Biowaste4SP

SEVENTH FRAMEWORK PROGRAMME

Catalogue of Biowastes & Bioresidues in Africa

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IVL Swedish Environmental Research Institute

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The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement 312111. The contents of this report are the sole responsibility of the Biowaste4SP project and can in no way be taken to reflect the views of the European Union.

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Summary

The Biowaste4SP project aims at investigating and identifying solutions that are simple and quick in order to stimulate growing bioeconomy sectors in the region with a special focus on Egypt, Ghana, Kenya, Morocco and South Africa. One of the fundamental challenges is to have information on the available bio-resources that would form the basis to build and produce value added products from. Thus, an important task of the biowaste4SP project is to identify biowaste as potential biomass feedstock for further utilisation and conversion to e.g. bioethanol, lactic acid, amino acid, protein and fertilizer.

The framework of the project builds on a broad distinction between on two categories of biowaste i.e. on the one hand sugar rich biomass (mainly starchy and simple sugar rich materials) and on the other hand nutrient rich biomass (mainly lignocellulosics and manure). Due to the very different approach in process technologies for the mentioned products, starchy materials will be considered as feedstocks for a (white biotech) sugar platform for bioethanol, lactic acid, protein and amino acids, whereas the lignocellulosic materials will be used for the more low technology processes for biogas and fertilizer production. Leftover sugars from all these processes can be used in supporting production of biogas and upgrading organic fertilizers.

The hereby presented catalogue provides a systematic information on various typical biowastes and bio-residues found in large quantities in the partner countries. There are a total of 49 biomass samples that have been studied and are included in this catalogue. 29 of these are what could be labelled sugar rich and 20 nutrient rich. Many of the biomass samples studied will be potential feedstock in processes requiring both nutrient rich and sugar rich feedstocks.

There are good reasons to rank biomass that will not fluctuate too much depending on season as good sources for biomass to more advanced processes. One approach to ensure this is to source the biomass from industries that would typically operate more independent of seasons than for example small scale industries. Examples from the studied biomass in this catalogue are:

- Rice, maize and other bran (for example rice bran from Egypt, Ghana, and maize and wheat bran from South Africa) are nutrient rich feedstock also containing some sugars,
- Biomass from food processing and packaging industries (for example cabbage Kenya, orange and tomato processing Morocco and vegetable and fruit waste South Africa) both sugar rich and nutrient rich feedstock.
- Sugarcane bagasse is a potential biowaste (for example Kenya and Egypt) but require 2nd generation technology to access the sugars. Normal practice today is to use the bagasse for process- or other energy purpose.

- From plantations rejected bananas and banana residues constitute a potential sugar rich and nutrient rich bio resource (for example Ghana and Morocco)

A common denominator here is that all these sources can be accessed on a specific site (the industry, collection point etcetera) and we classify this as point sources of a biowaste/bioresidue. Another aspect of most of the above mentioned biowastes/bioresidues are that the existing volumes are possible to assess beforehand.

Other potential feedstock for producing added value products comes from animal husbandry. Here mainly manure (animal faeces and urine) has been studied and provide clear results that these biomass are nutrient rich. The type of management of the manures will affect the potential of the feedstock. Much of the farming residues are rich in sugars but lignocellulosic making these challenging to transform with today's technology.

The catalogue includes biowastes with no value or use at present as well as bioresidues with an economic value to the operators of the process. With the latter we want to highlight that also biomass with an existing value are considered as potential feedstock in the Biowaste4SP framework. There are often ways of improving the processes and find new options for final added value products. This is also seen in many of the cases studied. The selected sources and biomass types would also be found in other African countries. Apart from the chemical characteristics that provide information on sugar and nutrient contents the catalogue also provides insights in the processes from which the biowastes and bioresidues stem. The available quantitates and variations in accessibility over the seasons will depend on the origin of the biomass, type of process as well as the scale of the operation.

The catalogue represents Deliverable 1.3 and Deliverable 2.3 in the Biowaste4SP project funded under the European Community's Seventh Framework Programme (FP7/2007-2013).

Preamble

This catalogue is a result of the collaborative work by five research teams from Egypt, Ghana, Kenya, Morocco and South Africa and a coordinating team of researchers from Sweden and Denmark. The catalogue is providing basic data on chemical analyses, origin and physical conditions of the identified biomasses as potential feedstocks for added-value products such as ethanol, lactic acid, amino acid, protein, biogas and ferlilizer. There are still more analysis to be made and we also foresee that the results presented herein will be basis for calculations of yields of the mentioned products or updated with experimental results from real processes carried out within the project. This means that the catalogue will be updated with more information during the final year of the Biowaste4SP project

The catalogue is a deliverable from two work packages (WP) in the Biowaste4SP project namely *WP1: Identification and characterization of biowaste from food industry and agricultural sources* and *WP2: Identification and characterization of biowaste from agriculture (lignocellulosic) sources and manure.* The division of biomass between these two WPs became somewhat difficult as much biomass would qualify as both sugar rich (the focus of WP1, which include easily hydrolysed, mainly starchy rich biowaste) as well as nutrient rich (the focus of WP2, which include ridged (difficult to hydrolyse) lignocellulosic biowaste and manure). In order to make a deliverable that would become as useful as possible for stakeholders the approach was to make a joint deliverable where both sugar rich and nutrient rich feedstock are displayed parallel to each other.

We hope, and trust, that this catalogue will become a useful source of information in pursuing and supporting a strengthened bioeconomy in Africa.

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Introduction

Africa is a continent with over 1.1 billion people (PRB 2014) where about 60% of the population were living in rural areas in 2010 (World Bank 2013). There are differences in demography and level of income level between the countries and hence also the challenges faced by the communities in terms of human well-being and development. One of the options for new activities seen in recent years is the opportunities seen in developing a bioeconomy (OECD 2009; UNEP 2011b). There are variations in how bioeconomy is defined (Staffas *et al.* 2013) but the basis of is that the bioeconomy involves new and innovate transformation and more efficient use of bio-based resources. The underlying assumption is that the society can become more efficient and ensuring that what we produce and exploit in terms of bio-resources is used with as little loss as possible. Loss here should be understood as both losses in terms of losses of the biomass along the value chain, and loss in terms of economic value.

The agricultural sectors are important in all African countries and contributed in 2010 to 11.5 % of share of GDP in the African countries (World Bank 2013). Looking at the Sub Saharan Africa (SSA) excluding South Africa countries the agricultural sector contributed in 2008 to almost one fourth of the GDP (World Bank 2013). Apart from contributing to a large share of the GDP the agricultural sector is also the sector where a large number of people get their livelihoods both for the formal economy, but also in the informal economy as subsistence farming is a common strategy in many parts of the continent. The post-harvest losses seen in the agriculture in Africa is substantial and this can be illustrated via losses in the food value chain (Figure 1).

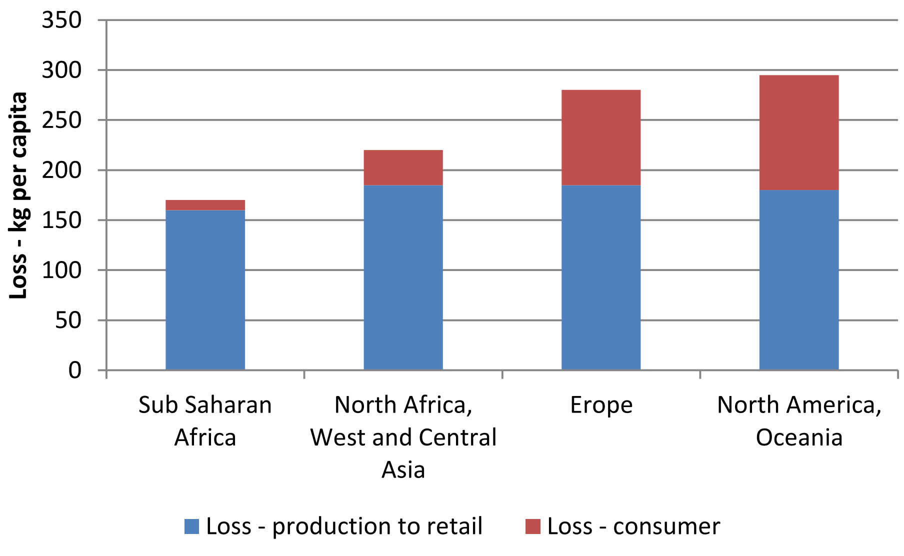

Figure 1:Per capita loss in food value chain in different regions of the world (based on Gustavsson et al. 2011)

The magnitude of the losses in the food value chain suggests that there are potentials for both reduce the losses and increase the yield (Zorya *et al.* 2011), but another option is to figure out options that make use of the losses for other productive purposes. Thus first priority is to reduce the losses, but if losses are there try to find productive uses for the biomass that is not used for its primary purpose.

An integrated part of the concept of bioeconomy is to use the bio-resources that we have access to in a smart and efficient way. Smart here refers to finding options that gives benefits in terms of economy, as well as other services and attributes to the setting in which the bioeconomy approach is adapted. For example cassava waste (peels and trimmings) can be hydrolysed by means of amylases in a simple wet-milling system (low temperature, ambient pressure) followed by fermentation to ethanol, lactic acid or amino acids. Parts of the effluent from such process could thereafter be added to a compost facility and with other biomass form organic fertiliser. 'Smart' is a relative word and the solutions will be contextualised. What is a 'smart' solution in one place, might turn up to be not-so-smart at another site. There is also a certain level of progress and continuous change intrinsic in the concept.

One of the strongest driving forces for entering and pursuing a larger bioeconomy is the potentials in economic development based on renewable resources (see for example the EU strategy European Commission 2012). Economic development is a strong driving force for the countries in Africa as it will support development processes both locally, nationally and on regional levels (see for example UNEP 2011a). New innovations in the field of chemistry and biotechnology gives opportunities upgrade biomass with a low or nil value to products with an added-value. But it would be misleading to say that the bioeconomy only relies on new technology as in many cases existing and mature technologies can fill the purpose. There are other barriers that hinder the development including access to financing, know-how, willingness, and of course that other alternatives are experienced as more attractive.

