Scientific Papers Series Management , Economic Engineering in Agriculture and Rural Development
Vol. 13 , Issue 1, 2013
PRINT ISSN 2284-7995 , E-ISSN 2285-3952

BIOGAS AS AN ALTERNATIVE ENERGY SOURCE TO PROMOTE INDIGENOUS COMMUNITIES DEVELOPMENT

Carlos SABORÍO VÍQUEZ

University of Costa Rica, San Jose, Costa Rica, E-mail: biocolibris@gmail.com

Corresponding author: biocolibris@gmail.com

Abstract

The key areas that determine the food and nutrition security are: availability, access, consumption and biological utilization. For this reason it is necessary to promote the health of vulnerable groups, in this case, indigenous communities, protecting and establishing conditions to ensure the human right to food. The initial plan focuses on developing facilities for small swine and poultry farms, familiar, non-commercial. The main objective of the pigs raised at the site will be the production of animal waste in order to implement digesters for the production of biogas as an alternative energy source, the production of meat stays in the background, thinking only about the community consumption and helping to ensure their food source, from this perspective, the technologies applied to rural and indigenous progress are environmentally friendly, socially just, economically viable and culturally acceptable. The theme of rural and indigenous Development is focused on their food security and the use of alternative energies, considering that energy is a key element in achieving sustainable development in all sectors, therefore sought from a broad perspective solidarity and actively promote greater and more rational use of energy and the environment in remote communities, through diversification of supply sources and efficient use, thereby contributing to environmental conservation and reduction of health problems through the use of appropriate technologies.

Key words**:** *alternative energy, biodigester, indigenous, rural development*

INTRODUCTION

According to the United Nations Organization for Food and Agriculture (FAO), the food security concept appears in the 1970s and refers to when people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food to meet their nutritional needs and cultural preferences for an active and healthy life. (FAO, 2011)

The key areas that determine the food and nutrition security are: availability, access, consumption and biological utilization. It is for this reason that from the Transfer Program of the Experimental Station Fabio Baudrit Moreno (University of Costa Rica) has been promoted the care of vulnerable groups, in this case, indigenous communities, protecting and establishing conditions to ensure the human right of food.

Currently the world is undergoing major adjustments at the environmental level, humanity has been talking about climate change since several years ago, and how this change in the Earth's global temperature is affecting and will continue to cause all kinds of havoc; this project raises food production and sustainable energy options, seeking to mitigate carbon emissions and above all are fit to deploy in areas of high socio-economic risk.

It is a given fact that human activities release greenhouse gases into the atmosphere, Botero (2000) says that agriculture and livestock are some of the most important, due to the release of methane gas, which is one of the gases responsible for global warming and climate change. Of the methane gas emissions generated by human activity, 30% comes from livestock.

Most of the methane released by livestock is produced by the "enteric fermentation" of food, by bacteria and other microorganisms in their digestive tracts. The methane gas emission due to anaerobic decomposition of manure also contributes to this effect, though to a lesser extent. (Castles, 2006)

Moreover, the use of chemical fertilizers increases emissions of other gases causing the greenhouse effect, nitrous oxide for example. According to Castles (2006), nitrogen containing fertilizers and many mineral fertilizers increases the natural processes of nitrification and de nitrification producing bacteria and other microbes in the soil. These

processes convert some nitrogen into nitrous oxide. The amount of this gas emitted for each unit of nitrogen applied to the soil, depends on the type and amount of fertilizer, soil conditions and climate.

It is an irrefutable fact that one of the new challenges we face today is, among others, the proper use of resources, to prevent misuse of them and eventually harm to us, to future generations and the ecosystem general. The use of biogas has become an excellent tool for the proper use of resources. An example of this is the possible cycling which could give agricultural products, which have the potential, through anaerobic decomposition, producing biogas, clean energy source. In this context, the biogas is an option to search for reducing dependence on small and medium producers to oil, and optimize agricultural production systems, in addition to helping reduce the environmental impact of human activities on the planet (Olivares et al. 2009). Works by Rojas et al., Canales et al. (2010) Dominguez et al. (2012) and Rivera (2010), are a good guide for the implementation of methodologies to study the variables related to the incorporation of digesters in rural areas. The methods include the study of different variables that indicate the status of the digester, the balance between carbon and nitrogen of the raw materials used the pH of the product, process temperature, and the components of biogas, among others.

