LOW COST BIODIGESTERS

to produce biogas and natural fertilizer from organic waste

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Innovation for Development and South-South Cooperation

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Presentation

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Organic waste, when left untreated, is a source of infection and is difficult to dispose of. In agriculture and small-scale livestock farming, waste can be treated and transformed into natural fertilizer and, in some cases, fuel.

Biodigesters are natural systems that use organic agricultural waste, primarily manure, to produce biogas (fuel) and biol (natural fertilizer) by means of anaerobic digestion.

Biogas can be used as fuel for cooking, heating or lighting. In large farms, biogas can be used to power an electricity generator. The fertilizer, called biol, was initially considered a byproduct, but now is considered to be of equal or even greater importance than biogas because it provides families with a natural fertilizer that greatly improves crop yields.

There are several types of biodigesters but the focus here is on low-cost biodigesters, namely those that require no active heating systems and/or mobile mixing mechanisms. Thus a low-cost biodigester is an appropriate technology because of its low investment costs, easy management, simple maintenance and accessibility to both small and large-scale producers.

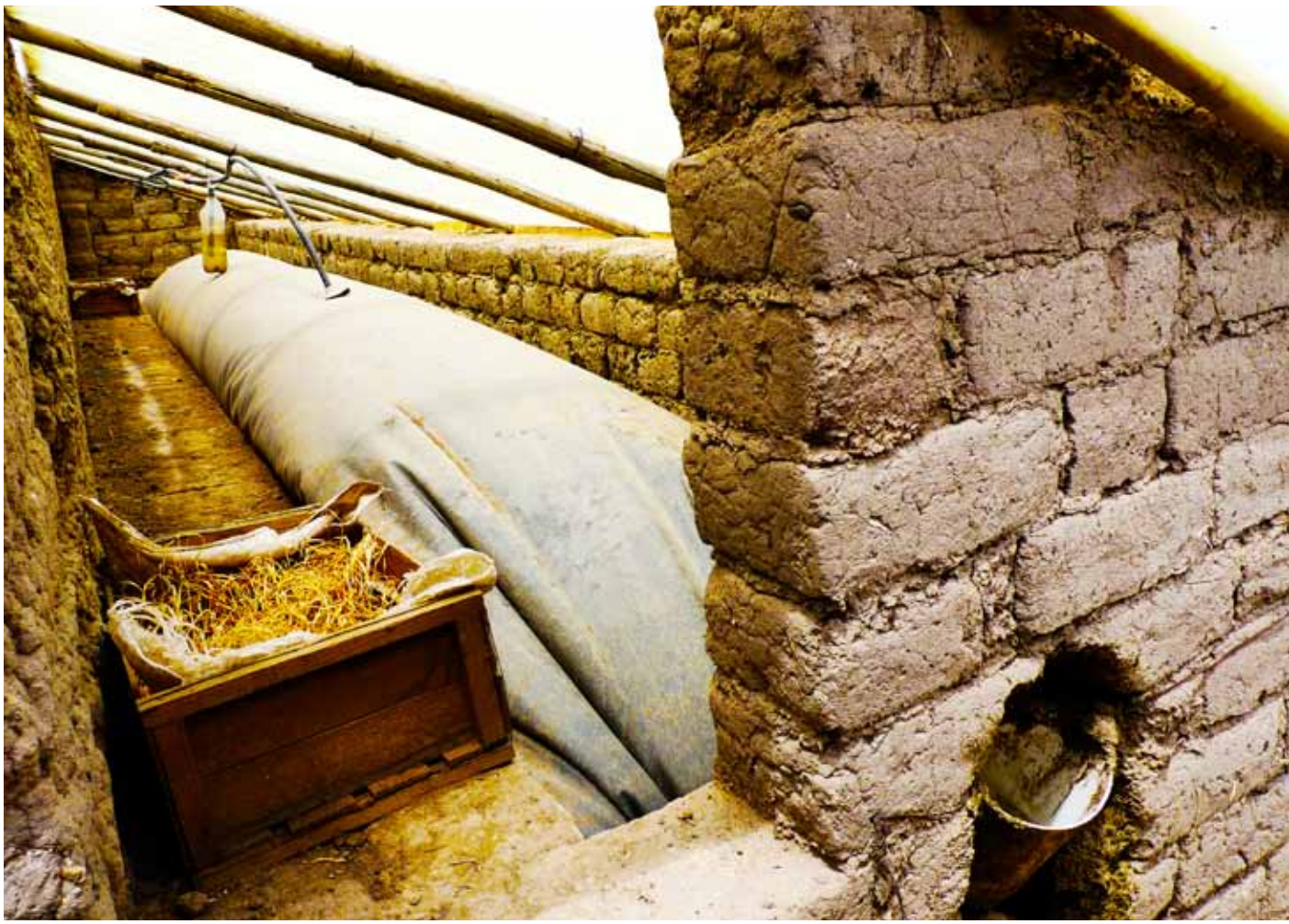
Not only can a family biodigester generate renewable and inexpensive energy but it also provides health benefits for the family, because biogas does not emit smoke when cooking. In cases where families need to collect firewood, a biodigester can greatly reduce the physical work involved, replaced by the loading of manure and water into the biodigester.