In Africa, it is fair to say that even though there are large losses along the value chains of food (Figure 1) and other biobased products this 'wasted' biomass does not lie around in heaps forgotten and to no use. More often the losses are diffuse and difficult to collect or the losses are used for some purpose, as it is or with simple conversions. Examples linked to the latter are market wastes that are used for feed to cattle or pigs. Other examples are rejected bananas that are used in composts and subsequently as soil conditioner and organic fertilizers. Biowastes can thus have a productive purpose and in many cases the biowaste is already used as a resource. The distinction can be done on low- or no-value bio-resources and on the whether the bio-resource is found on one spot (point) or more spread (diffuse). These distinctions will form a matrix that helps in categorizing the biomass discussed (Table 1).

Table 1: Categorization of various biowaste fractions

	Low or no-value	**Value**
Diffuse	Example: diffuse loss of crop kernels during harvest and transports	Example: rice straw on field
Point	Example: rice husk at small rice mill	Example: rice bran at rice mill

The most problematic biomass would be the one found in the low- or no-value/diffuse category. Here we find various forms of diffuse losses in for example crops due to inefficient harvest and transport solution. Point/value biomass is less complicated to collect as these are available on one site and also in many cases already possible to access and/or purchase.

The concept of biowaste is rather well defined in some specific contexts. For example in the European Union waste directive the definition states:

> *bio-waste' means biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food processing plants; (European Parliament 2008)*

This definition does not fully encompass the context in Africa as much of the loss biomass is found in the agricultural sector (as can be seen in Figure 1). Hence a slightly different definition is more relevant for the African context:

> *Biowaste is animal and vegetal waste arising from households, commerce and the food manufacturing industry. The food manufacturing industry includes the whole value chain hence farming and animal husbandry sectors are included.*

The aspect of waste as something that can have a value is important. In the work with this catalogue we found it useful to sometimes talk about bioresidues rather than biowaste. A bioresidue would be the bio-resources that have an economic or other value, while biowastes are experienced as those without or with only a nominal economic or other value.

The Biowaste4SP approach

The approach of the Biowaste4SP project has been to identify potential biowastes that can be turned into value-added products i.e. ethanol, lactic acid, amino acid, protein, biogas and fertilizer. Investigations of technology options with a low energy input, while receiving high value output, is a success factor in the project and for as such for establishing new activities in this sector. The ambition is identify solutions that are simple and quick in order to stimulate and facilitate further development processes within the bioeconomy sectors in the participating countries.

The identification of feedstocks (biowaste and bioresidues) has been made based on the characterization of bio-resources as sugar rich and/or nutrient rich. Depending on the existing biomass that can be used as feedstock in the upgrading process various added value products can be produced. A simplified framework is found in Figure 2 showing the feedstock and possible categories of value added products.

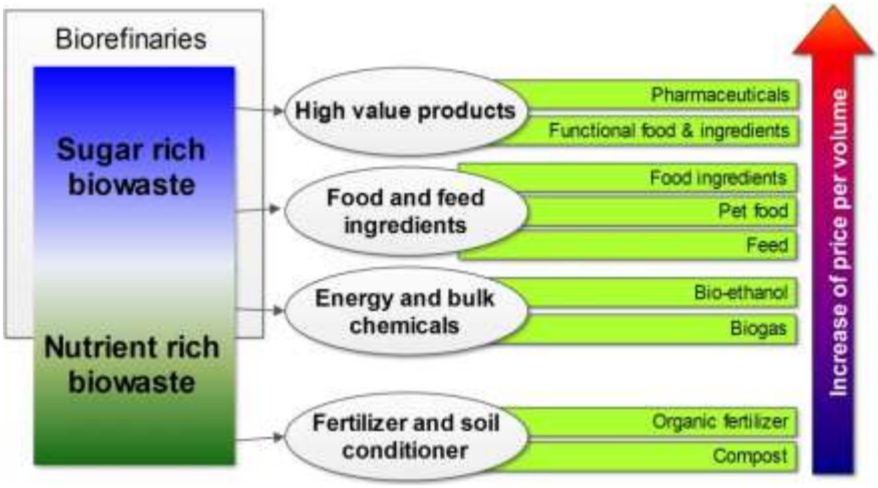

Figure 2: Framework of nutrient and sugar rich feedstock and examples of their respective products

Figure 2 illustrates the increase in retail price per volume of products as a function of biowaste input and the added-value of derived products. Pharmaceuticals will hold a high value per volume while bulk chemicals and energy carriers have a relatively lower value per unit etc. In assessing the business opportunity of a certain process, investment cost and also options for selling the produce will have to be included and assessed. Here some of the low value per unit products can stand out as more promising than advanced product as the investment and production costs can be expected to be reduced. For the African context organic high quality fertilizers and soil conditioners will have a high value and have a market also locally as it can result in improved yields in the agricultural practices. In many cases the effluent or waste from production of other value added products can be used in production of organic fertilizers and soil conditioners in a second stage. This is for example the case in biogas processes, where the biogas is one product from the primary anaerobic digestion process and the effluent from this process can be used as feedstock in a compost facility. The compost facility will provide organic fertilizer as a by-product in a second process. There are thus a chain of value-added products that should be considered when assessing the full potential of utilizing a certain biomass.

Other studies linking to the biowastes presented in this catalogue

The field of agricultural residues, biomass and bio resources, as well transformation technologies for use of these resources has been studied based on experiences from the African continent from many perspectives and angles. In this section a short presentation of some recent studies linking to these issues is made. The purpose here is to present some of the relevant literature directly linking to the information provided in the catalogue.

The FAO report on food losses (Gustavsson *et al.* 2011; Gustavsson *et al.* 2013) provides a background to the overarching potentials. The challenges in reducing post-harvest losses in food value chains are described in Zorya *et al.* (2011). Some examples of the costs linked to losses along the food value chain is found from

South Africa stating that these sums up to more than 2% of the South African GDP on a yearly basis (Nahman *et al.* 2012; Nahman and de Lange 2013).

Options to make use of the bio resources found in Africa is discussed in more general terms and in most cases based on official statistics is found in several papers (see for example Mangoyana 2009; Nzila *et al.* 2010; Amigun *et al.* 2011; Duku *et al.* 2011; Faraco and Hadar 2011; Wicke *et al.* 2011; Deenanath *et al.* 2012; Nakhla *et al.* 2013; Kemausuor *et al.* 2014). The conclusion is that there are in general potentials for further developing the use of these resources. The tool for doing this is to close in on different technologies.

One of the most discussed technologies is anaerobic digestion or biogas technology (Amigun and Blottnitz 2007; Mwirigi *et al.* 2009; Amigun and von Blottnitz 2010; Arthur and Brew-Hammond 2010; Bayitse *et al.* 2014; Orskov *et al.* 2014; Smith *et al.* 2014c; Tumwesige *et al.* 2014). These articles typically focus case examples, or challenges to popularise the technology. The Biowaste4SP project has included anaerobic digestion as one key technology, but the focus is set more on the value of the effluent and potential as a soil conditioner than the value of the biogas. This aspect has been reported in recent articles linking the potential given in the anaerobic process to provide organic fertiliser (see for example Smith *et al.* 2014a; Smith *et al.* 2014b). Another important technology to produce organic fertiliser is composting (see for example Ouédraogo *et al.* 2001; Manungufala *et al.* 2008; Mainoo *et al.* 2009; Kabore *et al.* 2010; Couth and Trois 2012). The effluent from a biogas reactor can be used in a second stage in providing biomass for the compost. The value of organic fertilisers is discussed based on experiences in Africa (see for example Rufino *et al.* 2007; Fening *et al.* 2010; Otinga *et al.* 2013; Rusinamhodzi *et al.* 2013; Castellanos-Navarrete *et al.* 2014)

Several feedstocks have been studied in more detail and there are some good overviews. A similar approach as have been applied in this report is the work presented in Thomsen *et al.* (2014) where agricultural residues from Ghana is studied in more detail and characteristics are given. There are other articles providing data on different crops and biomass types see for example on cassava (Adjei-Nsiah and Sakyi-Dawson 2012; Ademiluyi and Mepba 2013; Kristensen *et al.* 2014), rice including bran, husk and straw (Amissah *et al.* 2003; Yaning Zhang 2012; Said *et al.* 2013; Titiloye *et al.* 2013).

The outline of the *Catalogue of biowastes and bioresidues in Africa*

The aim of this catalogue was to systematically collect and analyze biomass that could be identified and labelled "biowaste" and/or "bioresidues" and was found in the five African countries Egypt, Morocco, Ghana, South Africa and Kenya. The "biowaste" and/or "bioresidues" identified all have the potential to be used in processes that would result in added-value products e.g. ethanol, lactic acid, amino acid, protein, biogas and fertilizer. We have closed on this by loosely categorizing feedstock as sugar rich or nutrient rich. In most cases nutrient rich feedstock, with some exceptions, also includes certain amounts of sugars, those which are found in lignocellulosic biomasses ie. cellulose and hemicellulose sugar polymers.

Another aspect of this catalogue is that we have tried to include information from where the feedstock has been sourced. The motivation behind this is that in most cases biomass will change its characteristics depending on where it is taken. This is the case for manure for example, where the management of the manure as well as type of cattle will make a difference and affect the quality of the manure. As one purpose is to find sources of biomass to be used in processes for production of value added products there is need to ensure certain amounts of biomass.

The outline of the catalogue is as follows. A brief introduction to the context of the Biowaste4SP project has been given in this introduction chapter. This is followed with a chapter that outlines the methodology applied in pursuing the shortlisting av feedstocks, the sampling and also the analysis. As the material presented in the catalogue stems from five different parts of Africa it has been essential to have protocols to follow in order for the data to become representable and comparable with results from other parts of Africa. The methodology chapter is followed with a chapter on results where the sampled biomass' main characteristics are found. The results are sorted on their characteristics rather than on the country of origin. The motivation behind this is that we believe that in many cases the sampled feedstock will be representable also for other countries. The results chapter is followed with a set of concluding remarks and references. The last section of this catalogue, and also most extensive, is the reporting sheets for all the samples. These data sheets are presented in country order and include information on various aspects linked to the context from where the biomass is taken, as well as some details on the sampling. We suggest that use of the characteristics of a biomass should at least involve a check of the corresponding data sheet in order to assess the relevance of the results presented herein as in relation to the biomass considered for your own purpose.

