining the following priorities:

- The reduction of waste production, increasing the reuse and recycling;
- The elimination of deposits, an environmentally correct treatment and the range broadening of services that are occupying with waste [PROSAB, 1999].

1) Recycling of waste in agriculture requires a supervised production and a clean input, ensuring the suitability of the product for agricultural use. It is necessary to define handling and restrictions for land use to obtain higher quality and an enhanced production of healthy food.

2) Experiences of inadequate handle of waste can make the practice feasible in the future generated due to the resistance of society based on potential environmental and health damage [ANDREOLI and BONNET, 1998].

3) Agricultural recycling of organic waste generated from the treatment plants combines low cost and favorable environmental impact when used considering all safety criteria. It is the most correct environmentally way, promoting the return of nutrients to the soil, acting positively in biogeochemical cycles of elements. The value of agricultural residues, seasonality of demand and costs involving their processing and transport, as well as a business plan for the activity and environmental monitoring are key aspects for analysis of this alternative [BETTIOL and CAMARGO, 2000].

4) In general, levels of nutrients in sludge from the treatment plant are higher than those are founding in most organic materials in regular using in agriculture. In some cases, depending on the way in which the nutrients are founding in organic material, particularly nitrogen, the sludge can be as efficient as various forms of minerals nutrients.

5) This study aimed to verify the effect of pie produced by a milky industry, originated from the processing of milky products, the development of *Brachiaria* and chemical characteristics of the soil.

Material and methods

This study was conducting in a greenhouse in Governador Valadares, MG.

The organic waste from the production of dairy products from a dairy factory also located in this municipality was collecting in the filter press, final step of treatment of waste, which is removing excess water.

This material is deriving from the waste treatment plant located inside the factory, where after partial decomposition in stabilization pond, the material is introducing into the filter press.

The "pie" had collected moisture content of around 85%.

The material was taking to the laboratory where it was prepared for experimentation.

The organic residue was keeping in trays in the shade for natural removal of excess moisture.

After two weeks of drying, the material had a moisture content of 4.14%.

After drying, the organic residue was ground in a Wiley mill, which was separating in three different particle size: powder, household (residue with average diameter of 2.0 millimeters) and granule (residue with average diameter of 6.0 millimeters).

Samples were taking and held chemical analysis of the major mineral components (Table 1); Method used is



according to norms of Embrapa (1997) [EMBRAPA, 1997]

In this experiment were used vessels with up to 7kg of soil.

The used soil is a Eutrophic Red-yellow Argis soil collected from B-horizons due to its lower content of organic matter.

Table 1.

Chemical composition of organic waste from dairy factory.

	Powder	Aggregate	Granule
Ca %	8.05	8.16	8.00
Mg %	2.32	2.21	2.19
K %	2.19	2.08	2.11
P %	2.15	2.01	2.10
N %	3.21	3.11	3.08
S %	0.37	0.33	0.34
B mg/kg	5.06	5.12	5.03
Zn mg/kg	247.00	232.00	240.00

Their chemical characteristics are showing in Table 2. The soil was drying at

shade, sieved on 0.5cm mesh screen and added to the vessels.

Organic wastes in their different particle size were incorporated individually in vessels in the following proportions: 5, 10, 15 and 20 kg. ha⁻¹, beyond the control treatment without incorporation.

Considering 2.000 kg. ha⁻¹ of soil at depth of 20 cm and density of 1.0 g.dm⁻³ was recalculated for relation of soil/organic material to be used at the vessels.

The substances were weighing separately and incorporating into the soil of each vessel. Immediately after this step were sown seeds of *Brachiaria brizantha*.

The first pruning is performing one week after planting, early germination of the seeds, remaining seven plants per vessel.

Table 2.

The chemical characteristics of substrate tests and substrate control (T1)

pH	P	K	Ca	Mg	Al	H + Al	S	t	T	V	MO	m
	mg/dm ³					Cmolc/dm ³					%	
6.1	7.6	62.35	1.36	0.19	0.20	1.30	1.71	1.91	3,01	56.81	0.42	0.42

After two weeks, new pruning was caring out keeping five plants per vessel.

