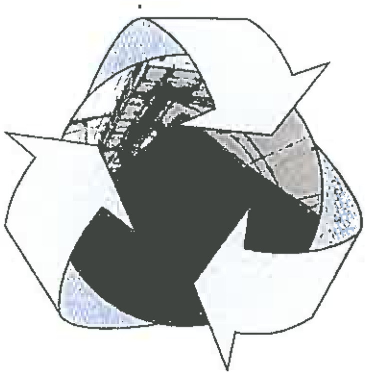


Wet anaerobic digestion is a highly effective and efficient form of treatment for biowaste, here we go in-depth to look at exactly how the BTA wet anaerobic digestion process works.

by **Robyn Haines**

The BTA Pulper

BTA benefits biowaste

Wet anaerobic digestion

As we move further down along the road to completely renewable energy sources, anaerobic digestion (AD) is set to become increasingly important. Used to break down organic materials in waste, the natural biological conversion – without oxygen – of organic materials to methane and carbon dioxide (biogas) is an energy positive process, i.e. it produces more energy than it requires.

The process takes place in sealed reactors which minimizes environmental impact and the biogas produced can be converted to electrical energy using a combined heat and power system (CHP). The stabilized digestate which contains soil improving nutrients, if pasteurized to meet the appropriate Animal By-products Regulation (ABPR), can be applied to land. This process has been successfully used for many years in the treatment of sewage sludges.

For the treatment of organic materials such as biowaste (a combination of source segregated food and green wastes) and similar commercial food wastes by wet anaerobic digestion, it is necessary to pre-treat these materials to form a homogeneous slurry/pulp and remove inert and contaminant materials. Wet digestion is defined by the material to be digested being 'pumpable' – typically with 6%–12% dry solids content.

BTA process® wet pre-treatment

One method that has been successfully used to provide pre-treatment of biowastes in over 20 treatment plants is the BTA process®. Developed in the 1980s by BTA Biotechnische Abfallverwertung GmbH & Co. KG, now BTA International GmbH, and licensed in the UK and Ireland by Enpure Limited, the BTA process® uses a hydro-mechanical pulping technology for the preparation of solid organic wastes and removal of contaminants/inerts prior to wet anaerobic digestion. The BTA pulper can accept biowastes or the organic fraction of residual waste up to 200mm in size. The BTA pulper, which was developed from equipment used in the paper manufacturing industry, uses hydro-dynamic forces to separate biodegradable materials into a thick pulp. It also separates and removes inert and contaminant materials prior to digestion. The grit removal system removes and separates small stones and broken glass down to below 2mm.

Pulping is performed to facilitate three objectives:

- disintegration of biodegradable waste to enhance the subsequent digestion process
- removal of non-biodegradable contaminants as a 'heavy' fraction (stones, large bones, batteries and metallic objects)
- removal of non-biodegradable contaminants as a 'light' fraction (textiles, wood, plastic film, string etc.).

