Original scientific paper
10.7251/AGRENG1703108C
UDC: 502:628.473

BIODIGESTER BALES: METHOD FOR THE ECOLOGICAL MANAGEMENT OF ORGANIC RESIDUES

Erasmo VELÁZQUEZ CIGARROA[1]*, Laura Catalina OSSA CARRASQUILLA[2], Natalia Helena JARQUÍN SÁNCHEZ[1], Liberio VICTORINO RAMÍREZ[1]

[1]Department of Rural Sociology, Chapingo Autonomous University, Texcoco, Mexico
[2]Faculty of Engineering of the University of Antioquia, Medellin, Colombia
*Corresponding author: erasmo.vcigarroa@gmail.com

ABSTRACT

The environmental and public health problems by inadequate management of organic waste continue to worsen in many parts of the world. The high rates of waste generation associated with deficiencies in collection and treatment services are a source of negative impacts; the inadequate disposition of the material bound to an incorrect separation causes proliferation of pest species, bad smells, toxic gases formation, fumes and dust that contribute to the contamination of the ecosystems. The cause of these problems that alter the quality of the environment and the health of the people is certainly of anthropic origin, because in nature, the recycling of nutrients is an essential function for life. In view of this scenario, it is proposed the implementation of an ecological method, alternative to traditional compost, which has been proven effective by developing it in higher education institutions and university. Among the benefits offered is the management of tons of organic material in small spaces, the sustainable use of waste derived from food consumed in schools, among others. Studies for the analysis and evaluation of the physicochemical and nutritional quality of the organic fertilizer obtained in different climatic conditions, from biodigester bales assembled in Medellín, Colombia and Texcoco, Mexico, showed favorable amounts of nutrients that benefit the growth of seedlings planted in the same bale or when applied as fertilizer in gardens and orchards. Therefore, the development of this proposal also benefits the urban and ecological agriculture areas.

Key words: *biodigester bale, organic fertilizer, sustainability, school.*

INTRODUCTION

The question of whether organic waste is an environmental public health or natural resource problem is easy to answer if analyzed from a comparative framework between how nature handles and recycles nutrients cyclically, unlike linear and determinists methods that humanity implements, which endanger the quality of ecosystems and thus the well-being of people. Humanity has undoubtedly walked

against the laws of nature, since the management of organic matter as polluting waste, deteriorates the environment and causes disease, while in soils they are a natural resource of nutrients and biodiversity.

In ecosystems such as forests, recycling of nutrients is an essential function for life, is generated through biogeochemical cycles and ecological processes of decomposition. Emulating those behaviors and strategies that are carried out in the upper mantle of the Earth, where decomposing organisms transform matter, mineralize and synthesize it by enriching the soil with nutrients and life, is possible through the method of Biodigester Bales; which is a microecosystem that is built in a handmade way, works outdoors and imitates the soil ecology, essentially in the organic horizon, where biodegradable matter accumulates and transforms into organic fertilizer, a stable and mature solid product similar to Humus; dark brown with water, air and living organisms (Ossa, 2016a).

The Biodigester Bale is a method for the biological digestion of all types of organic waste, for example, those that are generated in kitchens, such as fruit peels, vegetables, decayed or cooked foods residues or wastes. Also those produced in green areas such as leaves, seeds, fruits or branches, pruning of gardens or lawns and animal droppings (Ossa, 2016b). It is an autonomous transformation mechanism that digests organic waste through a fermentative decomposition process, without infrastructure and without any contamination. They allow disposal, treatment and use of biodegradable waste at the source, processing large quantities of organic material in confined spaces. In bales of one cubic meter for example it is possible to store between 500 and 600 kg of organic waste.

With the Biodigester Bale as organic waste is recycled and managed without generating bad odors, proliferation of flies, pollutant gases or high amounts of leachate (Cano *et al*., 2015). Biodigester Bales are cleaned and beautified environments, they also can be used as a landscape proposal for green areas, as planters or spaces conducive to the construction of organic gardens. Thus, Biodigester Bales are multipurpose by becoming also atmospheric carbon fixing systems due to the photosynthesis performed by plants that, by natural or induced ecological succession, develop on it. The process of digestion of the organic matter in the Bale takes about six months, after this period it is possible to obtain the organic fertilizer as the final product of biodegradation (Ossa, 2016c). Other studies that compares the substrates obtained from the Biodigester Bale method and composting prove the quality and maturity stage when they are submitted to fermentation processes (Posada, 2015).