The vessels were maintaining under irrigation in according with the necessities of the plants, with the exception of the period between the second and third cuts where plants were subjecting to water stress for a period of 30 days.

The first cut of the plants carried out 55 days after sowing. The second cut was performed 55 days after the first and the third cut 60 days after the second cut.

Forty days after the first cut it was performed fertilization with urea (100 kg. ha⁻¹).

After the last collection of plants, were collected soil samples in all the vessels to determine the residual fertility.

The sample was taking near the bottom of the vessel.

The soils samples were drying at normal conditions to spare, grinded, passed through sieve and sent to the laboratory to perform routine soil analysis.

Before each cut was executed a counting of the number of tillers of plants per vessel. The plants were cutting at soil surface level and conditioning in paper bags and placed in a forced ventilation oven at 75°C for 72 hours for drying.

The following variables were evaluating total number of tillers per vessel, dry weight of the aerial plants, concentrations of phosphorus, potassium, calcium, magnesium and soil organic matter per vessel.

The regimen used was a factorial 3x5 (three different particle sizes of organic waste and five levels of soil application, including witness).

The experimental design was a randomized block with four replications. In mathematical fit of the experimental data, were used a regression analysis from the statistical program ESTAT [ESTAT, 1994].

Were estimated the values of the model parameters as a function of the independent variable residual amount of incorporated elements.



The fit of the experimental data was basing on the significance of the regression coefficients and the magnitude of the adjusted coefficient of determination.

The points of maximum inflection of quadratic regressions were obtaining by calculations derived from the equations.

Results and discussion

The addition of waste ground provided highly positive effect on biomass production (Figure 1).

The increase in mass production of the material showed a linear increase with increasing the amount of waste used; each mg applied for increment of 1.34 to 1.64 g. vessel⁻¹ for application as a powder and added, respectively.

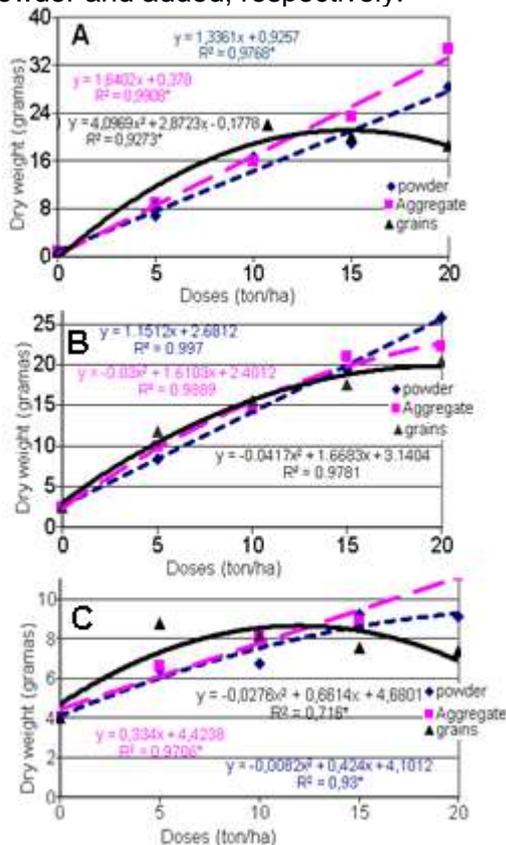


Figure 1. Accumulative effects at organic material of *Brachiaria Brizantha* with the different granulometry of organic waste in soils. A: first cut, B: second cut and C: third cut.

Regarding the application of the waste in the form of granules, the point of maximum obtained was 21.10 g of the seca. vessel⁻¹ dose of 51.8 g. vessel⁻¹.

Smaller particles have greater reactivity in the soil due to its high specific surface and hence, higher microbial activity and nutrient release.