Methods

The approach to complete this catalogue was to take a point of departure in shortlisting a set of potential feedstocks that would either be labelled biowaste or bioresidues. Based on that shortlist of feedstock, samples should be gathered from specific sites judged to be representable for this typical sector. Each sample should then be characterized based on a set of basic chemical characteristics. Each step is further presented below.

Shortlisting of feedstock

Shortlisting of the feedstock was done in a step-wise approach. The first step was to make an overview of production and waste streams in the five African partner countries. The results were presented in a project report (Gustavsson (ed) *et al.* 2013) that was circulated in the whole Biowaste4SP project group and reactions to the approach was given.

Based on the initial findings a conceptual model was designed based on the scope of the project and what was included in the biowaste concept. Each partner country conducted a country survey to identify hot-spots and potential volumes of wastes that should be further studied in the steps to come. These country reports (Bartali and Belmakki 2013; Bayitse *et al.* 2013; Gustavsson 2013; Oelofse and Muswema 2013; Owis and Tablawy 2013; Sila and Namu 2013) showed that there are a number of potential biowastes but there are only very few considered bio-resources that presently does not have any uses.

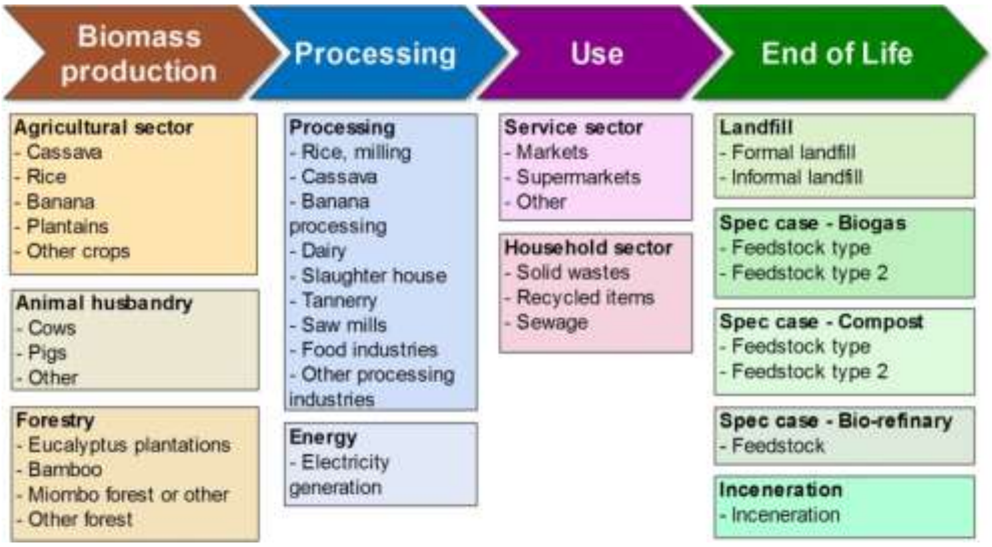

Figure 3: Framework of the value chain approach in the identification of potential biowastes for consideration in the Biowaste4SP project

From the country reports it was possible to focus on 4 sectors more specifically as potential sources for feedstock. Agriculture, animal husbandry, processing and service sectors as presented in Figure 3 stood out in the analysis as sectors and activities that should be focused when shortlisting sources for biomass for the continued work.

The country reports was then used as basis to shortlist five sugar rich and five nutrient rich feedstocks from each partner country. The shortlisting was done to try to cover as many feedstocks as possible based on potentials in the different countries and rather than doing the same biomasses in the different countries opt for biomass sources that were different. The shortlisted feedstock was discussed and decided on in the full Biowaste4SP project team.

Figure 4: Coning and quartering in progress as part of the process of creating a final sample. The biomass here is rice husk.

Methods for sampling and preparation of samples

A protocol for how sampling should be done had been prepared during the first 6 months of the project (Sundqvist *et al.* 2013). The protocol should ensure that sampling was done in the same manner in all partner countries. The protocol was tested in field in order to see if the steps worked out as planned. After the field test some adjustments were made and the final version of the protocol was distributed to all partners. All samples were done according to the protocol that included the following steps:

1. Identification of feedstock that should be tested and analysed
2. Take a set of primary samples from the identified biomass (covering randomly different parts of the total volume to be sampled)
3. Mix these primary samples

4. Use coning and quartering method to reduce the volume of the mixed primary samples. Reduce the mixed samples to about 10 kg
5. Have the sample dried in 60°C until it is dry. Particle size may be reduced in order to dry the sample, but no parts should be removed from the sample. The sample is dry when the weight of the sample is not reduced more between periods of time in the oven (<10%).
6. The sample particle size is milled to a size of <1mm
7. Sample is labelled and packed in sealed black plastic bags for storage.

The sampling procedure and preparation of sample was documented in a template designed in the Biowaste4SP project that included information on site and contact details, as well as details from completing the steps in the sample procedure. Each of these documents was filed and linked to the id of the sample.

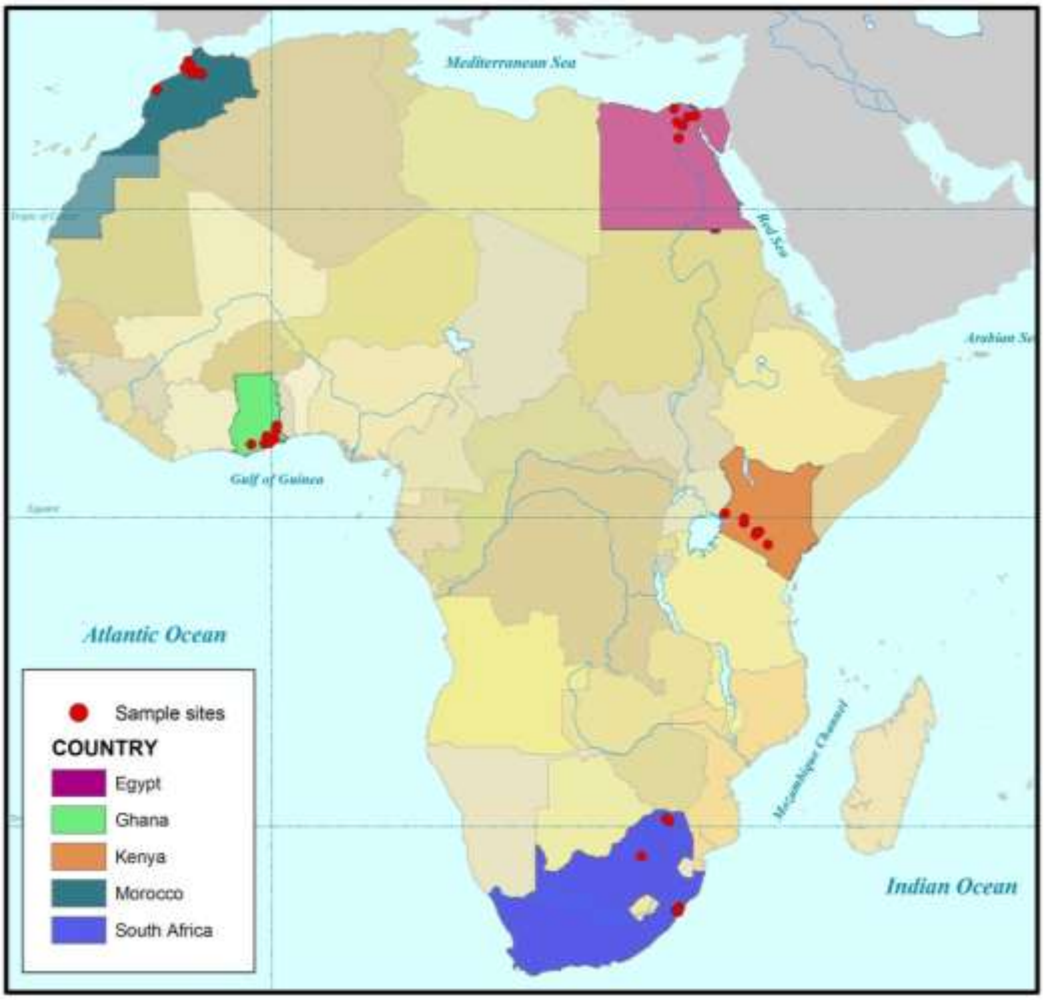

Figure 5: Locations of sampling (represented with red dots) in the five partner countries - Egypt, Ghana, Kenya, Morocco and South Africa

The sample reports are the basis for much of the text found in the data sheets. We have opted to provide information that is site specific rather than general descriptions on a more national level. This is based on the realization that biowaste is a relative concept where what is experienced as a biomass without value on one location will have a high level on another. One such example is rice husk which in many parts of Ghana does not hold any value as there is no technology for using this biomass as an energy source in industrial processes. If for example rice mills using rice husk as fuel for parboiling this would change very quickly putting a demand and economic value on the rice husk.

A total of 49 samples of different types of biowaste and bioresidues were taken covering agricultural, farm, industry and service sectors. Classification of samples in sugar rich (simple sugars, starch or cellulosic) or nutrient rich in the data sheet section is based on the number of crosses given in Table 3 and Table 4. Two or more crosses gives a classification as “rich”. This classification is however only an indication and in many cases the combination of nutrients and sugars is the main advantage of a certain feedstock – thus these categorisations should be considered with certain caution.

Methods for characterization of the biomass sampled

The chemical characterization of the samples was also based on prepared protocols. These protocols were also used as a basis for training before that actual lab work begun in the partner countries.

Dry Matter content determination

Dry Matter content (DM) of the prepared samples were measured according to the protocol A0001 from Enzyme Lab of DTI (Denmark), in principle by weighing the samples before and after overnight drying in oven at 105 °C.

Ash content determination

Ash content of samples were measured according to the protocol A0002 from Enzyme Lab of DTI (Denmark), in principle by weighing the samples before and after ashing at 550 °C for two hours in Muffle Furnace.