In agriculture, it provides a farmer with a natural and organic fertilizer which helps increase crop yields, whether vegetables, fruit, corn, potatoes, coffee, onions, quinoa, etc. Besides increasing productivity, biol gives ecological added value to products because they can be grown free of chemicals. What is more, farmers save money by not having to buy chemical fertilizers for their crops.

One of the most important ecological benefits is the reduction of deforestation due to the collection of firewood for cooking. Pollution is also reduced because a biodigester dispenses with the need for agrochemicals and provides good management of livestock waste, which in cases of high density, can contaminate aquifers. Having self-produced fertilizer increases yields and thus reduces the expansion of agricultural land. Finally, taking into account the greenhouse effect and climate change, emissions of methane gas, which otherwise would go into the atmosphere, are captured in the biodigester. Indeed, the negative impact of methane on climate change is 23 times greater than carbon dioxide.

Low-cost biodigesters have been implemented in developing countries since the 1980's. The first low cost tubular biodigester was the "red mud PVC" model designed in Taiwan by Pound in 1981. The next development was the continuous flow flexible tubular biodigester designed initially by Preston in Ethiopia, Botero in Colombia (1987) and Bui Xuan An in Vietnam (1994) for tropical climates. In 2003 Martí Herrero adapted Botero's design to the cold weather of the Bolivian highlands. Thus, low-cost biodigesters can currently be implemented in all eco-regions.

The technology is being promoted by different institutions in several countries such as Colombia, Ethiopia, Tanzania, Vietnam, Cambodia, China, Costa Rica, Bolivia, Peru, Ecuador, Argentina, Chile, and Mexico, among others.





What problem does it solve?

Biogas is generated naturally in swamps, where organic matter buried under sludge undergoes anaerobic digestion by bacteria. This gas is known as marsh gas. Biodigesters simulate the same natural process, in which bacteria convert manure into biogas and fertilizer, but in a controlled manner.

The first biodigesters were made in China in the mid-twentieth century. Biodigesters were made of brick and looked like giant cooking pots, buried and sealed. Costs were high, due to the amount of work required to build this type of biodigester, making this technology unaffordable for medium and small producers in rural areas with few resources.

In the 1970's industrial biodigesters were designed in developed countries, where large amounts of organic material produced massive amounts of biogas, usually used to generate electricity. However, the technology was complex and the high investment costs made biodigesters even less affordable for families with few resources and with few heads of cattle. In the late eighties family biodigestores were promoted as an appropriate technology for development, where investment costs are easily set off by a family in two or three years: this was the beginning of low-cost biodigesters.

The impact of the use of biodigesters

Agricultural activity is being promoted by governments as a strategy for poverty reduction. Uncontrolled agricultural development leads to agricultural land expansion, new human settlements, misuse of chemicals and pollution, poor management of organic waste (potentially contaminating aquifers and ecosystems), and deforestation for fuel, cooking and productive activities (coffee, cheese, yogurt, dried fruit, etc).

Wood consumption in households for cooking leads not only to deforestation but also causes breathing problems, cancer, eye irritation, and other diseases, mainly in women and children. Moreover, it is these two groups who have to bear the burden of finding and collecting firewood. For these reasons, agricultural development must be accompanied by awareness, capacity building, technologies and regulations that promote sustainable development.

If a family possesses two or three cows, or several pigs or a few dozen sheep, producing about 20 kilos of fresh manure per day, and has access to water for most of the year, a low-cost biodigester can bring the following benefits:



Energy

Biogas is mainly methane, much like the butane and propane gas sold in cylinders. It can be used for cooking, lighting and heating.

Production

The biol produced is a free natural fertilizer that improves crop yields by up to 30%. It can be poured directly onto the earth to stimulate seed growth or sprayed on leaves. In the case of dairy cows, the use of fertilizer on forage crops like alfalfa, increases production and quality, and this is reflected in higher milk production.