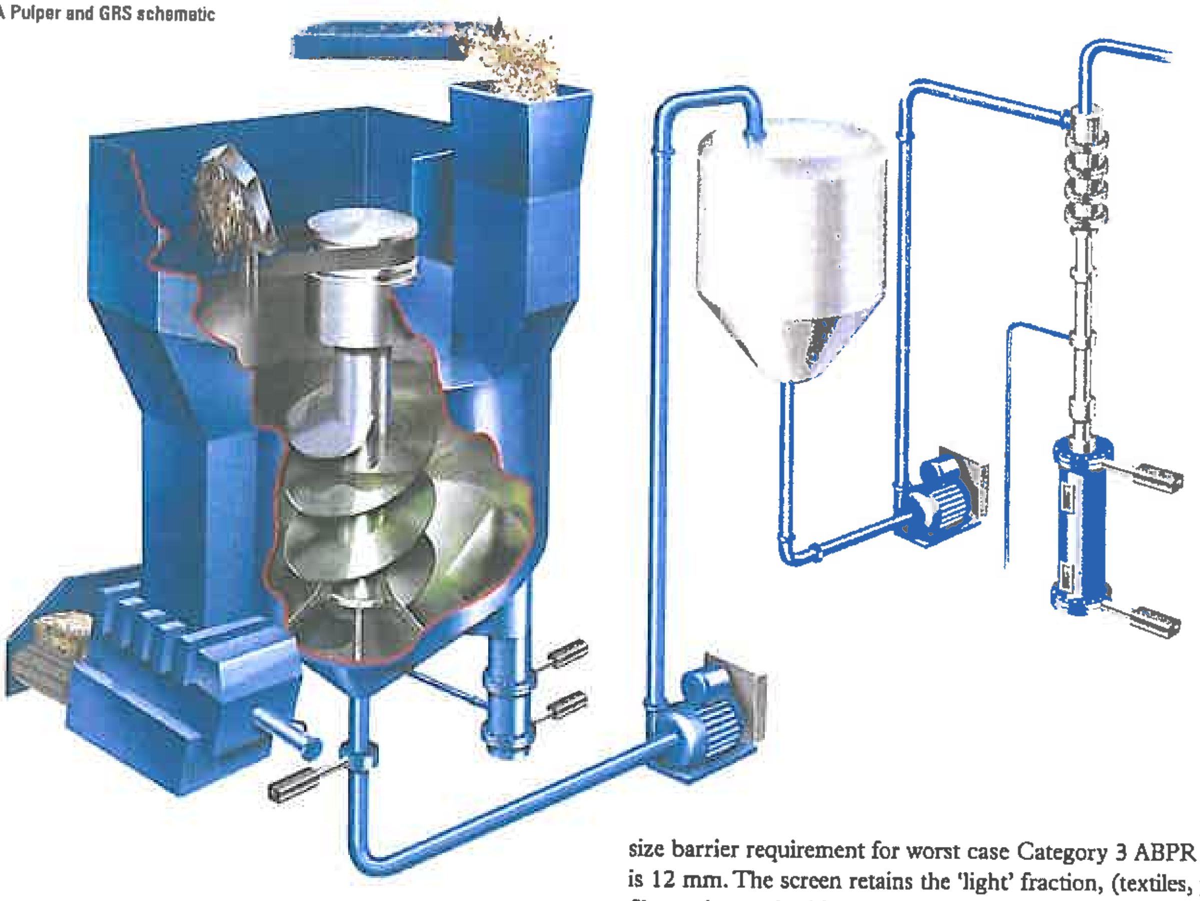
Waste and process water are fed to the pulper vessel, already partly filled with process water remaining from the previous batch, and material is fed to the pulper by feed conveyors. When sufficient material has been loaded into the pulper the conveyor will stop. Loading is carried out automatically. During the feed stage the pulper drive operates at low speed.

The pulper impeller is designed to impart high hydraulic shear to the vessel contents without causing mechanical damage to biologically stable materials, such as plastics, textiles, metal and glass. The pulper power and suspension concentration is closely controlled throughout the cycle in order to minimize energy usage and disintegration of inert materials and maximize the breakdown of the biologically inert materials. At the same time it optimizes the release of digestible substrate.

At the start of the pulping cycle, stones, glass, large bones, batteries and metallic objects fall to the vessel floor and, under the influence of centripetal force, drop into a peripheral heavy fraction pocket built into the vessel. The impeller is operated at low speed during this part of the cycle to minimize wear and mechanical damage to non-biodegradable materials.

The impeller then increases speed to pulp the pulpable materials and continues until the correct concentration is reached. On completion of pulping the vessel contents are pumped into the grit removal system surge tank. The pulp, at approximately 8%–9% dry solids content, leaves the pulper via a perforated plate screen with approximately 10mm openings. This provides the

BTA Pulper and GRS schematic



size barrier requirement for worst case Category 3 ABPR which is 12 mm. The screen retains the 'light' fraction, (textiles, plastic film, string etc.) which is not damaged by the impeller.

