Module 04 :
Planning operations

cewas

IWMI
International
Water Management
Institute

Week 02:
Understand the
treatment process

Resource Recovery and Reuse
(RRR) Entrepreneurship

Week 2 module 4: Understand the treatment system

"Welcome to week 2 of module 4: Understand the treatment system.

This week we are going to look at the **treatment system** that changes the characteristics and composition of waste streams, converting them into valuable RRR products.

Last week you learnt that production involves the transformation process of an input, such as organic solid waste, into an output, like for instance, compost.

You also learnt that the transformation process involves transportation, treatment and storage, and that you need to consider all these different elements when planning your process.

At the end of last week, you have prepared your process flow diagram, indicating the individual process steps in chronological order.

Now, it's time to look at the treatment system for converting the waste input into RRR products with an added value.

Technologies are usually arranged in a treatment system with 3 distinctive steps: Pre-treatment, Principal treatment and Value addition.

The aim of pre-treatment is to prepare the waste for the principal treatment. This could be by:

- Removing other waste fractions. For instance, the screening step that removes trash from wastewater, or the segregation and sorting carried out to separate the inorganic fraction from the organic solid waste.
- Adjusting the size of particles, like the shredding of agro-waste before it reaches a biogas plant.
- Mixing different types of raw material, for instance organic waste with faecal sludge in co-composting.

After the pre-treatment, the principal treatment transforms the waste into a product, by:

- Changing its composition.
- Changing its state, for instance from solid to gas through bio-gas production.

- Changing the volume and
- Reducing the pathogen content.

Finally, the aim of the value addition or polishing is to increase the value of the product. Examples of value addition are:

- Removing impurities, such as water vapour, carbon dioxide and hydrogen sulphide in the biogas.
- Adding supplements, which is the case with the production of fortified compost through the addition of nitrogen, phosphorous and/or potassium.
- Changing the form of the product, like pelletizing.
- and Packaging.

Usually, all these steps create secondary products that also need to be properly handled, either by further treatment or appropriate disposal, to avoid negative impacts on the environment.

For instance, any separation/segregation of solid waste produces an inorganic refuse that needs to be transferred to a recycling plant or any other solid waste management facility operating in your local area.

For each of the treatment steps, the treatment can be classified as:

- Biological treatment: which is the controlled conversion or degradation of waste by living organisms, for instance to produce compost.
- Physical treatment: which is the removal or particles by methods such as screening, settling and filtering, or the change of phase or size of a component.
- Chemical treatment: which is the use of chemicals that cause reactions, such as pH neutralization, oxidation or reduction and precipitation.

Because of the key role of biological treatment in RRR treatment processes, it is key to understand the differences between biological treatment under aerobic and anaerobic conditions – so with and without the supply of gaseous oxygen.

Keep in mind that under both aerobic and anaerobic conditions, the growing and reproducing microorganisms or bacteria, which degrade the organic matter, require a source of oxygen to survive. Exactly like we do!

Under aerobic conditions, the microorganisms access free, gaseous oxygen directly from the surrounding atmosphere.

The end products are primarily carbon dioxide, water, new cells and energy.

This is the case with composting, when the input material is organic waste and the resulting product is compost.

Under anaerobic conditions, there is an absence of gaseous oxygen. Therefore, anaerobic microorganisms obtain oxygen from other sources, like the organic matter itself.

The intermediate products are primarily alcohols, aldehydes, and organic acids plus carbon dioxide. In the presence of methanogens, the intermediates are converted to methane, carbon dioxide with trace levels of hydrogen sulphide.

This is what is called biogas, a key source of energy.

It is important to understand this difference, as technologies used for biological treatments usually offer aerobic or anaerobic conditions for bacteria to decompose the organic matter.

Keep in mind as well, that physical and chemical processes are combined in specific technologies for the conversion of waste into valuable RRR products. These are called:

Physico-chemical treatments, which refer to conversion processes that are induced by chemical reactions or apply physical mechanical forces. This is what is used to produce non-carbonized pellets.

And thermo-chemical treatments, in which heat is applied to induce chemical reactions as a mean of extracting and creating energy carriers as products. These include processes such as combustion, pyrolysis and gasification. This is what is used to produce carbonized pellets.

So, before I introduce the specific technologies, let’s recap what you have just learnt.

Now you know that in order to convert a waste stream into a RRR product you need a treatment system composed of three steps: Pre-treatment + Principal treatment + value addition.

You also know that for each of these steps you can have biological, physical or chemical treatments.

Biological treatments can be aerobic or anaerobic. Anaerobic degradation produces biogas.

Physical and chemical treatments can be combined in a technology offering physico-chemical and thermo-chemical treatments, the latter being relevant for the production of energy.

Now, let's take a look again at the overview of the waste-to-resources options.

We can categorize the different technologies available according to the potential for the recovery and reuse of:

- energy
- nutrients and organic matter
- and wastewater

This way we obtain clusters of technologies intended to recover nutrients and organic matter such as composting, co-composting and vermicomposting

Technologies to recover energy from organic waste, such as anaerobic digestion, densification, pyrolysis and gasification.

And technologies to recover water from wastewater for agriculture, forestry and aquaculture.

Next week we will take a closer look at these different technologies.

So, in week 3.A you will learn about technologies for nutrient and organic matter recovery such as composting and co-composting.

In week 3.B, you will get to know about technologies for energy recovery from organic waste like incineration, biogas production and charcoal pellets.

And in week 3.C, you will learn about wastewater treatment technologies for irrigation and aquaculture.

You should definitely watch the video in which I explain technologies associated to your business model, but you are welcome to watch all of them!

See you next week!"

List of Reference:

Graph sources:

- Unless otherwise noted, all graphics and case studies from OTOO, M. (Editor), DRECHSEL, P. (Editor) (2018): *Resource Recovery from Waste. Business Models for Energy, Nutrient and Water Reuse in Low- and Middle-Income Countries.* International Water Management Institute (IWMI). Routledge

Image sources:

- Unless otherwise noted, all images from IWMI flickr library www.flickr.com/photos/iwmi/
- Page 13: Photo 2: Flickr: Kome Waste Management Facility by Ken Doerr
- Page 18:
  Image 1: Flickr: 2019-01-06 Bio Bin by Allan Henderson: LINK
  Image 2: Flickr: Compost by U.S. Department of Agriculture: LINK

*Information and data were compiled to our best knowledge, but mistakes remain possible. In such a case we apologize and kindly ask for feedback to correct them.