Family Health

Burning biogas for cooking does not produce smoke, thus there is no black soot that enters the lungs of women and children, or that covers kitchen walls. This will prevent respiratory diseases, eye irritation and other diseases.

Animal hygiene

By putting the manure in a biodigester, odours, foci of infection and flies will be eliminated. The decrease in fly population has a direct impact on cows, reducing mastitis.

Environment

If each family generates their own fuel for cooking there is no longer any need to cut down trees for firewood, thus reducing pressure on the environment.

Workload and cost

Daily or weekly time spent by families to collect firewood, or the money spent on the purchase of fuel in the rainy season, is replaced by the 20 minutes a day required for loading the biodigester with fresh manure and water.

Sustainable Technology

Since the technology used is simple, it is accessible to anyone, even those with no prior knowledge. It is enough to follow a few simple instructions to set up a biodigester and understand the technology, daily operation, maintenance and repair work. All materials are available locally, without the need to import anything from abroad.

Low investment

The cost of a family biodigester depends on size and climate. In cold climates, the cost in materials is around 250 U.S. dollars, while in tropical climates this drops to $ 150. Investment costs are paid back in two to three years by savings in fuel, time and improved production.

A low-cost digester is a simple and accessible technology that has a positive effect on several aspects of family life, income and production; though not a solution to all problems, it is a resource that brings many significant improvements.



Low-cost Biodigesters in practice

Biodigesters

A biodigester is made of plastic (tubular polyethylene, PVC or polyethylene geomembrane). Other materials include 6" pipes for inputting manure and water, and outputing biol. For biogas ½" or ¾" irrigation tubing can be used, together with common accessories such as taps, elbow joints, tees, etc. All these materials are usually available locally in any country.

Since biodigesters are made of flexible plastic, they must be semi-buried in an open trench in the ground. The size of a family biodigester will vary according to region but an area of at least 1m wide by 8m long will be required. In highlands, a biodigester must be located under a shelter to protect it from the cold, and built in an east-west direction.

The construction and installation of a biodigester takes one morning (if a trench has already been dug), and the installation of all the biogas pipes takes an afternoon.

Biogas

A family biodigester produces around 700 litres of gas per day, enough to cook for about three hours. This gas, called biogas, is produced naturally within the biodigester as the manure ferments in the water. Biogas is very similar to bottle gas and can be used for cooking, lighting gas lamps, heating piglet hoods, etc. Cooking with biogas produces none of the smoke associated with firewood stoves, which is harmful to health.

Biogas is stored in a reservoir made of plastic, which acts as a cylinder. These reservoirs have to be placed near the kitchen and in a protected area under a roof. The reservoirs keep the biogas under pressure and each reservoir has enough for about an hour of cooking. Without reservoirs, the biogas would only last about 20 to 30 minutes.

Biol

Every time a biodigester is loaded with fresh manure and water via the inlet pipe, 80 litres of biol come out at the other end (outlet pipe). Biol consists of a mix of manure and water that has fermented in the biodigester. Biol is a liquid fertilizer that can completely replace chemical fertilizer. After it is filtered, biol can be sprayed on crops as a foliar fertilizer, or can be placed directly on the soil or into irrigation canals. Producers report an increase in crop production from 30% to 50%. In addition, biol protects against insects and helps plants recover from damage by frost.



The basic elements of a biodigester

To use a biodigester it is necessary to have animals, water and appropriate information.

A sufficient number of animals is required to produce a bucket of fresh manure a day (20 litre bucket). It takes two to three cows or six to seven pigs to produce a daily bucketful (20 L) of fresh manure. Manures from different animal (sheep, pig, donkey, etc) can be mixed but half the bucket must necessarily contain cow dung. To facilitate the collection of dung the animals should sleep in a corral or barn near the house. If the animals are loose and not brought in at night, it will be more difficult to collect the manure.

It is also necessary to have access to water, from a river, well, or spring. The ideal is to have a reservoir of water which is full all year, because 60 litres are needed every day. If there is a lack of water for a few weeks, you can still have a biodigester, but it will be more difficult to make it work.

Loading the biodigester

A family biodigester needs to be loaded each day with fresh manure and water, depending on the type of animals on the farm.