The implementation of the technology developed in this project, allows the development of renewable energy (biogas), which in turn helps to mitigate climate change by reducing emissions of methane from the manure's anaerobic decomposition and to replace the use of nitrogen fertilizer, while ensuring vulnerable communities a more sustainable option to cook their food and eventually generate electricity and reduce costs.

MATERIALS AND METHODS

The project is being directed to different indigenous communities in the country, but mainly in the areas of Talamanca and Moravia Chirripo, specifically the Bribri and Cabecar ethnicities; looking for a strengthening of the capacity to produce food for human consumption as well as how to cook these, thus enhancing food security within these social organizations. In order to aim this, we are promoting the operation of demonstration farms to transfer animal species for human consumption and grains and seeds preservations, assisting in the training and management of these demonstration farms, working with participatory techniques, in addition with the support of universal values such as friendship, trust, solidarity and active respect, it has been possible to build bonds between the University of Costa Rica and these indigenous communities.

Supported by the conviction that knowledge and study immerse in an area of freedom and mutual respect, indigenous families are able to organize and deliver their work. The people exchange seeds, build chicken coops and pigsties, the project provides species of poultry and pork. We have given training and support in the management of laying hens (Sex Link and Plymouth Rock) and herding chickens. According to this guideline, there is a total of more then 7000 animal species that have been delivered to them.

In the environmental axis, it is important to mention that biodigesters have been built; by this method animal excrement is transformed into methane gas, which is useful for carrying out the cooking of food. This practice has been a great impact on families benefited since the alternative they have always had is deforestation for cooking with firewood, a situation that is not sustainable with nature at all, also presents an immediate health problem.

To address these concerns, there is then the goal of the project: generate biogas as an alternative energy source, recording the response of the digesters over the use of different types of biomass for deployment in rural areas, comparing the use of mesophilic microorganisms and thermophilic as decomposers of organic matter used (agricultural products both animal and vegetable), and thus determine which is most suitable for implementation in high-risk areas.

Beneficiary families have continued the project broodstock poultry and swine; this has

been a great impact on the families' diet and ensures the food needed to survive. We make regular visits to monitor the progress of the communities, also to extend assistance and training, both in the breeding of animals and preservation of grains and seeds. Special emphasis is on the participation of women and promotes gender equity which allowed even a very successful job. Stated above, then stated that parallel the main objective of the project (see above), it supports indigenous communities in establishing sustainable agricultural projects and activities become socially sustainable, economically viable and environmentally friendly; giving farmers, by the University of Costa Rica, a consulting and training services, helping to increase organic production and use of alternative energy such as biogas, establishing a sustainable and integrated farming system; promoting training in resource management natural and appropriate technologies to increase production by training in management and agricultural production, using the organic farm as a model that promotes the organization and self-sufficiency.

The methodology that has been followed is as follows:

A.Preparation of conventional digesters under low-load system, with plastic bag. It's important to mention that we consider several types of variables to be analyzed, such as: types of biomass to be used, for example, corn stover and sorghum, corn stover and manure, dung alone, corn stover and manure, swine manure, among other combinations of substrates.

B.Characterization of the biomass used. We determine the physical, chemical and biological properties of each substrate, and its dry matter yield and volatile solids.

C.Comparison of the efficiency of thermophilic and mesophilic bacteria versus time needed for decomposition of organic matter determined shall be taken into account parameters such as gas quality obtained: physical and chemical qualities, concentration of methane, etc.

D. Identifying the biodigester. Be appointed each digester with a key to the type of bacteria (mesophilic or thermophilic), and organic matter used. For mesophilic digesters the key used is BM (BM1, BM2, BM3 ...) and for thermophilic is BT (BT1, BT2, BT3 ...).

E. Analysis of random samples for chemical studies, physical and biological. As for the sampling, normally there are a total of 15 samples for analysis.

In the case of the raw material that feeds the digester take samples of 500 g. in plastic bags, and the effluent was taken in 500 ml plastic containers. Laboratory tests are done in batches, following the standard norm #4630 from the Directors of the Association of German Engineers (VDI, for its acronym in English). For each test 1500g of bacterial inoculum is needed for each substrate and compare the ratio to 2:1 related volatile solids. To determine how much mass of the substrate is needed, the following formula is used:

$$\frac{\text{Msustrato} \cdot \text{MS} \cdot \text{SV}}{\text{Minóculo} \cdot \text{MS} \cdot \text{SV}} = 0{,}5$$

For analysis of the obtained biogas production, records are taken and gas obtained characterization. Samples were measured in the content of methane, carbon dioxide and oxygen.