Separation is facilitated by a set of screen wiper blades that rotate with the pulper impeller, which continues to run at low speed during pulp discharge. Once the pulp discharge cycle is complete, process water is pumped to the vessel and the light fraction is re-suspended.

The pulper drive is stopped and the raking cycle commences. A hydraulically-driven mechanical rake arm dips repeatedly into the vessel and transfers the light fraction into an adjacent chute where it descends into a hydraulic press. The light fraction is compressed to reduce the water content before being discharged via a collection conveyor arrangement to a storage bay or skip.

At the base of the heavy fraction pocket, a slide valve opens to allow the heavy material to drop into a small chamber where it is washed with process water before being discharged through a second slide valve into a collection receptacle.

Grit removal will be carried out in a batch process. Screened pulp from the pulper is re-circulated from the Grit Removal System (GRS) surge tanks, by means of a pump, through a dedicated hydro-cyclone and back to the surge tank. The pulp can be re-circulated to the feed tank and back through the hydro-cyclone to improve the removal efficiency. Grit falls to the bottom of the hydro-cyclone into a hydraulic classifier or elutriator, where process water flows counter-current to the falling grit. At the base of the classifier a slide valve opens intermittently to allow the grit to drop into a small chamber. The rate of accumulation is monitored and the grit removal cycle is terminated when the rate falls below a preset value. Grit held in the chamber is washed with process water before being discharged through a second slide valve onto a collection receptacle or grit classifier.

CASE STUDY

Toronto, Canada

Owner:	City of Toronto
Operator:	CCI – TBN
Capacity:	25,000 tonnes per year designed 30,000 tonnes per year actual
Start-up:	2002
Materials processed:	Source separated organics Commercial food wastes
Process:	BTA Process® with one-stage wet digestion
Plant description:	Waste reception BTA Process® pre-treatment Anaerobic digestion Digestate treatment
Special features:	Biowaste contains up to 15% plastics.

In the BTA waste pulper a homogenous, pumpable organic suspension is produced which can be easily handled and digested. Unwanted contaminants (such as plastics, textiles, stones, metals etc.) are efficiently separated and removed by means of a trap (heavy fraction) at the pulper bottom and by a rake (light fraction). The batch cycle of the pulper is specially adapted to the high content of plastic (up to 15%) in the biowaste.

To remove the still remaining fine inerts from the pulp (sand, eggshells, etc.) a BTA grit removal system is installed to prevent wearing of downstream plant components, sedimentation in the tanks and clogging of pipes.

The organic pulp, which just contains the dissolved and de-fibred organic components, is passed into a 3500m³ digester for methanization. The digester is easily mixed by compressed biogas through injection nozzles without any moving parts in the digestion tank and with minimum maintenance requirements.

The digestate is fed through screw presses for dewatering. The solid phase is aerobically treated in an external composting plant. Due to its low content of impurities the final high quality compost is sold in gardening stores or used for soil remediation.

On completion of the grit removal cycle the recirculation is stopped and the de-gritted pulp is transferred to the digester feed balance tank.

Benefits of BTA

The BTA Process® removes contaminates and contrary materials right at the start of the treatment, preventing cross-contamination during the biological process and improving the quality of the digestate. As a wet process the waste is pulped with water, treated and dewatered and the recovered water is recycled within the system. As the waste is both pre-treated and washed within the process, the end product is of high quality. Each of the heavy, light and grit fractions will contain less than 5% digestible organics, ensuring the maximum amount of digestible material is transferred to the anaerobic digester, hence ensuring maximum biogas production.

The BTA Process® wet pre-treatment also has the advantage that it can be retrofit to an existing anaerobic digestion plant – whether this be to accommodate changes in feed waste specification (increased contamination), to replace a failed pre-treatment system, or allow biowaste to be co-digested at an existing wastewater treatment facility, for example.

Pasteurization

Pasteurization, which involves holding the organic pulp at a specified temperature for a certain time period, ensures the destruction of pathogens such as salmonella and E. coli. Pasteurization is required to allow the anaerobic digestion treatment process output (digestate) to be applied to agricultural land by meeting the relevant ABP Regulations for the nature of the biowaste being treated.