Maintenance

Correct maintenance involves looking after the 3 parts of the biodigester

- Safety valve: made using a soda bottle, which fills with water. This bottle lets out excess gas. It is necessary to maintain the water level in the bottle.
- Sulphide Filter: To remove the smell (which is not manure) of biogas, it must be filtered by passing it through steel wool (normally used to wash pots). When the kitchen starts to smell, the steel wool must be changed.
- Water condenses in the biogas pipes, which from time to time must be drained. This water is easily removed through the taps or the joints of the biogas pipes.

Biodigester care

Family biodigesters aren't expensive but they are delicate. Since they are made of polyethylene, which is thicker than the plastic used for greenhouses, they can easily rip if not protected. Small holes up to 5 cm can be repaired, but not if they are larger. To avoid problems, such as an animal accidentally treading on the plastic tank, it is advisable to place a wall around or near the biodigester. Similar care should be taken of the reservoirs that store the biogas. They should be located in a covered, enclosed area intended only for the reservoirs.

Duration

A well-looked after biodigester can last from 5 to 6 years. After this time the plastic needs to be replaced, while other materials last longer. Some well looked after biodigesters have lasted 11 years without replacing the plastic. However if care is not taken to stop animals from entering, a biodigester can be broken within a few days after installation.

Results

Biodigesters offer a effective way of treating organic waste, also generating biogas and biol. Biodigesters can therefore help mitigate pollution through good waste management; they produce fuel and thus prevent deforestation; they produce natural fertilizer and avoid the use of chemicals, increasing productivity and reducing the expansion of farmland.

Quality of life in communities is improved, primarily in terms of the health of women and children, since meals can be cooked without smoke. The production and use of natural fertilizer gives added value to products, which can be marked as biological, and increases agricultural production by between 30 and 50%, thus boosting family income. Biol may also be sold by farmers as organic fertilizer, generating other income. To market biol and apply it on crops, it has to be stable and free of any pathogens. For this reason biodigesters can, where necessary, be integrated into constructed wetlands for the treatment of biol, thus mitigating pollution and offering an effective method of wastewater treatment and reuse.

Low-cost biodigesters are an effective technology for waste treatment. Alternatives include septic tanks or seepage pits. These solutions, however, require maintenance, which is not easy in rural areas, and are only used to clean up waste, missing the opportunity to generate other usable products. Composting, which is another valid approach because it generates a valuable product such as compost, requires increased workload and space. Furthermore, composting does not produce fuel. For all these considerations, where there is enough water for the mix, the right organic matter, and with proper training and understanding, the biodigester is a very interesting alternative offering multiple benefits.

How to set up low-cost biodigesters in other countries

Low-cost biodigester projects can be implemented for small and medium producers who raise cattle and generate organic waste requiring treatment. Biodigesters can be implemented also in industrial processes: dairy products, coffee, soft drinks, slaughter houses, and others. Interest in wastewater treatment has increased in recent years and there have already been numerous experiences in this field, making low-cost biodigesters a valid alternative to basic sanitation in social infrastructure.

Biodigester implementation projects can be designed at national, regional, sectoral or specific levels, but should always initiate from a demand by stakeholders. This means that potential users must be aware of the effectiveness of this alternative technology.

Therefore, to initiate a biodigester implementation project, the first step is to disseminate the technology as widely as possible, illustrating:

- The direct benefits, such as biogas and biol
- The indirect benefits, such as health, hygiene, cost savings, increased productivity and proper waste treatment.
- Daily biodigester management
- Biodigestion system maintenance
- Installation costs
- The different scenarios in which a biodigester can be used

The second stage, when there is a conscious demand from potential users, involves capacity building and methodology transfer.

The first level of capacity building and technology transfer to promote national, regional and industry projects is aimed at companies, institutions, governments and universities. Training includes:

- Types of low-cost biodigesters
- Technology and knowledge transfer
- Design methodologies adapted to local materials and temperature,
- Research methodologies and adaptation to new circumstances
- Project management
- Maintenance service
- Low-cost biodigester project sustainability

A second level of training, to implement specific executive projects, is aimed at producers and installers. In this case theoretical and practical training includes:

- Locally available materials for the construction of biodigesters
- Installation of various types of low-cost biodigesters
- Biogas applications (cooking, heating, lighting and motors)
- Biol applications (application type, crops, dosing and post-treatment)
- Capacity building for producers
- Low-cost biodigester operation and maintenance.

International interest

There are several projects for the dissemination of biodigesters. In Asia, Dutch Cooperation (SNV) has led major national programmes in Bangladesh, Cambodia, Nepal, Vietnam, Indonesia and other countries. China and India have their own national programmes. In Africa, Dutch Cooperation SNV and German Technical Cooperation (GIZ) have programmes, primarily in Tanzania, Kenya and Rwanda.