F.Temperature measurement. There are thermometers to determine the average temperature of the different digesters. Results are documented to have a scientific basis to tell us which method is best for us to develop in this case, comparing building materials, substrates used and the temperature of the medium.

G.Bacteriological analyses are done periodically in the laboratory, in order to determine the microorganisms' health and thus the digestate. Overall, it looks for "flakes of bacteria" look of golden brown under the microscope, if not, it means that the inner content of anaerobic digester is contaminated, usually with heavy metals which are inhibitors of the fermentation process bacterial and this leads to lower production of biogas.

RESULTS AND DISCUSSIONS

1.Diagnosis

1.1.About the indigenous communities

In Costa Rica there are identified eight

indigenous communities, spread across 22 territories. The gap characteristic of the country is also present in indigenous rural areas. The national indigenous population is 63,876 people representing 1.7% of the total population, the percentage of 60% of the population live in "shacks" with floor and roof made of palm leaves, 69% of territories have no water and use the water directly from rivers and streams, and only 65% have latrines

The majority of the Indigenous population is employed in agriculture and faces the same difficulties of rural households engaged in these activities.

Table 1. Distribution of indigenous areas in Costa Rica

Zones	Territories	Etnicities
Huétar Norte	Quitirrisí y Zapatón	Maleku
San Carlos	Guatuso	Maleku
Chorotega	Matambú	Chorotega
Atlántico	Salitre, Cabagra, Talamanca, Kekoldi y Cocles	Bribri
Cabécar	Alto Chirripó, Tayni, Talamanca Cabécar, Telire, Bajo Chirripó, Nairi Awari y Ujarrás	Cabécar
Brunca	Boruca y Rey Curré	Boruca
Pacífico Sur	Abrojo Montezuma, Coto Brus, Conte Burica y Osa	Guaymí
Teribe	Térraba	Teribe

However, some of the indigenous people are located in rural areas in decline, with a significant deterioration in their economic and social fabric. This becomes more acute their poverty and food and nutrition insecurity. The people and territories are divided as follows:

1.2.Geographic Location of Indigenous Territories: inherent in its development. There were a total of 63,876 Indigenous, of whom 79% live in rural areas. (Saborio 2011). It is necessary to specify the situation of indigenous people and territories in defining strategies and rural development initiatives that respond to their specific conditions regarding the disadvantages certainly show these territories, settlements as a remote location, lack of public services, lack of communication; is successful for these reasons the implementation of socio-productive development strategies, as this system takes into account the particular forms of social organization, modes of relationship established with the local base of natural resources, cultural identity and the possible development budget that can be given relating to the academic community and the private sector in a sustainable manner.

1.3.Contribution to increase organic production and use of alternative energy. The project is supported by a sustainable agricultural system, integrated and organic; promoting the use of alternative energy through biogas production based on the waste generated by animal species. Also everything is conceived within the indigenous culture whose ancestral part is based on a vision of sustainability. The poultry component relies on this specific objective but like any other laying hen project requires concentrate or supplements, the vitamins required for these birds and at this point have been productive deficiencies due to lack of resources, however the values are acceptable and are around 75% position. Progress in integration understood as it has been found that all households in the project work within the framework of organic production.

Specific achievements have been made, for example: improving the quality of life of many indigenous families, as they are currently having a good number of laying birds and have consumed more than a thousand chickens. Clearly satisfaction between the families is seen, by having a continuous supply of pigs, including a boar of excellent quality. Today over 200 people have received maize seeds birds and Diamonds, about 20 families have benefited from the project pigs and now has three demonstration

gardens with their piggeries and poultry. At the administrative level there are two instruments, one for data and one participating families to make the visit reports. Furthermore, the garment has four manuals:
1.Recommendations for the care of newborn chicks and chicks
2.Guidelines for the construction and management of poultry farms
3.Guide management of laying hens
4.Food Safety Manual: Transfer of appropriate technologies for preservation of grains and seeds, to develop pig and implementation of alternative energy.
We plan to translate these books into the languages Cabecar, Guamíe and Bribri, to facilitate communication with the people involved and continue with the dissemination of the project.