The pasteurization unit comprises of three stirred and insulated tanks that are operated on a batch basis. Heating of the organic pulp is carried out externally to the tanks.

The organic pulp from the digester feed balance tank is pumped into the pasteurization unit through the inlet heat exchangers. The first inlet heat exchanger raises the temperature of the feed, using heat recovered from cooling the pasteurized feed before it is fed to the digester. The second inlet heat exchanger raises the temperature of the feed to the pasteurization unit to the required temperature using waste heat from the CHP system.

First, a tank is filled over a period of an hour. Next, the material is held in the tank for 60 minutes with the stirrer operating to eliminate cold spots – for example near the walls – while the temperature is monitored. Finally, once the required temperature has been held for the required time and validated by the control system, the tank contents are fed forward to the next process. If the required time and temperature are not validated for any reason, the pasteurization tank contents are returned to the feed holding tank and are re-processed. The pasteurised material passes through a cooling heat exchanger which reduces the temperature to that required by the anaerobic digestion process and recovers heat which is re-circulated to the first inlet heat exchanger. The cooled material is then fed to the anaerobic digester.

Anaerobic digestion

The anaerobic digester is a completely mixed stirred reactor where the biodegradable organic components of the organic

CASE STUDY

Barcelona, Spain

Client:	UTE Ecoparc
Capacity and materials processed:	250,000 tons per year municipal solid waste 50,000 tonnes per year biowaste 50,000 tonnes per year to BTA Process® pre-treatment system
Start-up:	2001 first start-up 2008 start-up after refurbishment by BTA/BIOTEC
Original plant design:	Mechanical pre-treatment with drum screen (>120mm) and suspension tank Wet anaerobic digestion
Operation problems:	Insufficient elimination of contaminants resulting problems in processing and digestion
BTA refurbishment:	BTA Process® pre-treatment system BTA® gas mixing system for one digester BTA® process control system.

The Barcelona plant is a good example of the importance of pre-treatment for reliable removal of waste contaminants and ensuring maximum transfer or digestible organics to the anaerobic digesters for biogas production. Efficient separation of these fractions increases reliability and availability, resulting in maximum biogas yield and reducing the costs for landfill or combustion. Problems of the original Barcelona design included:

- insufficient elimination of contaminants, clogged pipes
- floating layers and massive sediments in digesters
- inefficient mixing of digesters
- high loss of organics in the separation, resulting in a too low biogas yield
- unacceptable quality of the separated residues
- too high fraction to be landfilled.

The operator (UTE Ecoparc) decided to remove the existing pre-treatment and also to refurbish the anaerobic digestion plant. BTA, via its licensee BIOTEC, was assigned to:

- Integrate a complete new BTA Process® pre-treatment system consisting of three 32m³ BTA pulpers complete with corresponding light fraction presses and four BTA grit removal systems
- To refurbish one of the existing 6000m³ digesters and equip it with the BTA gas mixing system
- Replace the existing process control system with one designed by BTA.

CASE STUDY

Kirchstockach, Germany

Owner:	County of Munich
Operator:	M. Ganser GmbH & Co. Entsorgungsbetriebe KG
Capacity:	20,000 tonnes per year (designed) 30,000 tonnes per year (in 2006)
Start up:	1997
Materials processed:	Biowaste with a high content of garden waste (>30%)
Process:	BTA Process® with two-stage digestion
Plant description:	Waste reception and pre-treatment; Hydrolysis and methanization of organic components (two-stage digestion process); Digestate treatment; Biogas utilization

The delivered waste is registered at a vehicle weighbridge and deposited onto a flat bunker within the delivery hall. Using a front loader, it is fed into a screw mill and roughly chopped. A conveyor belt transports the waste via a magnetic separator to two BTA waste pulpers. In the pulpers the waste is mixed with water to produce a thick, pumpable suspension (pulp). Contaminants are separated and removed, either as heavy fraction (e.g. glass, stones, metals) or as light fraction (e.g. plastics, textiles). Fine contaminants like sand, little stones, and glass splinters are separated by the subsequent BTA grit removal system, before the pulp is stored in a suspension tank.