This effect also observed by Santos and collab. verifying that the aerobic biodegradability structure increases with the reduction of particle size [SANTOS *et al.*, 2004]. In the second cut (Figure 1 B) the plants continued to respond with the same intensity.

In addition to the residual effect of the nutrients present in organic material incorporated into the soil, nitrogen fertilization performed during plant development before the second cut also contributed.

The integrated action of the elements in soil is important for maintaining plant productivity [VOISIN, 1986].

Between the second and third cut, the plants underwent a stress period of approximately 30 days without getting water. In order to verify its behavior (Figure 1–C) that plants reduced their response in relation to dry matter production where production showed maximum values near 11 g. vessel⁻¹, unlike the previous cuts where productivity reached values above 20 g. vessel⁻¹ indicating the effect of water stress on plant development.

The results obtained showed that during treatment with the organic residue also promoted the development of tiller number of plants in first cut (Figure 2–A).

In testimony, treatment plants showed an average between five and six tillers. vessel⁻¹.

For the second cut (Figure 2B), the number of tillers of plants increased significantly in relation to the use of organic waste.

The use of the organic material in powder form induced plants to a maximum of formation of tillers from the application of 35 g. vessel⁻¹, stabilizing their average values at 35 tillers. vessel⁻¹ keeping to the final dose tested (70 g. vessel⁻¹), this number is nearly doubled with the addition of 17.5 g of residue per vessel⁻¹ to the soil, regardless of particle size.



This intense increase remained approximately to the use of 52.5 g. vessel⁻¹. From this dose up there was stabilization in the number of tillers for treatments dust and aggregate.

With the use of waste in the form of granules, the peak of development in the number of about 16 tillers. vessel⁻¹ occur with the residual application of 47.8 g. vessel⁻¹.

The slower degradation of organic waste was due to the larger size of the particles and most probably it generated the highest amount applied temporal production of acetic, formic, butyric [FADINI and FADINI, 2001].

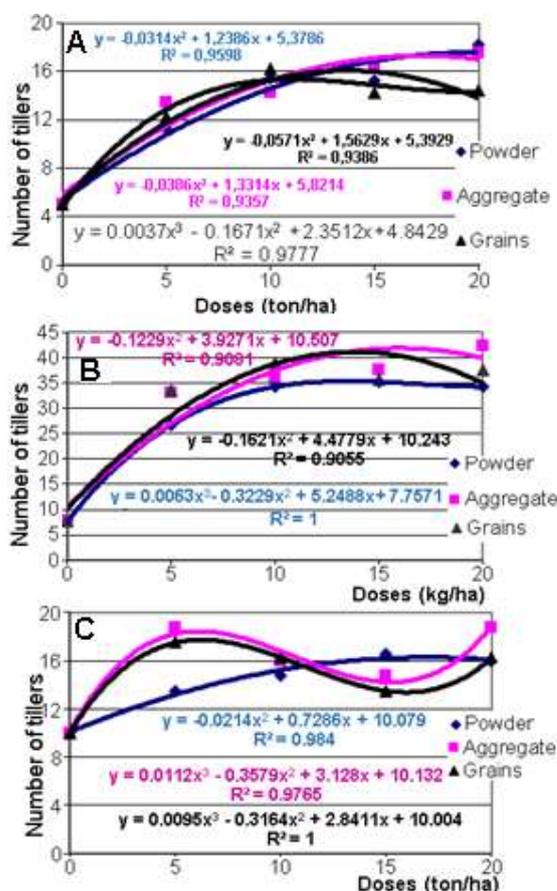


Figure 2. The relation to number of *Brachiaria Brizantha* tillers with the different granulometry of organic waste in soils. A: first cut, B: second cut and C: third cut.

Among other features, phytotoxic and slower mineralization of nutrients by inhibiting the development of the tillers of

the plants did not occur with the other treatments due to the small particle size and acceleration of mineralization.

The degree of screening of the sludge may be a factor to considered [BOEIRA, 2005] because the incubation experiment, which uses large lumps of waste, can under estimate their potential of vessel mineralization of aggregate.