2. Impact

2.1.Food Security

It is unquestionable that food security is an issue of global and national course and that, changes in climatic conditions affect it through their impacts on all components of the global and national food systems.
Climate problems are accentuated more in our country as a tropical territory are droughts and floods, which are already suffering now direct impact on food production, the food distribution infrastructure, the incidence of food crises, goods and opportunities for livelihoods and human health in both rural and urban areas. (Arauz, 2008)
These project initiatives encourage better use of natural resources by indigenous rural communities in order to build facilities with appropriate technologies for livestock and livestock interest for planting, harvesting and preservation of grains and seeds.
All this, in order to mitigate the negative effects that humans have made to their environment. The loss of biodiversity and ecosystem functioning in natural habitats should be mostly deforestation indigenous families performed in order to obtain heat energy to cook their food, that besides being environmentally destructive is a problem immediate public health because all the smoke from the burning of wood is inhaled by people and cause diseases such as whooping cough, pneumonia, lung cancer, among others.
Families recognize the urgent need to address the needs of produce and consume their own food, but more than that they are pleased with the opportunity to cook their food in a more clean and healthy through biogas.

2.2. Productive

The main indicator of success is formed by low mortality rates poultry and swine, this shows that they are concerned about raising animals, participating families have achieved expertise in managing care techniques for poultry and pigs.
All families have poultry houses and piggeries in good condition. However weather conditions and terrain did not allow easy handling and installation of the biodigester.

Photo 1. Don Heriberto Herrera, working on cleaning the swine installations. Photography: C. Saborío

One digester was constructed in the Upper Chirripó, specifically in the family plot Aguilar Garcia, this was kept running until the weather caused the plastic bag was torn and therefore stopped working. We sought private sponsorship Olefins Company (marketer of plastics for agriculture in Costa Rica) and with the help of them are implementing organic digesters built with better materials, this to ensure the smooth functioning of the same and thus generate steadily biogas.

2.3 Training

Since its inception, the whole scheme of this project is based on the philosophy of knowledge transfer, therefore is to train future trainers. For this, we have completed different

activities for participants to interact with other participants and their future learners. Within this framework, it should take several steps to successfully carry out the project, as described below serves almost as a pre-feasibility study:

Table 2. Attendance at training workshop "Alternative Energy Transfer: Biogas"

Name	Procedence
Olivieth Cruz Arias	Cerere
Emilse Fernández M	Cerere
Heiner Fernández M	Cerere
Jairo Reyes Domínguez	Cerere
Abraham García Méndez	Bajo Chirripó
Abelino País País	Talamanca
Belkis Leiva	Talamanca
Micaías Morales	Talamanca
Acdiel Pita Smith	Talamanca
Ruth Leiva García	Talamanca
Jeannette Marín Mejía	Guatuso
Iris Blanco Elizondo	Guatuso
Mercedes Hernández	Guatuso
María Adelita Lázaro	Rey Curré
Alderico Aguilar García	Tsipiri Chirripó
Maricela Rosales H	Tsipiri Chirripó
María Dominga Lázaro	Rey Curré
Gerson Moya Reyes	Tsipiri Chirripó
Jorge Aguilar Rosales	Tsipiri Chirripó
Humberto Fernández	Tsipiri Chirripó
Mardania Moya Herrera	Tsipiri Chirripó
Gabriel Barquero	Tsipiri Chirripó
Dimas Durán Araya	Talamanca

1. Selection of participants should be clearly defined who or who will be the direct beneficiaries of the project, in that sense, they have already established links with different leaders and indigenous families.
We performed a digester building at the headquarters of the University of Costa Rica in Turrialba which was built for educational purposes in a training workshop was held on the first day of October, 2012, who attended the workshop will be the first beneficiaries.

Photo 2. Costarrican Indigenous building a biodigester with academic purposes. Photography: J. Rodríguez

Photo 3. Biodigester finished. Photography: C. Saborío

2.Availability of a suitable site for the construction of the biodigester: it must take into account that most areas where it wants to impact are highly rural and hard to reach, so you must choose the best, you can also find suitable properties soil, groundwater and not very high spaces available for further application of organic fertilizer produced.
3. Consistent long-term availability of suitable substrates that, since the composition and the paper should at least amount possible variable. If possible, only work with substrates with high energy potential and avoid transportation costs of organic material.
4. Marketing medium and long term products seeking to strengthen the subsistence economy of the indigenous communities involved, it is intended that once started and stabilized the production of biogas, every family will be able to exchange or sell gas and

fertilizer hours, as a method of interacting with each other.