Carbohydrate content characterization

The Carbohydrate composition of samples were determined following the protocol A0003 from Enzyme Lab of DTI (Denmark), in principle of releasing the monomer sugars by two steps acid hydrolysis and quantify the released sugars by HPLC analysis. Samples were first made soluble in 72% (w/w) H_2SO_4 at 30°C for 60 minutes and then hydrolyzed in 4% (w/w) H_2SO_4 at 121°C for 60 minutes. Klason lignin contents were measured as the ash free residue contents after hydrolysis. The released monosaccharides were quantified by high performance liquid chromatography (HPLC) system using refractive index detector equipped with an Aminex HPX-87H column (Bio-Rad Laboratories Ltd., USA) running at 63°C with 4 mM H_2SO_4 as eluent with a flow rate of 0.6 ml/min.

Validity and generality of the results presented

The approach in this catalogue is to work with actual samples taken from agriculture, animal husbandry, processing and service sectors. One of the challenges has been to work in five different African countries with five different teams. As a consequence the work has followed strict protocols and each step has been documented in order to be able to follow-up and scrutinize the results.

Each sample is however unique as it will comprise a certain volume of biomass at a certain point of time. The data will however be representative of these actual types of biomass found in these spots. The results from this catalogue suggest that the processes from which the biomass is sampled will have impacts on the actual chemical characteristics of the sample taken. Examples here are manure and the way it is managed.

Figure 6: Rejected green banana at banana plantation in Ghana

Results

The feedstocks that are presented in this catalogue are all real biomass taken from actual operations in agriculture, animal husbandry, processing of the produce from agriculture and animal husbandry and lastly from service sectors. This means that interpretation of the chemical characterization provided in this chapter should also include checking the data sheets where more details on the actual process and context from which the sample stems. Data sheets are found after the main report.

Weight reduction in preparing the samples

The samples taken were all prepared according to a Biowaste4SP developed protocol in order to make the storage of the sample safe and to enable transportation. Information on the weight reduction from the sample taken in the field to the prepared sample was recorded. Some samples shows very high reduction of weight before and after drying (up to about 90%), while other biomass sampled is already dry at the time of the collection of sample. We have collected information on these weight reductions for all the samples, except vinasse as it was in liquid form. Table 2 provides information on all the weight reductions from the highest to the lowest. The dried samples would have different moisture content, which is further seen in the Dry Matter variable in Table 3, but the weight reduction here gives a crude estimate of the moisture content of the biomass that the sample stems from.

Table 2: Weight reduction before and after preparing sample

	Country	Weight of primary sample [kg]	Weight of dried sample [kg]	Weight reduction [%]
Cabbage packaging waste	Kenya	63.0	6.5	90
Sisal processing waste	Kenya	68.0	7.5	89
Water hyacinth	South Africa	3.0	0.4	88
Coffee Pulp	Kenya	55.0	6.7	88
Open Market Agricultural Waste	Kenya	90.0	11.7	87
Pineapple peels and used cores	Kenya	80.0	11.9	85
Flower waste - greenhouse	Kenya	42.0	7.5	82
Cattle manure	Morocco	25.2	4.8	81
Cow dung – sheds	Ghana	20.1	4.5	77
Orange pulp	Morocco	26.0	6.5	75
Tomato pulp	Morocco	21.0	5.3	75
Cassava peels and trimmings	Kenya	52.0	15.5	70
Green banana fruit	Egypt	15.0	4.7	69
Crop residues of faba bean	Morocco	10.4	3.3	68
Crop residues of maize	Morocco	11.3	3.6	68
Crop residues of sugarcane	Morocco	7.5	2.9	61

	Country	Weight of primary sample [kg]	Weight of dried sample [kg]	Weight reduction [%]
Pig manure from pig rearing farm	Ghana	11.0	4.5	59
Empty cocoa pods	Ghana	8.0	4.0	50
Sugarcane Bagasse	Kenya	16.0	9.6	40
Pomace from olive oil processing	Morocco	13.2	8.1	39
Banana waste - whole banana	Ghana	10.4	6.4	38
Cassava Peel, small scale	Ghana	10.4	6.9	33
Cassava beer processing waste	Ghana	30.4	20.6	32
Olive pomace	Egypt	5.0	4.0	20
Crop residues of banana	Morocco	5.3	4.3	19
Coffee Husk	Kenya	12.0	10.0	17
Farmyard manure (mixed with soil)	Egypt	6.0	5.0	17
Fruit & Vegetable Waste	South Africa	1.0	0.8	15
Sugarcane bagasse	Egypt	5.0	4.3	14
banana fruit	South Africa	2.0	1.7	14
banana peels	South Africa	2.0	1.7	14
Wheat bran	South Africa	10.0	8.8	12
Dried beet pulp	Morocco	58.0	51.3	12
Empty oil palm fruit bunch	Ghana	42.0	37.2	11
Garden Waste	South Africa	0.8	0.7	11
Rice bran	Egypt	5.0	4.5	10
Rice husk	Egypt	5.0	4.5	10
Maize Bran	South Africa	10.0	9.0	10
Soya bean field residues	South Africa	0.8	0.7	9
Manure cattle (collected pasture)	South Africa	0.9	0.8	7
Saw dust	South Africa	0.5	0.5	7
Poultry droppings	Ghana	8.0	7.5	6
Corn stover field residues	Egypt	5.0	4.7	6
Cotton stalks field residue	Egypt	5.0	4.7	6
Rice straw	Egypt	5.0	4.7	6
Sugarcane Bagasse	South Africa	0.5	0.5	4
Wood bark	South Africa	1.0	1.0	4
Rice bran – no parboil	Ghana	41.9	41.9	0
Sugarcane Vinasse (liquid)	Egypt	na	na	

The results show that some of the biomass studied has been subject to drying before the sampling was made or the process that the biomass has been going through makes the biowaste/bioresidue change in terms of moisture content as compared to its original moisture content. This is for example the case of bagasse in Kenya as compared to bagasse in Egypt. Another example is manure where the samples taken displays large variations in moisture content of initial sample. The possible explanation here is the management of this resource, as well as how long it has been exposed to sunlight and the air.

Characteristics of dry matter, sugars and nutrients

Biomass will change its characteristics as part of its life cycle. For banana for example the green banana fruit will be starch rich, while this starch is transformed to simple sugars as part of the process of maturing. Another aspect to consider is the process from which the biomass is sourced. For example rice bran can come from processes where the rice has been undergoing a parboiling process before it is milled or not. In the case of the rice bran sourced from a small rice mill in Asuthare in Ghana it was not parboiled, while the rice bran sourced from a rice mill in Egypt had been parboiled. The parboiling process will lead to a change in texture and also affect the nutritional value of the rice bran.

Two tables have been produced to display the characterisation results on all the samples. One table (Table 3) focuses what could be labelled the more sugar rich feedstock and the second table (Table 4) focuses the more nutrient rich feedstocks. A sugar rich feedstock might very well have values as a nutrient rich feedstock as well.

Dry mass in this case refers to the dry mass of the sample and is the result using the methodology presented in Dry Matter content determination. The ash content was studied based on the methodology presented in Ash content determination. High ash content indicates that there are nutrients in the sample and thus the ash content has been used to assign the value of sample in terms of nutrient richness. The categorisation of the samples in the "Nutrient rich" column was done based on the following principle; below 2.5 no cross, 2.5-8 ash 'x', 8-12 ash 'xx' and 12-above is assigned 'xxx'.

Glucan content is more or less the sum of the content of starch and cellulose and has been used to assess the sugar richness of the feedstock. Sugars are divided into "simple sugars", "starch rich" and "lignocellulosic". The first two categories here are typically associated with first generation technologies, while "lignocellulosic" sugars typically require second generation technologies to be utilised to access the sugars (see for example Luque *et al.* 2008). Hence with today's technology feedstock that is rich in starch or simple sugars will be easier to convert to added value products, than feedstock rich in lignocellulosic materials.

Sugar rich feedstock

Sugar rich feedstocks (low ash content indicating low levels of nutrients and high glucan content) have been identified as the biowaste/bioresidue in many processes. Many of these feedstocks are the result of transformation or treatment in industrial processes.

The results from the characterisation are found in Table 3 below. Additional information on the samples is found in the data sheets. Data on glucan for banana fruit South Africa is possibly too low as the boiling of the biomass in the hydrolization stage made the simple sugars to break up.

Table 3: Full set of characterisation data of feedstock that would be categorized as ***more sugar rich***.

SUGAR RICH FEEDSTOCK	Dry matter*	Ash content	Glucan	Xylan	Arabi-nan	Klason Lignin	Non cell wall material	Country	SUGARS			Nutrient rich**
									Rich in simple sugars	Starch rich	Ligno cellulo-sic*	
Cassava beer processing waste	97.60	0.94	92.50	2.60	2.70	2.10	-0.84	Ghana		xx	xx	
Saw dust	93.52	0.62	47.52	7.40	0.18	34.40	9.88	South Africa			xxxx	
Sugarcane bagasse	93.32	1.84	38.62	20.43	1.72	23.13	14.26	Egypt			xxxx	
Coffee Husk	97.90	2.14	32.60	24.40	24.40	7.30	9.16	Kenya			xxxx	
Pomace from olive oil pro-cessing	94.30	2.26	15.75	10.49	5.80	27.56	38.14	Morocco	x	x	xx	
Sugarcane Vinasse (liquid)	8.33	32.88	7.37	15.95	8.25	13.11	22.44	Egypt	xxxx			
Cassava Peel, small scale	89.70	6.43	83.40	2.30	2.30	1.90	3.67	Ghana		xx	xx	x
Banana waste - whole ba-nana	95.40	6.19	77.50	3.00	3.00	8.30	2.01	Ghana		xxx		x
Green banana fruit	95.24	3.80	72.02	1.43	1.02	10.12	11.61	Egypt		xxx	x	x
Sugarcane Bagasse	95.85	5.64	65.81	5.89	0.13	18.09	4.44	South Africa			xxxx	x
Pineapple peels and used cores	97.80	2.53	53.10	6.40	6.50	4.40	27.07	Kenya	xx		xx	x
Maize Bran	91.22	3.92	46.53	10.81	8.23	1.73	28.78	South Africa		xx	xx	x
Rice bran	95.82	6.56	39.63	11.92	4.57	21.15	16.17	Egypt		xx	xx	x
Banana fruit	88.18	6.90	39.11	0.56	0.43	11.52	41.48	South Africa	xxx	x		x
Corn stover field residues	97.47	6.47	37.92	21.56	3.27	18.41	12.37	Egypt			xxxx	x
Rice husk	94.51	8.67	36.76	15.62	1.68	21.34	15.93	Egypt			xxxx	x
Crop residues of sugarcane	94.24	6.26	35.68	20.61	2.81	21.72	12.92	Morocco	x		xxx	x
Wheat bran	89.09	5.73	34.78	10.59	7.18	9.25	32.47	South Africa		xx	xx	x