Some communities that have been responsible for the organic waste they generate and recycle them by Biodigester Bales, show the benefits of this mechanism by providing healthy environments and protecting public health. The method of Colombian origin that has been applied in institutional, communal, neighborhood, industrial, residential, recreational and even investigative environments has proven to be ecologically efficient and economically viable for the integrated management of organic waste. In addition, these actions are related to the state of knowledge generated by the Ecopedagogy, considered as a new paradigm that focuses on life.

It is education for a responsible action towards and by the environment, linked to space and time, where the relations between the human being and the environment take place (Antunez and Gadotti, 2005). The purpose of this study is to carry out a comparative analysis based on the experience of the University of Antioquia, Medellin-Colombia and the Official High School Number 100 (EPO 100), Texcoco-Mexico, in order to demonstrate the socioecological importance of recycling and properly managing organic waste in educational institutions of higher education and university level, through the technique of Biodigester Bale. As a comparison mechanism, a qualitative analysis was implemented in the laboratory to evaluate the quality and the physicochemical and nutritional characteristics of organic fertilizer obtained from the assembled biodigesters in both contexts.

MATERIALS AND METHODS

The Biodigester at the University of Antioquia was assembled in the green zone between block 20 and 21 of the Faculty of Engineering, through the classroom project conducted with the students of Introduction to Sanitary Engineering of the semester 2015-2. Approximately 200 kg of kitchen waste and 400 kg of vegetable waste were used as well as a metal frame about one meter wide, one meter long and a half meter high (Ossa, 2016a). The images 1, 2 and 3 shows (Biodigester Bale setting-up) the Biodigester Bales assembled at the University of Antioquia during its construction, decomposition and extraction of the organic fertilizer sample, respectively.

Fig. 1. Construction process

Fig. 2. Decomposition process.

Fig. 3. Organic fertilizer extraction

The process at EPO 100 began at the end of 2016 through a theoretical workshop on training and awareness-raising, developed at the institution by the environmental engineer Catalina Ossa, under Erasmo Velázquez´s coordination, with a participatory environmental education proposal for students and teachers to learn the ecological management of organic waste with Biodigester Bales. This gave rise to a process of integral management of the organic residues from kitchen that are generated there, through the treatment at the bale setting and was used as organic fertilizer for the school's garden crops (Velázquez C.& Victorino, 2016)..
The first bale was made as a prototype for participants to learn how to build them. Currently, two bales are made per week of 1 cubic meter each, using pine wood mold, recycling about a ton of organic waste per week with students work. All this, through the cross-linking of specific thematic contents in subjects of natural and social sciences areas, where the teachers of these academic disciplines integrate the technique of the "Biodigester Bales" as part of their educational praxis, which is included in their didactic lesson planning (Velázquez, 2016). For this, aspects of the technical theory of the curriculum are taken up, in which "... society and culture are considered as an external network of the school and the curriculum, as a context characterized by social needs and objectives Which education must respond by discovering those needs and developing programs to achieve the goals and objectives of society "(Kemmis, 1998: 112)

Figure 4. Students and teacher´s participation in the "Biodigester bales" elaboration process at EPO100.

At the end of the decomposition process of the organic residues in the bundles or bales assembled at the University of Antioquia and in the EPO 100, a sample of organic fertilizer of 250 and 500 grams respectively was taken, which were sent to the Soil Department laboratory in the Chapingo Autonomous University (UACh) located in Texcoco and to the laboratory of the Interdisciplinary Group of Molecular Studies (GIEM) located in Medellín, respectively, in order to know its quality by means of a qualitative analysis of its physicochemical properties and the macro and micronutrients content, from the evaluation of the following parameters:

- Ph: Potentiometric in relation. Sample: Water 1: 5
- Electrical Conductivity (CE): Suspension conductivity bridge. Sample: Water, 1: 5.
- Organic matter: Calcination
- Apparent density: Probe method.

• Cation Exchange Capacity (ICC): Ammonium acetate 1.0 N Ph 7.0 and determined by steam entrainment.
• Nitrogen (N): Digested with diacid sample and determined by steam entrainment.
• Phosphorus (P): Digested with diacid sample and determined by photocolorimetry by reducing reduction with molybdo-Vanadate.
• Potassium, Sodium (K, Na): Digested with diacid sample and determined by flame emission spectrophotometry
• Calcium, Magnesium, Zinc (Ca, Mg, Zn): Digested with diacid sample and determined by atomic absorption spectrophotometry.
• Carbon / nitrogen ratio (C / N): Determined by calculation.