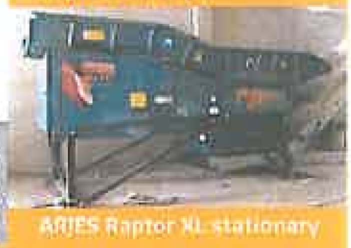
The plant is based on a multi-stage digestion. Digestion is divided into two steps: hydrolysis and methanization in a fixed film reactor. Before being fed into the biological stage of the process, the pulp is separated into a liquid and a solid phase. The liquid phase with a high amount of already dissolved organic material is pumped directly into the methane reactor. The dewatered solids are mixed with process water and fed into the hydrolysis reactor to dissolve the remaining organic solids. After 2–4 days, the suspension is dewatered and the resulting liquid also fed into the methane reactor.

The resulting solid hydrolysis residue, contaminant free and low in salt, is further stabilized in the plant's existing composting facility together with garden waste. The digestate forms a key part of a range of high quality composts produced for sale. Most of the water is reused as process water in the pulpers. The effluent water is transferred into a wastewater treatment system consisting of a flotation and nitrification/de-nitrification steps. The effluent is discharged into the public sewage system.

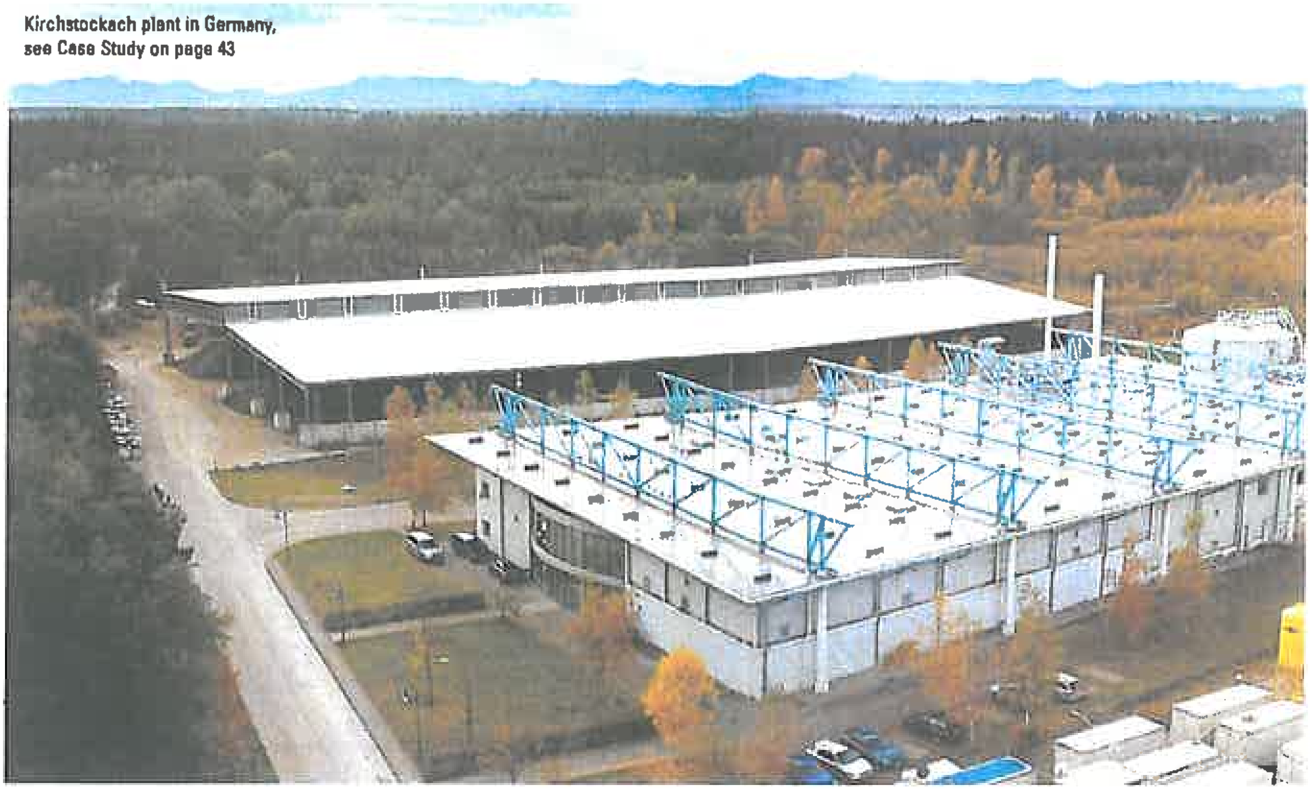
To utilize the biogas, it is fed into two CHPs. The energy produced then is available to meet the consumption of the plant and surplus energy is fed into the national grid.