SUGAR RICH FEEDSTOCK	Dry matter*	Ash content	Glucan	Xylan	Arabi-nan	Klason Lignin	Non cell wall material	Country	SUGARS			Nutrient rich**
									Rich in simple sugars	Starch rich	Ligno cellulo-sic*	
Crop residues of maize	94.97	5.32	34.21	17.51	3.01	21.30	18.65	Morocco			xxxx	x
Cotton stalks field residue	96.36	5.48	33.54	18.62	2.53	13.71	26.12	Egypt			xxxx	x
Empty oil palm fruit bunch	89.60	5.10				29.50		Ghana				x
Olive pomace	95.83	3.15	30.92	17.15	1.53	38.95	8.30	Egypt	x	x	xx	x
Dried beet pulp	88.54	5.23	24.51	7.99	16.25	16.00	30.02	Morocco	x		xxx	x
Wood bark	94.32	6.23	22.55	3.14	2.88	48.37	16.83	South Africa			xx	x
Orange pulp	90.30	4.17	18.53	9.03	6.71	18.47	43.09	Morocco	x	x	xx	x
Cassava peels and trim-mings	97.10	5.01	17.90	8.10	8.20	20.00	40.79	Kenya		xx	xx	x
Crop residues of faba bean	96.06	4.63	16.75	9.33	3.97	15.01	50.31	Morocco			xxxx	x
Tomato pulp	95.18	4.09	15.10	8.47	5.29	22.43	44.62	Morocco	x		xxx	x
Flower waste - greenhouse	96.40	6.83				21.00		Kenya			xxxx	x
Sugarcane Bagasse	96.40	5.05				22.80		Kenya			xxxx	x

** This is the dry matter of the dried and milled sample. The methodology is presented in the methods chapter.*

*** Sugars have been classified based on the content of glucan (lignocellulosic is given crosses according to 10-15 glucan 'x', 15-30 is 'xx' and 30-45 is 'xxx' and 45-above is 'xxxx')*

**** Nutrients are seen in the ash content and the following thresholds have been used to assign numbers of crosses: below 2.5 no cross, 2.5-8 ash 'x', 8-12 ash 'xx' and 12-above is assigned 'xxx'.*

Nutrient rich feedstock

Nutrient rich feedstocks (high ash content indicating high levels of nutrients and with varied degrees of sugars) is found from many industrial processes, but also found as part of animal husbandry. Based on the findings in this catalogue the nutrient rich feedstocks sampled have been used frequently as compost material or directly as soil conditioners.

Figure 7: The cattle manure sample from Morocco. Note the mix of cattle manure and straw in the sample.

The results from the characterization are found in Table 4 below. Additional information on the samples is found in the data sheets.

Table 4: Full set of characterisation data of feedstock that would be categorized as ***more nutrient rich***.

NUTRIENT RICH FEEDSTOCK	Dry matter *	Ash content	Glucan	Xylan	Arabi-nan	Klason Lignin	Non cell wall material	Country	SUGARS			Nutrient rich ***
									Rich in simple sugars	Starch rich	Ligno cellulo-sic **	
Rice bran – not parboiled	90.30	14.50	38.00	12.30	3.60	19.60	12.00	Ghana		x	xxx	xxx
Banana peels	87.81	16.45	35.41	0.63	1.11	12.76	33.64	South Africa			xxxx	xxx
Cattle manure	93.88	20.02	27.61	18.06	2.51	24.14	7.66	Morocco			x	xxx
Crop residues of banana	94.29	14.69	19.00	14.69	3.53	24.17	23.92	Morocco			xxxx	xxx
Cattle Manure (collected pasture)	93.16	31.20	14.61	8.58	1.51	25.01	19.09	South Africa			x	xxx
Water hyacinth	93.64	30.68	14.32	3.13	4.82	26.04	21.01	South Africa			xx	xxx
Soya bean field residues	93.93	30.67	14.31	3.12	4.81	26.04	21.05	South Africa			xx	xxx
Farmyard manure (mixed with soil)	86.42	66.85						Egypt			x	xxx
Cow dung – sheds	93.40	29.00				27.70		Ghana			x	xxx
Pig manure from pig rearing farm	95.20	39.70				22.00		Ghana			x	xxx
Poultry droppings	94.10	29.70				21.40		Ghana			x	xxx
Cabbage packaging waste	97.60	13.11				15.10		Kenya	xx		xx	xxx
Open Market Agricultural Waste	90.40	10.29				19.90		Kenya	xx		xx	xxx
Rice straw	96.76	18.59	34.39	20.62	3.97	15.18	7.25	Egypt			xxxx	xx
Coffee Pulp	96.10	10.00	32.10	20.20	20.20	26.70	-9.20	Kenya			xxxx	xx
Fruit & Vegetable Waste	86.62	9.54	22.49	1.44	1.70	13.43	51.40	South Africa	xx		xx	xx
Garden Waste	90.31	10.75	18.87	5.60	2.98	37.12	24.68	South Africa			xx	xx
Empty cocoa pods	95.00	14.00				33.90		Ghana			xxx	xx

NUTRIENT RICH FEEDSTOCK	Dry matter *	Ash content	Glucan	Xylan	Arabi-nan	Klason Lignin	Non cell wall material	Country	SUGARS			Nutrient rich ***
									Rich in simple sugars	Starch rich	Ligno cellulo-sic **	
Sisal processing waste	95.20	8.17				17.90		Kenya				xx

** This is the dry matter of the dried and milled sample. The methodology is presented in the methods chapter.*

*** Sugars have been classified based on the content of glucan (lignocellulosic is given crosses according to 10-15 glucan 'x', 15-30 is 'xx' and 30-45 is 'xxx' and 45-above is 'xxxx')*

**** Nutrients are seen in the ash content and the following thresholds have been used to assign numbers of crosses: below 2.5 no cross, 2.5-8 ash 'x', 8-12 ash 'xx' and 12-above is assigned 'xxx'.*

Concluding remarks

The purpose of this catalogue is to systematically collect and analyze biomass that could be labelled biowaste or bioresidues and was found in the African context. Based on the findings we can conclude that there are many sources of "biowaste" and/or "bioresidues" that potentially can be used in processes that would produce value-added products. At the same time this catalogue shows that most of the feedstocks studied are not waste in the sense that the biomass is left somewhere without any productive use but in most cases is rather the opposite where a certain biomass has a productive and valuable use. In some cases the use does not have a monetised value but fills a role in provisioning peoples' livelihoods or to support the own operations. This is the case of for example bananas that are used in a compost facility to provide soil conditioner or manure that is used in the agriculture. As a result any operation that includes exploitation of biowastes and/or bioresidues in the African context should pay attention to the sustainability of the operation considering effects on local livelihoods and environment.

There are good reasons to rank biomass that will not fluctuate too much depending on season as good sources for biomass to more advanced processes. One approach to ensure this is to source the biomass from industries that would typically operate more independent of seasons than for example small scale industries. Examples from the studied biomass in this catalogue are:

- Rice, maize and other bran (see for example rice bran from Egypt, Ghana, and maize and wheat bran from South Africa) are nutrient rich feedstock also containing some sugars,
- Biomass from food processing and packaging industries (see for example cabbage Kenya, orange and tomato processing Morocco and vegetable and fruit waste South Africa) both sugar rich and nutrient rich feedstock.
- Sugarcane bagasse is a potential biowaste (see Kenya and Egypt) but require 2^{nd} generation technology to access the sugars. Normal practice today is to use the bagasse for process- or other energy purpose.
- From plantations rejected bananas and banana residues constitute a potential sugar rich and nutrient rich bio resource (see Ghana and Morocco)

A common denominator here is that all these sources can be accessed on a specific site (the industry, collection point etc) and we classify this as point sources of a biowaste/bioresidue. Another aspect of most of the above mentioned biowastes/bioresidues are that the existing volumes are possible to assess beforehand.

Other potential feedstock for producing added value products comes from animal husbandry. Here mainly manure (animal faeces and urine) has been studied and provide clear results that these biomass are nutrient rich. The type of management of the manures will affect the potential of the feedstock. Much of the farming residues are rich in sugars but lignocellulosic making these challenging to transform with today's technology.

The potential of a biomass also include an economic aspect. In the data sheets some indications are given on whether the biowaste/bioresidue holds an economic value or not. The information is however relative the present situation and would possibly change if a demand for the biomass was created.

The results presented in this catalogue show that there are a range of biowastes and bioresidues found in Africa that would fulfil the criteria to be used as feed-stock in processes to produce value added biobased products.

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DATA SHEET SECTION

EGYPT

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Banana fruits - green, from banana stockholder

General

Biomass material	Banana fruits - green, from banana stockholder
Id code of sample	BanFru 2013-03-15 EG Ashmoun a Tahlawy
Responsible project partner	ARC - Egypt

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ **Starch rich** ~~Lignocellulosic~~ ~~Nutrient rich~~
Results	see tables below

	Result [%]
Dry matter (DM)	95.24
Ash content (Ash)	3.80

	Mass – [% of DM]
Glucan	72.02
Xylan	1.43
Arabinan	1.02
Klason Lignin	10.12

Glucan is the sum of starch and cellulose.