Figure 5. Obtaining the sample for the laboratory analysis of the substrate of the biodigester Bale in EPO 100.

By means of a validation carried out according to the optimum and quality ranges required by Colombian Technical Standard (NTC) 5167 for commercial organic fertilizers, analysis and discussion of the results obtained in the laboratory of both cases was made.

RESULTS AND DISCUSSION

The qualitative analysis of the laboratory to evaluate the quality of the samples of organic fertilizer obtained in each of the Biodigester Bales assembled in the University of Antioquia and in the EPO 100, showed the data recorded in table 1, where the physicochemical parameters and the respective macro and micronutrient content as well as the optimum quality value required by Colombian Technical Standard (NTC) 5167 for commercial organic fertilizers.

Table 1. Physicochemical parameters and nutrient content of organic fertilizer samples.

Parameter	**Result of organic fertilizer UdeA**	**Result of organic fertilizer EPO 100**	**Units**	**Optimal value**
pH	7.12	7.96		>4 y <9
Electrical coductivity (CE)	0.076	1.06	dS/m	Smaller than 3
Cation Exchange Capacity (ICC)	51.8	47.1	meq/100g	Mínimun 30. Optimal >67
Density	0.42	0.85	g/cm3	Max. 0,6
Total oxidizable organic carbon	21.8	15.54	%	Minimum 15%
Nitrogen (N)	1.6	1.05	%	Between 2% y 3%
Potassium (K)	0.6	0.85	%	> 1%
Phosphorus (P)	0.47	0.21	%	> 1%
Magnesium (Mg)	0.38	0.22	%	> 1%
Sodium (Na)	N.R	0.41	%	> 1%
Calcium (Ca)	4.38	0.47	%	> 1%
Zinc (Zn)	N.R	57	mg/kg	> 1%
Relation C/N	13.7	14.8		Smaller than 20

*N. R: No Record.

The physicochemical parameters have the characteristic to determine and to reflect the properties and constituents of the organic fertilizer; they are used as an indicator that establishes the quality and state of maturity of the organic matter transformed by numerical quantities (Ossa, 2016a). The physicochemical and nutritional characteristics of the samples evaluated vary according to the environmental conditions of each site, the type of material originally used for the assembly of the biodigesters, the digestion time of the material and the organisms involved in the degradation. According to the data recorded, both samples of organic fertilizer showed favorable conditions and important amounts of nutrients. The pH is an indicator to demonstrate the process of digestion of organic matter, in both samples were registered values between a range of 6 and 8, very close to neutrality, which means that the material has stabilized, acquiring a large presence of humic compounds. In the case of electrical conductivity, both samples reported values lower than 3dS / m, which is characteristic of organic fertilizers with great potential for seed germination and plant development. The density is considered a determinant of the quality of the fertilizer, it represents the capacity of absorption, aeration and structure of the material. According to NTC 5167/2004, the maximum allowable value for tradable organic fertilizers is 0.6 g/cm^3, of the analyzed samples only the fertilizer produced in the biodigester bundle of EPO 100 does not comply with this parameter, which means that this material, although of very good quality, could not be marketed according to the referenced standard. The (ICC) and the carbon-nitrogen ratio are directly related, represent the state of maturity of the organic fertilizer. In both samples analyzed the results are within the optimum value, which means that they are at suitable maturity level for use as substrate for soils, organic crops or as a source of nutrients for plants. In addition, according to

the registered macro and micronutrients content, both samples are an organic fertilizer of very good quality, due to the variety of elements that can contribute as carbon, nitrogen, phosphorus, potassium, calcium, magnesium, zinc, sodium, which improve the productivity of crops, fertility and biodiversity in the soil, garden or garden, and plant health. According to NTC 5167/2004 a high quality organic fertilizer must contain higher amounts of macronutrients such as carbon and nitrogen and at least 1% of each micronutrient. In the particular case of the organic fertilizer sample of the U. de A., the carbon and nitrogen contents were 21.8% and 1.6%, respectively. No sodium and zinc contents were recorded; the potassium, phosphorus and magnesium were in amounts less than 1%, unlike calcium which represented a percentage of 4.78. In the organic fertilizer sample of EPO 100, the amount of macronutrients such as carbon and nitrogen was 15.54% and 1.05% respectively; Although phosphorous, potassium, calcium, magnesium, zinc and sodium contents were recorded, all showed less than 1%. Both studies show that the substrate of the bales can be used for the soil to benefit plants and trees, providing nutritional inputs that favor its development. In turn, the germination of seeds until their growth in seedlings within the Biodigester Bales turns out to be a timely alternative in areas where the soil is eroded or contaminated.