The maximum production of tillers occurred with the use of approximately 52.5 g. vessel⁻¹ maintaining an average, with values above 40 tillers. vessel⁻¹ up to the highest dose.

Regarding treatment plants with beads showed a good performance in the development of tillers up to a dose of approximately 49 g. vessel⁻¹, where the average values were higher than 40 tillers. vessel⁻¹.

From this point, there was a decrease in the values reaching 35 tillers. vessel⁻¹ with the application of 70 g. vessel⁻¹, similar behavior as it occurred in the first cut.

Results can be also associated with a longer time of microbial activity and organic acids release due to the size of granules and largest amount of material present in the soil.

The number of tillers of plants significantly reduced due to the drought stress and the effects of the applications of organic waste showed similar.

The final average number of tillers varies little between the different treatments, showing values between 15 and 17 tillers. vessel⁻¹ at the highest dose used.

After Costa and collab. a greater amount of organic material in the soil promotes greater resistance of plants to drought stress probably by maintaining water levels in the soil for longer than soils with lower levels of organic waste [COSTA et al., 2006].

The plants respond to the increased amount of organic waste in soil, mostly in the form of aggregate.

Using the organic material in powder form, the response of plants showed a reduction in the rate of development with addition of biomaterial about 35 g.vessel⁻¹.



This behavior probably (Figure 3) occurred due to the reduced presence of available phosphorus in the soil due to greater uptake by plants during the early stages of the experiment.

Rossi and Monteiro also achieved the same behavior of the plants, where they observed linear increase in phosphorus concentration in plants and in the production of dry matter with increasing doses of phosphorus in soil [ROSSI and MONTEIRO, 1999].

Another possibility of low phosphorus availability in soil treatment with waste in powder form is the higher concentration of calcium (Figure 3), inducing the formation of calcium phosphate, compound with low solubility [COSTA, 2008; BUTNARIU *et al.*, 2005].

In some cases, the reduced degradability of the organic fraction can occur due the physical characteristics of

the residue (granulometry) and the establishment of environmental water stress or concentration of soluble salts in the soil that limit microbial activity, especially in higher dosages [CARMO, 2000].

Organic material presented 2.04 % total phosphorus in its composition and this concentration reflected in the content of soil phosphorus.

After the plants with three cuts export elements, the amount of phosphorus remaining in the labile soil was significant, increasing with the increase of application of organic waste (Figure. 3).

With the application of 20 kg/ha, the amount of phosphorus in the soil was determined between 12 and 15 mg/dm³ and soil control values of not treated soil between 4 and 5 mg/dm³.

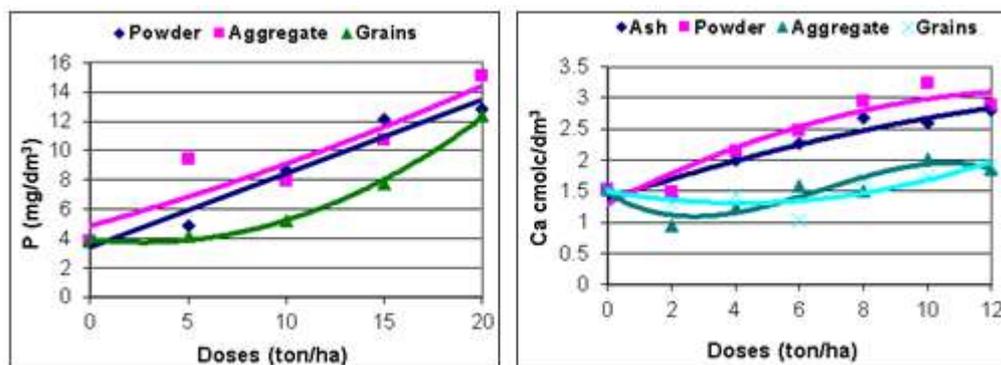


Figure 3. Phosphorus and calcium behavior in the experimental tests with the different granulometry of organic milk residues.