Details of the site and present use of the feedstock

Site name	Ashmoun
District or local community	Ashmoun city, Menofia Governorate
Country	Egypt

Date(s) of sampling	2013-03-15
Weather at site during the sampling	Sunny, clear sky and partly cloudy
Outside temperature	About 25°C
Contextual aspects considered (rainfall etc)	

Describe the process source from which the biowaste/bio-residue stem	The green fruits are stored on the degree of 14-13oC and relative humidity 90-85% for a period of 4-3 weeks, with the removal of ripe fruits, which started in maturity. Private food banana stockholder for ripping and sell the banana fruit.
Category (field residue, farm or industry)	Service sector (banana retailer)

Brief site-specific description of the management of the biomass from which the sample is taken	The banana fruit biomass is originated from a private banana stockholder for ripping and sell the banana fruit in Ashmoun city, Menofia governorate, Egypt. The banana sampled was the green (immature) banana at this retailer The biomass is kept as cluster (Bunch) of banana fingers rolled with paper or plastic sheets. The available amount is largely varied according to the production rate in the local area and season but unable to be detected exactly. The main energy sources used are electricity and gasoline.
Any visible environmental aspects seen at the site	None
Present usage of the sampled biomass	The waste of banana fruits biomass is composted as amendment during composting of other agricultural residues.
Does biomass from which the sample is taken hold an economic or other value	No, the rejected green banana fruits haven't an economic value at the present.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The banana fruit biomass was collected during the process of ripping green banana to be mature or yellow banana fruits. The sample represented as a one or two whole clusters of green fingers which weighted about 30 – 40 kg per cluster at the second degree of maturation index.
Purity	Pure, 96 - 98 % green fruits of banana.
Colour	Green as fresh biomass and dark creamy-yellow as a powder after preparation (slices, air drying and milling)
Wet/dry/mixed	Wet as fresh and dry after preparation.
Particle size	As a clusters of green fingers of banana and less than 0.1 mm after preparation.
Type of storage at site	The biomass rejected in a landfill

Weight of sample before drying and milling	15 kg
Weight dried sample	4.7 kg
Weight reduction	69%

Pictures

Figure 8: Green banana bunch, Egypt

Figure 9: Green banana tier, Egypt

Figure 10: Dried banana fruit slices, Egypt.

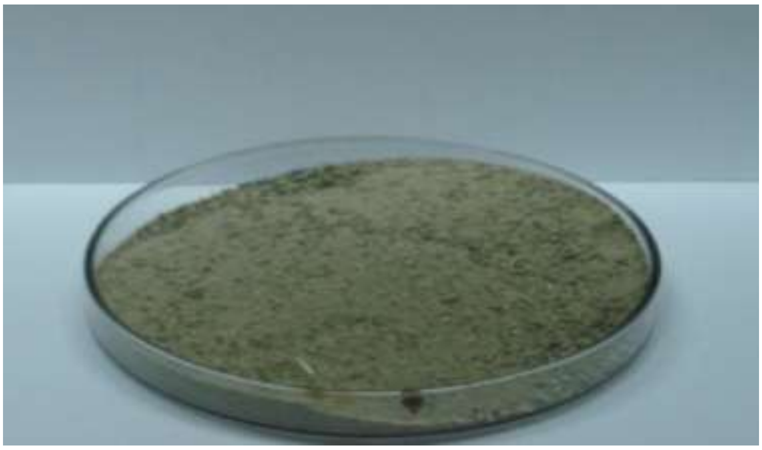

Figure 11: Dried and milled green banana, Egypt

Cattle and buffalo manure mixed with straw and soil

General

Biomass material	Cattle and buffalo manure mixed with straw and soil
Id code of sample	FM 2013-11-7 EG Seds b Essa
Responsible project partner	ARC-Egypt

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ ~~Lignocellulosic~~ **Nutrient rich**
Results	see below

	Result [%]
Dry matter (DM)	86.42
Ash content (Ash)	66.85*

*The animal droppings were mixed with soil and hence the ash content result became high.

	Mass – [% of DM]
Glucan	-
Xylan	-
Arabinan	-
Klason Lignin	-

Glucan is the sum of starch and cellulose.

Details of the site and present use of the feedstock

Site name	Seds
District or local community	Seds research station, ARC, Bani suif governorates
Country	Egypt

Date(s) of sampling	7-Nov-2013
Weather at site during the sampling	Sunny, hot and dry
Outside temperature	About 32oC
Contextual aspects considered (rainfall etc)	Day: 32°C. Night:28°C.

Describe the process source from which the biowaste/bio-residue stem	The manure represent the animal droppings at in the Seds site. The animals is cattle and buffalos.
Category (field residue, farm or industry)	Farm

Brief site-specific description of the management of the biomass from which the sample is taken	• The manure collected from small farms at the rural area around the Sed Research Station. • The droppings of animals are collected in the morning from the husbandry. • The droppings is mixed with bed of straw and soil. • The droppings is transferred away the husbandry to accumulated in a manure heaps. • The heap is left to be air dried at storage site.
Any visible environmental aspects seen at the site	Smell emission of ammonia during storage.
Present usage of the sampled biomass	• Manure is used as a organic fertilizer and/or soil conditioner. • Bioorganic amendments in the composting of agriculture wastes of crops. • Production of biogas.
Does biomass from which the sample is taken hold an economic or other value	• The manure as organic fertilizer save the amount of mineral fertilizers. • Production of biogas as biofuel contribute in the renewable energy production in rural area. • The manure itself is sold into other farms as soil conditioners.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The sampled was air dried manure (urine and faeces) mixed with bedding (straw and soil).
Purity	Mixed with straw and/ soil.
Colour	Dark brown
Wet/dry/mixed	wet
Particle size	Sample with variable particle diameters
Type of storage at site	In Piles

Weight of sample before drying and milling	6.0 kg
Weight dried sample	5.0 Kg
Weight reduction	17%

Pictures

Figure 12: Animal dropping at the husbandry, Egypt

Figure 13: The animal droppings left at the field, Egypt

Corn stover collected at the field

General

Biomass material	Corn stover collected at the field
Id code of sample	CorSt 2013-11-13 EG Ismailia a Abd-Wahab
Responsible project partner	ARC - Egypt

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** ~~Nutrient rich~~
Results	see tables below

	Result [%]
Dry matter (DM)	97.47
Ash content (Ash)	6.47

	Mass – [% of DM]
Glucan	37.92
Xylan	21.56
Arabinan	3.27
Klason Lignin	18.41

Glucan is the sum of starch and cellulose.

Details of the site and present use of the feedstock

Site name	Ismailia
District or local community	A city in north-eastern Egypt, belongs to Ismailia Governorate.
Country	Egypt

Date(s) of sampling	13-Nov-2013
Weather at site during the sampling	Sunny
Outside temperature	28°C
Contextual aspects considered (rainfall etc)	None

Describe the process source from which the biowaste/bio-residue stem	The biomass represent an agriculture residues that is outcome of the cultivation and harvesting process of the maize.
Category (field residue, farm or industry)	Field residue

Brief site-specific description of the management of the biomass from which the sample is taken	The corn stover biomass is originated form the Ismailia site that is located in the east region of the Egypt and represents the experimental station of ARC at which the maize is cultivated and managed as the following: • Area of maize cultivated farm about 4.2 ha. • Productivity of farm about 6.5ton corn grain per hectare. • The mount of corn stalks biomass is about 19 ton per hectare. • The total amount of stalks biomass is about 80 ton at the farm. • The green shoot is about 47.5 ton per hactare. • The harvest of cotton is done manually by labours at the field • The stalks biomass is left at the field to be air dried for about 10 days after then it is collected in the bundle forms and transferred away and accumulated at the field boundary. • The stalks biomass is usually chopped in the field by chopper which operated by solar as energy source.
Any visible environmental aspects seen at the site	Smoke or dust
Present usage of the sampled biomass	• The chopped green shoots is fermented in compressed piles with some additives of molasses, agric. wastes and nutrients to produce the silage, which used as livestock fodder. • The bundles is burned to used as a fuel in ovens in the houses. • The stalks is left at the field as a soil conditioner or the chopped biomass is composted to be organic fertilizer.
Does biomass from which the sample is taken hold an economic or other value	Yes, the above-mentioned usages could be considered as economic management of the corn biomass under Egyptian conditions.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The biomass represent a chopped form of the corn stover, which represent a fibrous and lignocellulosic biomass.
Purity	96% dried corn shoot.
Colour	It is a yellowish colour
Wet/dry/mixed	dry
Particle size	<180 and 2.5 cm, bundle and chopped biomass, respectively.
Type of storage at site	In chopped form

Weight of sample before drying and milling	5.0 kg
Weight dried sample	4.7 kg
Weight reduction	6%

Pictures

Figure 14: Dried corn stover bundles

Figure 15: The unprepared corn stover sample

Figure 16: Chopping the corn stovers

Figure 17: Chopping of corn stover, tractor used to power the equipment

Figure 18: Accumulated chopped corn stover biomass

Figure 19: Filtration system, equipped with a vacuum pump connected to, by plastic hose, a Büchner flask that is fitted with a Gooch crucible.

Figure 20: Dried and milled corn stover sample, Egypt

Cotton stalks collected at cotton field

General

Biomass material	Cotton stalks collected at cotton field
Id code of sample	CotSt 2013-11-10 EG Seds a Essa
Responsible project partner	ARC - Egypt

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** ~~Nutrient rich~~
Results	(see tables below)

	Result [%]
Dry matter (DM)	96.36
Ash content (Ash)	5.48

	Mass – [% of DM]
Glucan	33.54
Xylan	18.62
Arabinan	2.53
Klason Lignin	13.71

Glucan is the sum of starch and cellulose.