In Latin America and the Caribbean, where there are no national impact programmes, there are many different experiences operating, mainly in Mexico, Honduras, Nicaragua, Costa Rica, Cuba, Colombia, Ecuador, Peru, Bolivia and Brazil.

In particular, the Project EnDev-Bolivia Access to Energy of the GIZ, is being developed in Bolivia and it is at the present moment the largest project in Latin America on bio-digesters. The project designs and disseminates promotional material, didactic design of bio-digisters, social management of projects and trains the Centre of Biodigesters Biogas and Biól research (CIB3). More than 400 bio-digesters have been installed in the last years in the framework of this Project.

The **Network of Biodigesters for Latin America and the Caribbean** (REDBioLAC) brings together various institutions involved in research, development, dissemination and implementation of low cost biodigesters in 9 Latin American countries. Its members include biodigester manufacturers, NGOs, research centres and universities that share common goals, such as to:

- Exchange information and experiences among RedBioLAC members
- Identify and overcome technical, environmental, social and economic barriers
- Propose projects, mechanisms and ideas to spread biodigester technology in other countries
- Build partnerships that facilitate the adoption of biodigester technology.
- Systemize research and dissemination among partners (health, finance, politics, education, industry and marketing).
- Promote the participation of other organizations, institutions and researchers working in the field of biodigesters.
- Promote actions that can influence and impact policies related to biodigesters.

REDBIOLAC consists of:

- CIMNE (Spain) www.cimne.com
- EARTH University (Costa Rica)
- UPC (Spain)
- IRRI (Mexico)
- ISF (Spain)
- ITDG (Peru)
- Asofenix (Nicaragua)
- CIDELSA (Peru)
- UMSA (Bolivia)
- UNSAAC (Peru)
- GIZ (Bolivia)
- CARE (Ecuador)
- Green Empowerment (United States)
- UNI atlántico (Colombia)

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To learn more

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- Libro publicado online por la FAO, contiene toda la información biológica, técnica sobre la digestión anaerobia y los biodigestores en general (Inglés) http://www.fao.org/docrep/t0541e/T0541E00.htm

Websites

- A selection of the most important articles on biodigesters can be found at: http://www.mekarn.org/publ.htm
- Livestock Research for Rural Development. This on-line magazine has a lot of information about biodigesters, including technical and social studies, reviews, etc. http://www.lrrd.org/
- REDBIOLAC is a network of universities, businesses and NGOs in Latin America concerned with biodigesters: http://www.redbiolac.org
- Biodigester research, development and projects in Bolivia can be found at http://tallerbiogas.blogspot.com
- Paul Harris, a professor at Adelaide University in Australia, has posted a great deal of information about biogas on his website (in English and Castilian), both for beginners and experts: http://www.adelaide.edu.au/biogas/

More information

With its scientific, technical and social experience REDBIOLAC can provide assistance for low cost biodigester research, development, dissemination and implementation projects. The following experts can provide more information on low-cost biodigesters.

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The IDEASS Programme - Innovation for Development and South-South Cooperation - is part of the international cooperation Initiative ART. IDEASS grew out of the major world summits in the 1990s and the Millennium General Assembly and it gives priority to cooperation between protagonists in the South, with the support of the industrialised countries.

The aim of IDEASS is to strengthen the effectiveness of local development processes through the increased use of innovations for human development. By means of south-south cooperation projects, it acts as a catalyst for the spread of social, economic and technological innovations that favour economic and social development at the local level. The innovations promoted may be products, technologies, or social, economic or cultural practices. For more information about the IDEASS Programme, please consult the website: www.ideassonline.org.

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ART - Support for territorial and thematic networks of co-operation for human development - is an international co-operation initiative that brings together programmes and activities of several United Nations Agencies. ART promotes a new type of multilateralism in which the United Nations system works with governments to promote the active participation of local communities and social actors from the South and the North. ART shares the objectives of the Millennium Development Goals.

In the interested countries, ART promotes and supports national co-operation framework programmes for Governance and Local Development - ART GOLD. These Programs create an organized institutional context that allows the various national and international actors to contribute to a country's human development in co-ordinated and complementary ways. Participants include donor countries, United Nations agencies, regional governments, city and local governments, associations, universities, private sector organizations and non-governmental organizations.

It is in the framework of ART GOLD Programmes where IDEASS innovations are promoted and where cooperation projects are implemented for their transfer, whenever required by local actors.