material are converted largely to methane gas and carbon dioxide by hydrolytic, acidogenic and methanogenic bacteria. The anaerobic digestion process can be either mezophilic or thermophilic; i.e. operating at a temperature of approximately 35°C or 55°C, respectively. The digestion process can also be carried out as a single-stage or multi-stage process. The single-stage hydrolysis and methanization occurs in a single digestion tank whereas for a multi-stage process, hydrolysis occurs in the first tank and methanization in a separate reactor.

The reactor is insulated to minimize heat loss and continuously



Kirchstockach plant in Germany, see Case Study on page 43



CASE STUDY

Leoben, Austria

Client:	LE Gas GmbH
Materials processed:	Biowaste, restaurant wastes, commercial food wastes, diary sludges
Capacity:	18,000 tonnes per year
Start-up:	January 2009
Process:	Waste reception Shredding of biowaste and grass cuttings BTA process® pre-treatment

The organic pulp produced by the BTA wet pre-treatment process is co-digested with sewage sludge in the digesters of the Leoben wastewater treatment plant.

mixed using biogas recirculation. The biogas is re-circulated using injection nozzles that can be cleaned externally and removed individually, if required, without entry to the digester tank. The reactor is fitted with pressure and vacuum relief systems, temperature monitoring and control and a foam suppression system. The processing time in the anaerobic digester is typically in the range of 16 to 20 days.

The digested material, or digestate, is fed to a centrifuge, which separates the digestate into a high solids cake for further processing, and a liquid centrate which is re-circulated for waste pulping. The digestate cake can then be aerobically stabilized to produce a nutrient-rich high quality soil improver.

Biogas

Biogas produced in the anaerobic digester is fed via flame traps and condensate drains to a low pressure gas holder for balancing storage prior to use. The main use for the biogas is to generate electricity and heat in a combined heat and power (CHP) system. The electricity produced can be used to operate the plant and the surplus exported to the grid. The waste heat is used to heat the pasteurisation and digestion process, surplus heat can be used for heating buildings, etc. A safety waste gas destructor is fitted to all plants. This is used to safely combust any surplus biogas, for example if the CHP system is being serviced.

In summary

The BTA Process® provides effective treatment of organic wastes by anaerobic digestion, producing a high quality digestate which can be used for soil improvement and renewable electrical power from the biogas generated by the digestion process. This process has been successfully used in over 20 facilities for the treatment of household source-segregated biowaste, commercial organic wastes from food manufactures, supermarkets and catering facilities. With its robust technology and proven track record it has also been used to replace the pre-treatment stage at a number of competitor-built facilities which have failed to perform successfully. With the ever-growing need to protect the environment and meet stricter legislative requirements to divert organic materials from landfill, the BTA process® is ready to perform.

Robyn Haines is business development manager,
Waste Sector, Enpure Limited
e-mail: rchaines@enpure.co.uk

Enpure/Robyn Haines will be available on Stand F18 at the Futuresource exhibition at ExCel, London, 9–11 June.

■ This article is on-line. **Please visit www.waste-management-world.com**