Details of the site and present use of the feedstock

Site name	Seds
District or local community	Seds research station, ARC, Bani suif governorates
Country	Egypt

Date(s) of sampling	10-Nov-2013
Weather at site during the sampling	Sunny
Outside temperature	About 29°C
Contextual aspects considered (rainfall etc)	None

Describe the process source from which the biowaste/bio-residue stem	The biomass represent an agriculture residues that is outcome of the cultivation and harvesting process.
Category (field residue, farm or industry)	Field residue

Brief site-specific description of the management of the biomass from which the sample is taken	The cotton stalks biomass is originated form the seds site that is located in the upper region of the Egypt and represents the experimental station of ARC at which the cotton is cultivated and managed as the following: • Area of cotton cultivated farm about 15 ha. • Productivity of farm about 2.3 cotton per hectare. • The mount of cotton stalks biomass is about 5 ton per hectare. • The total amount of stalks biomass is about 75 ton at the farm. • Picking of the cotton is done manually by labours at the field • The stalks biomass is left at the field to be air dried for about 15 days after then it is collected in the bundle forms and transferred away and accumulated at the field boundary. • The stalks biomass is usually chopped in the field by chopper which operated by solar as energy source.
Any visible environmental aspects seen at the site	Smoke or dust
Present usage of the sampled biomass	• The bundles is burned to used as a fuel in ovens in the houses. • The stalks is left at the field as a soil conditioner or the chopped biomass is composted to be organic fertilizer. • The stalks also enter the wood industry.
Does biomass from which the sample is taken hold an economic or other value	Yes, the above-mentioned usages could be considered as economic management of the biomass waste under Egyptian conditions.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The biomass represent a chopped form of the cotton stalks, which represent a fibrous and lignocellulosic biomass.
Purity	95% cotton stalks biomass
Colour	Brown colour
Wet/dry/mixed	dry
Particle size	< 120 and 2.5 cm, bundle and chopped biomass, respectively.
Type of storage at site	Chopped biomass form.

Weight of sample before drying and milling	5 kg
Weight dried sample	4.7 kg
Weight reduction	6%

Pictures

Figure 21: Cotton bundles at the field

Figure 22: Cotton stalks are chopped at the cotton field

Figure 23: The chopped cotton stalks biomass is packed in bags

Olive pomace collected at olive oil press industry

General

Biomass material	Olive pomace collected at olive oil press industry
Id code of sample	OPP 27-02-2013 EG Giza a El-Tawil
Responsible project partner	ARC - Egypt

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** ~~Nutrient rich~~
Results	see tables below

	Result [%]
Dry matter (DM)	95.83
Ash content (Ash)	3.15

	Mass – [% of DM]
Glucan	30.92
Xylan	17.15
Arabinan	1.53
Klason Lignin	38.95

Glucan is the sum of starch and cellulose.

Details of the site and present use of the feedstock

Site name	Kilo 50, Cairo Alexandria Road
District or local community	Giza.
Country	Egypt

Date(s) of sampling	27-Feb-2013
Outside temperature	About 29°C
Contextual aspects considered (rainfall etc)	Day: Sunny. Highs around 29°C. North northwest wind 9 to 24 KPH (6 to 15 MPH). Night: Clear. Lows around 27°C. Northwest wind 9 to 22 KPH (5 to 14 MPH).

Describe the process source from which the biowaste/bio-residue stem	Olive pomace or olive cake, is the solid remains of olives after pressing for juice or oil. The continuous centrifuge two-phase process generates a liquid phase (olive oil) and organic slurry (two-phase olive mill waste). This semi-solid waste (also known as olive wet cake, olive wet husk or olive wet pomace) has a strong odor and doughy texture.
Category (field residue, farm or industry)	Industrial residue

Brief site-specific description of the management of the biomass from which the sample is taken	The olive pomace is accumulated at the olive seed mills as a heaps and rejected out or shipped to the stockholders reused as soil conditioner. In Egypt, the annual average production of olive is 330.000 tones per year. About 80% of the total production is consumed as table olive and the residual (20%) is used for oil production. The production of olive oil generates three phases and two wastes: olive oil (20 %), solid waste (30%) and aqueous liquor (50%). These olive mill wastes are produced in significantly large quantities during short periods of time. Origin: Olive farm at Fefa For Food Industries All production (Table olive & oil) is for exporting. Production: 9 ton/ha. Oil mill capacity: 5 ton/hour Total olive area: 273 ha (600 table olive cvs. + 50 oil cvs.) Biowaste (%): 20% pomace + 60% vegetative water + 15-18% oil Pomace biowaste is kept in the open air in sunny area till December to be applied as composite in the winter fertilization program. Biowaste (pomace) is added to the compost and applied to the trees in the farm as fertilizers. This farm applied clean culture system. Seasonal changes in availability: Available yearly, because the olive oil mill in the farm is working on the farm and other olive farms products. Main energy sources: Electricity
Any visible environmental aspects seen	Vegetative water leachate
Present usage of the sampled biomass	Use as soil conditioners
Does biomass from which the sample is taken hold an economic or other value	Disposal of olive wastes from olive oil mills is already a major environmental issue in several olive growing countries in the world. Spreading the solid waste on farm lands causes enormous pollution to the land and air.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	Olive pomace or olive cake, is the solid remains of olives after pressing for juice or oil.
Purity	It contains the skins, pulp, seeds, and stems of the fruit.
Colour	Dark brown
Wet/dry/mixed	wet
Particle size	Up to 0.2 mm
Type of storage at site	The olive pomace is accumulated at the olive seed mills as a heaps and rejected out or shipped to the stockholders reused as soil conditioner.

Weight of sample before drying and milling	5.0 kg
Weight dried sample	4.0 kg
Weight reduction	20%

Pictures

Figure 24: Olive tree farm

Figure 25: Olive fruit washing

Figure 26: Olive fruit squeezing

Figure 27: Heap of olive pomace

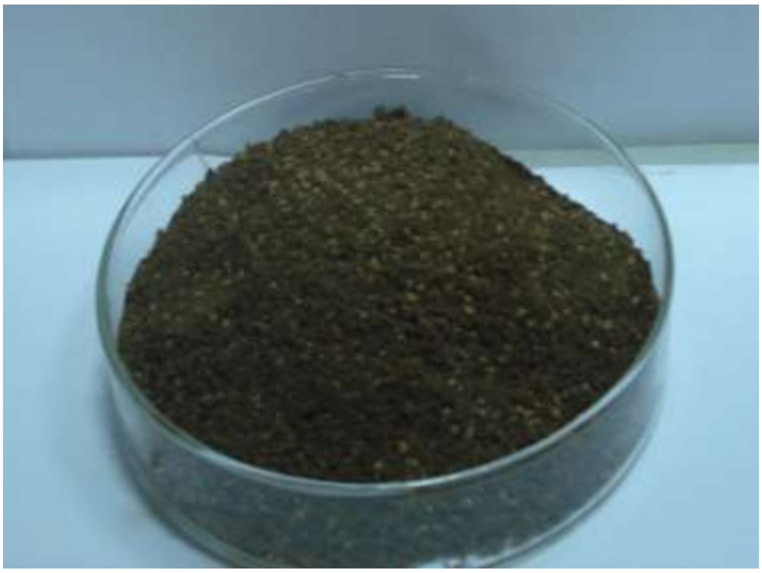

Figure 28: Dried and milled sample of olive pomace

Rice bran from industrial scale rice mill

General

Biomass material	Rice bran from industrial scale rice mill
Id code of sample	RicBr 2013-6-05 EG Desok a Tahlawy
Responsible project partner	ARC - Egypt

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** ~~Nutrient rich~~
Results	see tables below

	Result [%]
Dry matter (DM)	95.82
Ash content (Ash)	6.56

	Mass – [% of DM]
Glucan	39.63
Xylan	11.92
Arabinan	4.57
Klason Lignin	21.15

Glucan is the sum of starch and cellulose.

Details of the site and present use of the feedstock

Site name	Desouk
District or local community	Is a city in northern Egypt, belongs to Kafr El-Sheikh Governorate.
Country	Egypt

Date(s) of sampling	5-Jun-2013
Weather at site during the sampling	Sunny
Outside temperature	About 31^{o}C
Contextual aspects considered (rainfall etc)	Non

Describe the process source from which the biowaste/bio-residue stem	The bran is a by-product during Whitening or Polishing Process of the rice paddy. The bran layer and germ are removed from the rice kernel by applying friction to the grain surface either by rubbing the grains against an abrasive surface.
Category (field residue, farm or industry)	Industry

Brief site-specific description of the management of the biomass from which the sample is taken	The bran directly output at the processing site (rice mill). The bran basically accumulated in heaps and after then filled in plastic PPL bags. The outcome product is variable depending on the rice yield. The amount of bran removed is normally between 8-10% of the total paddy weight during Whitening or Polishing Process. The electricity is the main energy source.
Any visible environmental aspects seen at the site	Smoke
Present usage of the sampled biomass	As poultry, fish and/or livestock feed
Does biomass from which the sample is taken hold an economic or other value	Oil extraction, some pharmaceutical ingredients.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	Rice bran is one of by-products of rice milling. Rice bran represents the polish of the outer layer and the germ of the rice grain, which represent about 10% of the rice grain weight. It is a byproduct of whitening and\or polishing procedures of paddy rice processing process at rice mill.
Purity	Small broken rice grains and the husk particle passing along with bran
Colour	Uniform light brown color.
Wet/dry/mixed	Mixed with some rice dribs and rice husks.
Particle size	0.18-0.85 mm
Type of storage at site	In pile or filled in bags

Weight of sample before drying and milling	5.0 kg
Weight dried sample	4.5 kg
Weight reduction	10%

Pictures

Figure 29: Dried and milled sample of rice bran

Rice husk from industrial scale rice mill

General

Biomass material	Rice husk from industrial scale rice mill
Id code of sample	RicHus 2013-4-05 Desok a Tahlawy
Responsible project partner	ARC - Egypt

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** ~~Nutrient rich~~
Results	see tables below

	Result [%]
Dry matter (DM)	94.51
Ash content (Ash)	8.67

	Mass – [% of DM]
Glucan	36.76
Xylan	15.62
Arabinan	1.68
Klason Lignin	21.34

Glucan is the sum of starch and cellulose.