Due to the larger particles of waste in the form of granules, the release of the element occurred at a slower absorption and consequently plants reduced dry.

Results can be also associated with a longer time of microbial activity and organic acids release due to the size of granules and largest amount of material present in the soil.

Due to the larger particles of waste in the form of granules, the release of the element occurred at a slower absorption and consequently plants reduced dry matter production.

Teixeira and collab. report that the increased presence of particulate matter in the sludge makes microbiological

activity difficult, demanding more time for the degradation of organic matter [TEIXEIRA *et al.*, 2008].

Smaller particles are more easily hydrolyzed favoring microbial digestion [ZHANG, 2005].

Biological behavior noting that the hydrolysis of the organic matter occurs by the influence of specialized biological enzymes and that among the external factors that affect the speed of reaction are the particle size and the surface area [CAUNII *et al.*, 2015].

At the treatment with the use of granules, the concentration in the soil of the vessels (Figure 3) was lower than in the blind, with the exception of the



highest dose, indicating a slow release of organic material, clearly below the absorption capacity of the plants.

By use of waste in powder form and aggregate, the particle size is smaller and therefore reacted more intensely with the soil causing a quadratic releasing of this element with maximum doses at 48.65 and 45.85 g. vessel⁻¹ respectively.

Behavior explained by the greater development of plants (braquiara) caused by larger doses of residue application, with consequently higher absorption of this element in the soil (figure 1, 2 and 3).

For the calcium, the response was linear with mineralization in soil increases with the addition of organic material.

On higher doses, there was a greater element release with application of waste in powder form (Figure 3).

This linear response is probably due to the higher concentration of calcium in the waste (8.75 %), much

higher than the other elements that did not show the same behavior during the mineralization process.

Inverse results were obtained in relation to magnesium (figure 4), where the additional application of organic material resulted in a reduction of its availability in soil.

This is possible an effect caused by the immobilization of compounds by the microbes in the soil.

Studies made by Costa and collab. show that the concentration of this element in plants (*B. Brizantha*) [COSTA *et al.* 2007, BOSTAN *et al.*, 2013], independently of the cut, is low, varying around 0.3 % dry matter.

Incorporating of goat manure into the soil, Freitas and collab. found that the magnesium content decreased after the third month of inclusion in all soil layers due to the immobilization of the element [FREITAS *et al.*, 2007].

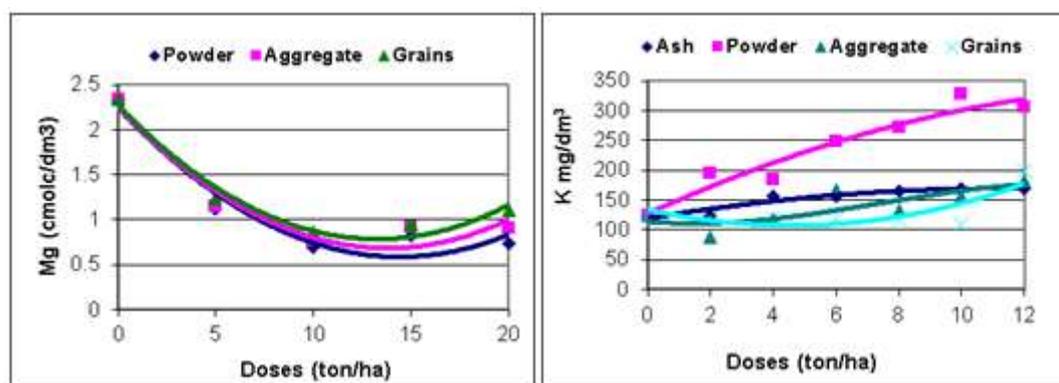


Figure 4. Incorporation of the organic waste in soils of different granulometry. The graphs show the accumulative effects on potassium for plantation of *B. Brizantha*

About the organic matter, it verified that there was an increase in the concentration of the soil with the increase of the applied amount of dairy residue.

The increase was linear with waste treatment in the form of granules, probably due to less rapid decay process due to the larger particle size.