CONCLUSIONS

Biodigester Bales allow to treat all types of biodegradable waste; it is an efficient producer of fermented organic fertilizer that represents a macro content and important micronutrients, perhaps not in the amounts that stipulate the norm, but to supply the demand of the plants and improve the quality and fertility of soils. To obtain specific amounts of nutrients in the organic fertilizer, it will be necessary to determine the characteristics of the initial material that is available and used in the process of assembling the Biodigester Bale, which represent the final quality of the substrate. The evaluated samples showed favorable physicochemical and nutritional conditions, which means that the organic fertilizer obtained through the method of the Biodigester Bale can be used to improve the nutrient source of the soil, its biology and quality or as a substrate for seedlings, nurseries, orchards or gardens. It reduces costs in the acquisition of industrial fertilizers and definitely favors the sustainable management of organic waste that can be applied successfully in the areas of urban and ecological agriculture. The implementation and follow-up of this method allows to generate an own experience that provides relations between the individual and nature; is reflected the link with the environment and the development of a social conscience for the benefit of people and the environment. Educational institutions are the way to promote these ecological practices, respect for the environment begins at home and also at school. The awareness of young people about these settings and the way they learn to treat them will help them become responsible adults. For this, teachers play a key role in the development of these activities and to achieve them, it is possible to link the contents of the subjects with the ecological question, thus achieving a curricular environmental awareness.

REFERENCES

Antunez, A. and M. Gadotti (2005). Eco-pedagogy as the appropriate pedagogy to the earth charter process, in P. Blaze Corcoran (ed.), The Earth Charter in Action: Toward a Sustainable World, KIT Publishers, Amsterdam.

Cano C. J., Silva P. G., Delgado, A., Liset, J. & López A., Y. (2015). Descomposición de residuos orgánicos en pacas: aspectos fisicoquímicos, biológicos, ambientales y sanitarios. (Decomposition of organic waste in bales: physicochemical, biological, environmental and health aspects). *Producción+ Limpia*, Medellín, Colombia.10(2), pp.38-52.

Kemmis (1998). El currículum más allá de la teoría de la reproducción. (The curriculum beyond the theory of reproduction). Ed. Morata. Madrid, España.

Ossa C. L. (2016a). Aplicación de las Pacas biodigestoras para el tratamiento ecológico de los residuos orgánicos de la Universidad de Antioquia. (Application of the Biodigeste Bales for the ecological treatment of the organic residues of the University of Antioquia). Universidad de Antioquia. Medellín, Colombia. https://drive.google.com/file/d/0BwecnWVz7HZoXzUxOUhOel9WZTQ/view Accessed on 18/04/2017.

Ossa C. L. (2016b). Aplicación de la tecnología de las Pacas Biodigestoras para el tratamiento ecológico de los residuos orgánicos de la Universidad de Antioquia. (Application of the technology of the Biodigester Bales for the ecological treatment of the organic residues of the University of Antioquia). En R. Rivera E., Alternativas sustentables y participación comunitaria. (págs. 153-163). Universidad Autónoma de Chapingo, México: Universidad de Málaga. www.eumed.net/libros-gratis/2016/1544/residuos.htm Accessed on 19/04/2017.

Ossa C. L. (2016c). Pacas Biodigestoras: de los residuos al abono orgánico. (Biodigester Bales: from the residues to the organic fertilizer). Revista Experimenta, 22-25. Universidad de Antioquia, Medellín, Colombia.

Posada A. (2015). Evaluación de dos sistemas de degradación biológica en zona rural del corregimiento San Antonio de Prado. (Evaluation of two biological degradation systems in the rural area of San Antonio de Prado).Universidad de Antioquia. Medellín, Colombia.

Velázquez C. E.(2016). EPO100 hacia la sustentabilidad. Génesis de una propuesta. (EPO100 towards sustainability. Genesis of a proposal). En Castellanos, José A. (ed.). Territorio, ambiente, turismo y tecnología. Universidad Autónoma Chapingo, México.

Velázquez C. E. & Victorino R.L. (2016). Los huertos escolares en Instituciones de educación media superior. Una experiencia en la comunidad de la Unión y Tepexoxuca, Puebla.(School gardens in Higher Education Institutions. An experience in the community of the Union and Tepexoxuca, Puebla). En Pérez, R. & Victorino, L. & Quintero, M. (eds.). Educación ambiental y sociedad. Saberes locales para el desarrollo y la sustentabilidad. Laberinto ediciones, México.