CONCLUSIONS

Regarding the development of communities, it is recognized that there has been a significant transformation of rural indigenous, we have tried to create an environment with better links between urban and rural, the emergence of new product agricultural labor markets in the which handles increasingly population. The increased participation of women and youth in these markets is a significant fact that poses new challenges in terms of equity. The socio economy should be integrated as a systemic, thought in terms of local development regional-national, seeking to address rural-urban joint and regional imbalances generate permanently vulnerable populations migrate to the greater metropolitan area of the country. Also become relevant issues of gender equality, protection of natural resources and the participation of the municipal system, and introduces new guidelines for rural development, particularly in regard to the extension of principles, such as citizen participation in the processes of development, equity and sustainability. The main purpose of this work sustainably pursued, is to promote the welfare of vulnerable populations in more rural areas. Strengthening agricultural activities, diversification of the territories, creating diverse employment opportunities and ensuring food not only in quantity but also in quality, pursue reverse the decline and stagnation of indigenous, disadvantaged with changes in the economic growth model and the institutional system.
Encourage the use of biogas among rural communities, bring great benefits both environmentally (reducing GHG emissions and mitigating the ecological footprint), and in terms of human health (by reducing the puffs of smoke, product of burning wet wood). Within this context it is important articulation of universities in designing comprehensive strategies, looking triangular efforts among producers (beneficiaries), academia (government) and business (private), that go beyond the sum of shares sector performed in the territories, and achieve effective integration into the planning and development goals, defined from rural areas, is one of the major challenges faced in promoting the development of rural and indigenous.

REFERENCES

[1]Arauz, L.F. ,2008, Seguridad alimentaria y ambiente. Universidad de Costa Rica. San José, Costa Rica
[2]Canales, M. C., Rivas, L. A., Sorto, R. J., 2010, Estudio del proceso bioquímico de fermentación en digestores para la producción de biogas y fertilizante a partir de residuos orgánicos provenientes del campus de la Universidad de El Salvador. Trabajo de graduación para optar por el título de Ingeniero Químico. 185 p.
[3]Fodepal, C., 2004, Capacitando gestores para el desarrollo rural
[4]CENSO Nacional de Población, 2000, INEC.
[5]Castillos, A. ,2006, Biogas: construcción y funcionamiento de biodigestores plásticos de flujo continuo. PNUD. Uruguay
[6] Defensoría de los Habitantes, Informe Anual 2000-2001. Población Indígena.
[7]Domniguez, G., Salazar, G., Galindo, J., Xelhuantzi, J., Castneda, M., Sanchez, F., Hernandez, P., 2012, Implementación de biodigestores para pequeños y medianos productores porcícolas. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. Centro de Investigación Regional Pacífico Centro. México. 32 p.
[8]Earth Escuela de Agricultura de la Región Tropical Húmeda, 2007, El Biodigestor. Tecnología sencilla y amigable con el ambiente y al alcance de todos. Guácimo, Costa Rica.
[9]Filmtex, 2008, Manual para la generación de biogás y bio abono a partir del estiércol en la industria Agropecuaria. Capítulo 2. Descripción de los Sistemas de Aprovechamiento de la Cerdaza (SAP). Bogotá, Colombia.
[10]Flasco, 2009, Proyecto Sociedad Rural, Economía y Recursos Naturales.
[11] Olivares, C., Garrido, D., Martinez, G., Perez, S., 2009, Un análisis y propuesta de manejo de biodigestores. Universidad Nacional Autónoma de México. Centro de Investigaciones en Ecosistemas. 19 p.
[12] Oncayo, G., 2008, La Paz, Bolivia. Manual Práctico de diseño: Dimensionamiento, diseño y construcción de biodigestores y plantas de Biogás.
[13] Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO), 2011, Seguridad Alimentaria: conceptos y mediciones. Capítulo 2.
[14] Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO), 2011, Guía

práctica: una introducción a los conceptos básicos de la seguridad alimentaria.

[15] Rebewables Academy, 2013,. Programa de formación en Biogás. Universidad Earth. Costa Rica.

[16] Rivera, V., 2010, Estudio cinético de la digestión anaeróbica termofílica de pollinaza a escala piloto. Tesis para optar por el grado de Maestría en Ciencias en Bioprocesos. Instituto Politécnico Nacional. México. 104 p.

[17]Rojas, M., Castro, P., Ortega, S., Noyola, A., 2000, Digestión anaerobia mesofílica y termofílica de lodos biológicos de desecho y lodos de tratamiento primario avanzado. Puesta en marcha del proceso. Universidad Nacional Autónoma de México. Instituto de Ingeniería. 15 p.