The treatments with powder and aggregate behaved similarly, increasing organic content in soil to 42.88 and 43.4

g. vessel⁻¹, respectively with small drop at the maximum dose tested.

Higher values of phosphorus when compared to treatment with coarse grained waste at the highest dose are probably connected to the further development of the root system of plants, accumulation of organic matter in the soil and microbial activity.

The rhizosphere of plants stimulates microbial ecosystem [MOREIRA and SIQUEIRA, 2002; FERENCZ *et al.*, 2012, BUTNARIU *et al.*, 2012],



favoring the proliferation and activity of microorganisms responsible for specific processes such as decomposition of organic matter.

This organic material has relative C/N relation close to 17 considering its carbon content between 52 and 55 %, which, as cited by Kiehl, intensifies the processes of decomposition and mineralization of nutrients [KIEHL, 1985].

This Process does not occur with the same intensity for lipid, the main component present in this type of organic material, being more resistant to decomposition.

Assumption pointed out by Moreira and Siqueira, mentioning waxes and oily hydrocarbons as difficult to decomposition due to their long carbon chains [MOREIRA and SIQUEIRA 2002; BUTNARIU and BOSTAN, 2011].

After Andrade organic waste bio solids similar to that used in this work presents the levels of lipids in their composition varying between 2.61 % and 13.20 % [ANDRADE, 2004], significant values compared with other organic compounds in bio solids and confirmed by other authors [ROWELL *et al.*, 2001, BUTU *et al.*, 2014].

Stevenson pointed out that low reactivity and insignificant lipids content of soil [STEVENSON, 1982, BUTNARIU *et al.*, 2006], in some cases, has a direct influence on the properties of soil and plant growth.

Conclusions

The organic material of the dairy factory ETE showed a promisor dry matter accumulation in plants (braquiarião), when used in powder form or aggregate.

The number of tillers of plants increased with increasing amount of organic residue incorporated, indifferent of its granulation.

With the incorporated of the larger amounts of the organic waste, the residual phosphorus concentration at the soil increases.

Acknowledgments

This work supported by FAPEMIG (Fundação de Amparo a Pesquisa de Minas Gerais), Federal University of Jequitinhonha e Mucuri Vallays (UFJMV) and Institute

Geosciences of the Federal University of Minas Gerais (UFMG). We also thank the French Embassy and the Rectorate of UFMG for the grant of a visiting professor Essaid Bilal (ENSMSE, France) in the framework of the France–UFMG Academic Chair.

References

1. Aggelides, S.M.; Londra, P.A. Effects of compost produced from town wastes and sewage sludge on the physical properties of a loamy and clay soil. *Bio resource Technology*, **2000**, 71: 253–259.
2. Andrade, C.A. de. Fração orgânica de biossólidos e efeito no estoque de carbono e qualidade de matéria orgânica de um latossolo cultivado com eucalipto. *Tese de Doutorado. Escola Superior de Agricultura "Luiz de Queiroz", Piracicaba*, **2004**: 121.
3. Andreoli, C.V.; Bonnet, B.R.P. Manual para análise microbiológica e parasitológica em reciclagem agrícola de lodo de esgoto. *Curitiba, SANEPAR*, **1998**, 86.
4. Balmat, J.L. Biochemical oxidation of various particulate fractions of sewage. *Sewage and industrial wastes*, **1957**, 29: 757–761.
5. Bettiol, E.W.; Camargo, O.A. Impacto ambiental do uso agrícola do lodo de esgoto. *Jaguariuna, Embrapa CNPMA*. **2000**, 312.
6. Boeira, R.C. Aspectos experimentais na avaliação da mineralização de nitrogênio de lodos de esgoto incubados com solos. *Jaguariúna, Embrapa CNPMA. (Comunicado Técnico, 27)*, **2005**, 5.
7. Bostan, C.; Butnariu, M.; Butu, M.; Ortan, A.; Butu, A.; Rodino, S.; Parvu, C. Allelopathic effect of *Festuca rubra* on perennial grasses. *Romanian Biotechnological Letters*, **2013**, 18 (2): 8190–8196.
8. Butnariu, M.; Bostan, C. Antimicrobial and anti-inflammatory activities of the volatile oil compounds from *Tropaeolum majus* L. (Nasturtium), *African journal of biotechnology*, **2011**, 10(31): 5900–5909.
9. Butnariu, M.; Caunii, A.; Putnoky S. Reverse phase chromatographic behaviour of major components in *Capsicum Annuum* extract, *Chemistry Central Journal*, **2012**, 6 (1): 1–6.
10. Butnariu, M.; Goian, M.; Ianculov, I.; Gergen, I.; Negrea, P. Studies about



- CO²⁺ ion influence on soy plants development and acumulation of other chemical elements (Iron, magnesium, calcium, potassium and phosphorus), *Revista de Chimie–Bucharest*, **2005**, 56(8): 837–841.
11. Butnariu, M.; Sumuleac, A.; Dehelean, C.; Chirita, R.; Saratean V. Studies concerning fertilizer influence (NPK in different doses) on quantity of corn plants chlorophyll, *Revista de chimie–Bucharest*, **2006**, 11: 1138–1142.
12. Butu, M.; Rodino, S.; Butu, A.; Butnariu M. Screening of bioflavonoid and antioxidant activity of *Lens culinaris* medikus. *Digest Journal of Nanomaterials & Biostructures*, **2014**, 9(2): 519–529.
13. Carmo, J.B. Impacto da aplicação de biossólidos nas atividades microbianas do solo. Tese de Mestrado. *Escola Superior de Agricultura “Luiz de Queiroz” Piracicaba*, **2000**, 105.
14. Caunii, A.; Negrea, A.; Pentea, M.; Samfira, I.; Motoc, M.; Butnariu M. Mobility of heavy metals from soil in the two species of the aromatic plants. *Revista de Chimie–Bucharest*, **2015**, 66(3): 382–386.
15. Correia, A.A.D. Bioquímica nos solos, nas pastagens e forragens. Lisboa, *Fundação Calouste Gulbenkian*. **1986**, 791.
16. Costa, A.S.V. Fósforo no sistema solo–planta. *Governador Valadares, Editora Univale*, **2008**, 64.
17. Costa, A.S.V.; Silva, M.B.; Galvão, E.R.; Rufini, J.C.M. Monteiro, C.L.O. Alterações na capacidade de retenção de água no solo após a aplicação de resíduo sólido proveniente de uma fábrica de celulose. *Revista Universidade Rural, Ciências da Vida*, **2006**, 26:1–10.
18. Costa, K.A.P.; Oliveira, I.P.; Farquin, V.; Neves, B.P.; Rodrigues, C. Sampaio, F.M.T. Intervalo de corte na produção de massa seca e composição químico–bromatológica da *Brachiaria brizantha* cv MG–5. *Ciência e Agrotecnologia*, **2007**, 31:1197–1202.
19. Debosz, K.; Petersen, S.O.; Kure, L.K.; Ambus, P. Evaluating effects of sewage sludge and household compost on soil physical, chemical and microbiological properties. *Applied and Soil and Ecology*, **2002**, 19:237–248.
20. Embrapa–Centro Nacional de Pesquisa de Solos Manual de métodos e análise de solos. *Rio de Janeiro, EMBRAPA–CNPS*, **1997**, 212.
21. Estat. Sistema de análises estatísticas. DCE–FCAV/UNESP. **1994**.
22. Fadini, P.S. Fadini, A.B. Lixo: desafios e compromissos. *Cadernos Temáticos de Química Nova*, **2001**, 9–17.
23. Ferencz, A.; Juhasz, R.; Butnariu, M.; Deer, A.K.; Varga, I.S.; Nemcsok, J. Expression analysis of heat shock genes in the skin, spleen and blood of common carp (*Cyprinus carpio*) after cadmium exposure and hypothermia. *Acta Biologica Hungarica*, **2012**, 63(1): 15–25.
24. Freitas, M.S.C.; Araujo, C.A.S.; Silva, D.J. Mineralização do cálcio e magnésio de esterco em função da profundidade e do tempo de incorporação. In: *II Congresso de Pesquisa e Inovação da Rede Norte Nordeste de Educação Tecnológica, João Pessoa, Anais*. PB. **2007**, 1–8.
25. Kiehl, E.J. Fertilizantes Orgânicos. Piracicaba, *Editora Agronômica Ceres*, **1985**: 492.
26. Moreira, F.S.M.; Siqueira, J.O.; Microbiologia e bioquímica do Solo, Lavras, *Editora UFLA*. **2002**: 626.
27. Prosab Programa de pesquisa em Saneamento Básico. Uso e manejo do lodo de esgoto na agricultura. Rio de Janeiro, *Associação Brasileira de Engenharia Sanitária e Ambiental*. **1999**, 97.
28. Rossi, C.; Monteiro, F.A. Doses de fósforo, épocas de coleta e o crescimento e diagnose nutricional nos capins braquiária e colônia. *Scientia Agrícola*, **1999**, 56:1101–1110.
29. Rowell, D.M.; Prescott, C.E.; Preston, C.M. Decomposition en nitrogen mineralization from bio solids and other organic materials: relationship with initial chemistry. *Journal of Environment Quality*. **2001**, 30:1401–1410.
30. Samfira, I.; Butnariu, M.; Rodino, S.; Butu M. Structural investigation of mistletoe plants from various hosts exhibiting diverse lignin phenotypes. *Digest Journal of Nanomaterials and Biostructures*, **2013**, 8(4): 1679–1686.
31. Santos, H.R.; Prado, G.S.; Vidal, C.M.S.; Moruzzi, R.B.; Campos, J.R. Aplicabilidade das técnicas de determinação de tamanho de



- partículas em sistemas de tratamento de água e esgoto sanitário. *Engenharia Sanitária Ambiental*, **2004**, 9:291–300
32. Silva, J.E.; Resck, D.V.S.; Sharma, R.D. Alternativa agronômica para o biossólido produzido no Distrito Federal I: efeito na produção de milho e na adição de metais pesados em latossolo no cerrado. *Revista Brasileira de Ciência do Solo*, **2002**, 26:487–495.
33. Silva, J.E.; Resck, D.V.S.; Sharma, R.D. Feitoza, L. Utilização do lodo de esgoto como fonte de fósforo e nitrogênio para o milho. In: CONGRESSO BRASILEIRO DE CIÊNCIA DO SOLO, 26, Rio de Janeiro. Anais, *Sociedade Brasileira de Ciência do Solo*, **1997**, 1–4.
34. Siqueira, J.O.; Franco, A.A. Biotecnologia do solo: fundamentos e perspectivas. Lavras, *Ministério da Educação e Cultura, ABEAS, ESAL, FAEPE*. **1988**, 236.
35. Sloan, J.J.; Dowdy, R.H.; Dolan, M.S.; Linden, D.R. Long term effects of bio solids applications on heavy metal bioavailability in agricultural soils. *Journal of Environmental Quality*, **1997**, 26:966–975.
36. Stevenson, F.J. Humus chemistry: Genesis, composition, reactions. *John Wiley & Sons*. **1982**, 443.
37. Teixeira, A.R.; Chernicharo, C.A.L.; Aquino, S.F. Influência da redução do tamanho de partículas na taxa de hidrólise de esgoto bruto doméstico. *Engenharia Sanitária Ambiental*. **2008**, 13:405–415.
38. Voisin, A. Adubos: Novas leis científicas de sua aplicação, São Paulo, Editora Mestre Jou. **1986**, 130.
39. Zhang, B. The influence of pH hydrolysis and acidogenesis of kitchen wastes in two fases anaerobic digestion. *Environment Pollution*. **2005**, 26:329–339.

Received: November 23, 2014
Article in Press: March 17, 2015
Accepted: Last modified on