Details of the site and present use of the feedstock

Site name	Dessouk
District or local community	Is a city in northern Egypt, belongs to Kafr el-Sheikh Governorate.
Country	Egypt

Date(s) of sampling	5-Apr-2013
Weather at site during the sampling	Sunny
Outside temperature	31°C
Contextual aspects considered (rainfall etc)	None

Describe the process source from which the biowaste/bio-residue stem	Rice husks is one of the by-products of rice processing during the whiting and polishing steps.
Category (field residue, farm or industry)	Industry residue

Brief site-specific description of the management of the biomass from which the sample is taken	• The rice husks directly output at the processing site (rice mill). • The husks basically accumulated in piles and after then filled in plastic PPL bags or left in open area behind the factory. • The husks outcome product is variable depending on the rice yield. • The electricity is the main energy source.
Any visible environmental aspects seen at the site	Smoke
Present usage of the sampled biomass	As poultry and/or livestock feed
Does biomass from which the sample is taken hold an economic or other value	The husks use contribute in solving the fodder problem in Egypt.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	Rice husk is the outermost layer of protection encasing a rice grain and has a convex shape.
Purity	>95% rice husks
Colour	It is a yellowish colour
Wet/dry/mixed	dried
Particle size	< 7mm
Type of storage at site	In pile or bages

Weight of sample before drying and milling	5.0 kg
Weight dried sample	4.5 kg
Weight reduction	10%

Pictures

Figure 30: A handful of rice husk

Figure 31: Rice husk sample

Figure 32: Water bath used in the analysis of the samples

Figure 33: Autoclave used in the analysis of the sample

Figure 34: Dried and milled sample of rice husk

Rice straw at collection point for straw sales

General

Biomass material	Rice straw at collection point for straw sales
Id code of sample	RicSt 2013-4-05 Abo-Hammad a Abd-Wahab
Responsible project partner	ARC - Egypt

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** **Nutrient rich**
Results	see below

	Result [%]
Dry matter (DM)	96.76
Ash content (Ash)	18.59

	Mass – [% of DM]
Glucan	34.39
Xylan	20.62
Arabinan	3.97
Klason Lignin	15.18

Glucan is the sum of starch and cellulose.

Details of the site and present use of the feedstock

Site name	Abou Hammad
District or local community	Is a city in northern Egypt, belongs to Al Sharqia Governorate.
Country	Egypt

Date(s) of sampling	5-Apr-2013
Weather at site during the sampling	Sunny
Outside temperature	27°C
Contextual aspects considered (rainfall etc)	None

Describe the process source from which the biowaste/bio-residue stem	The biomass represent an agriculture residues that is outcome of the cultivation and harvesting process of the rice.
Category (field residue, farm or industry)	Industry/field – the straw was sampled at a collection point for the straw sales.

Brief site-specific description of the management of the biomass from which the sample is taken	The site represent stockholder responsible of collection, balling, and selling of the rice straw. The amount depending on the production rate of the rice in the area of collection. Solar is the main energy source.
Any visible environmental aspects seen at the site	Smoke or dust.
Present usage of the sampled biomass	As compost production, paper production and/or livestock feed About 20 -30% of the produced straw only uses and/or recycled.
Does biomass from which the sample is taken hold an economic or other value	As energy source by consumption in some cement factories and/or recycling into organic fertilizers.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The biomass represent a chopped form of the rice straw, which represent a lignocellulosic biomass.
Purity	About 92% rice straw
Colour	It is a yellowish colour
Wet/dry/mixed	dry
Particle size	up to 70 cm
Type of storage at site	In bales

Weight of sample before drying and milling	5 kg
Weight dried sample	4.7 kg
Weight reduction	6%

Pictures

Figure 35: Rice straw bales at the collection point

Figure 36: The rice straw bales at the composting site

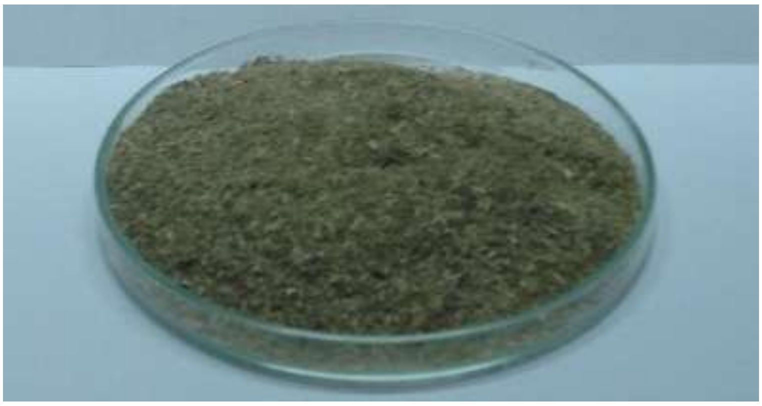

Figure 37: Dried and milled sample of rice straw

Sugarcane bagasse sourced from sugar mill

General

Biomass material	Sugarcane bagasse sourced from sugar mill
Id code of sample	SugBag 2013-5-03 EG Hawamdia a Abd-Wahab
Responsible project partner	ARC - Egypt

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** ~~Nutrient rich~~
Results	see below

	Result [%]
Dry matter (DM)	93.32
Ash content (Ash)	1.84

	Mass – [% of DM]
Glucan	38.62
Xylan	20.43
Arabinan	1.72
Klason Lignin	23.13

Glucan is the sum of starch and cellulose.

Details of the site and present use of the feedstock

Site name	Hawamdia - Giza
District or local community	El-Hawmdia City, belongs to Giza Governorate, some 20 km southwest of central Cairo.
Country	Egypt

Date(s) of sampling	3-May-2013
Weather at site during the sampling	Sunny
Outside temperature	About 28°C
Contextual aspects considered (rainfall etc)	None

Describe the process source from which the biowaste/bio-residue stem	Bagasse is a fibrous pulp material left over after the juice has been squeezed out of sugarcane stalks.
Category (field residue, farm or industry)	Industry

Brief site-specific description of the management of the biomass from which the sample is taken	Bagasse is originated from squeezed sugarcane stems in a sugar mill. Left out on concerted floor. For each 10 tonnes of sugarcane crushed, nearly 3 tonnes of wet bagasse is produced. Bagasse is continuously flow during all season.
Any visible environmental aspects seen at the site	None
Present usage of the sampled biomass	Bagasse is used fuel in sugar mills, also contribute in animal feed production and compost production.
Does biomass from which the sample is taken hold an economic or other value	Yes

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	Bagasse is the fibrous pulp material of sugarcane stalk.
Purity	97%of squeezed sugar cane stalks.
Colour	White to light green
Wet/dry/mixed	Wet
Particle size	<2.5 cm
Type of storage at site	In heaps and plastic bags.

Weight of sample before drying and milling	5 kg
Weight dried sample	4.3 kg
Weight reduction	14%

Pictures

Figure 38: Milling machine used for milling the samples Egypt

Figure 39: Weighing the sample

Figure 40: Pipetting the sample

Figure 41: Dried and milled bagasse Egypt

Sugarcane vinasse from processing industry

General

Biomass material	Sugarcane vinasse from processing industry
Id code of sample	SugVin 2013-5-03 EG a Abd-Wahab
Responsible project partner	ARC - Egypt

Summary and chemical characteristics

Nutrient and/or sugar rich	**Rich in simple sugars** ~~Starch rich~~ ~~Lignocellulosic~~ ~~Nutrient rich~~
Results	(see tables below)

	Result [%]
Dry matter (DM)	8.33*
Ash content (Ash)	32.88*

*The vinasse was in liquid form.

	Mass – [% of DM]
Glucan	7.37
Xylan	15.92
Arabinan	8.25
Klason Lignin	13.11

Glucan is the sum of starch and cellulose.

Details of the site and present use of the feedstock

Site name	Hawamdia - Giza
District or local community	El-Hawmdia City, belongs to Giza Governorate, on the west bank of the Nile, some 20 km southwest of central Cairo.
Country	Egypt

Date(s) of sampling	3-May-2013
Weather at site during the sampling	Sunny, hot and dry
Outside temperature	About 31^{o}C
Contextual aspects considered (rainfall etc)	Day: Sunny. Highs around 31°C. North northwest wind 9 to 24 KPH (6 to 15 MPH). Night: Clear. Lows around 26°C. Northwest wind 9 to 22 KPH (5 to 14 MPH).

Describe the process source from which the biowaste/bio-residue stem	The vinasse is the outcome product of molasses fermentation to produce the bioethanol.
Category (field residue, farm or industry)	Industry

Brief site-specific description of the management of the biomass from which the sample is taken	The factory site to produce sugar and various chemical compounds from the sugarcane. The production capacity of vinasse is 400 ton per year. The fresh vinasse shall to be collected in sterile polyethylene bottles directly from the industry site. Vinasse is the byproduct of the distillation procedure , with 9–20 liters of vinasse generated per liter of ethanol. Electricity and heat from bagasse consumption is the main energy resource.
Any visible environmental aspects seen at the site	Some filter mud cake leachate and smoke.
Present usage of the sampled biomass	Vinasse is also used as an additive or feed supplement for conventional ruminant and non-ruminant livestock.
Does biomass from which the sample is taken hold an economic or other value	Vinasse is used as additives for animal feed preparation and/or fertilized component as potassium source.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	Vinasse, stillage is a liquid of low viscosity at 25^{o}C
Purity	Vinasse is an aqueous solution containing both organic (e.g., carbohydrates, proteins, and vitamins) and inorganic (e.g., nitrogen, sulfur, and minerals) compounds;
Colour	Having a very dark brown.
Wet/dry/mixed	A liquid of low viscosity at 25^{o}C
Particle size	A liquid of low viscosity at 25^{o}C
Type of storage at site	Stored in High Density Polyethylene (HDPE) bottles or storage tanks.

Weight of sample before drying and milling	This sample was wet and used as it was (6.5kg)
Weight dried sample	Na
Weight reduction	Na (5l)

Pictures

Figure 42: The sample of sugarcane vinasse

Figure 43: The sample of sugarcane vinasse

GHANA

Council for Scientific and Industrial Research – Ghana (CSIR-GH)

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Banana waste, rejected green banana at plantation

General

Biomass material	Banana waste, rejected green banana at plantation
Id code of sample	BAF 2014-02-26 GH-Accra 1a Richard Bayitse
Responsible project partner	CSIR-GH

Summary and chemical characteristics

Nutrient and/or sugar rich

~~Rich in simple sugars~~
Starch rich
~~Lignocellulosic~~

~~Nutrient rich~~

Results

	Result [%]
Dry matter (DM)	95.4
Ash content (Ash)	6.19

	Mass – [% of DM]
Glucan	77.5
Xylan	3.0
Arabinan	3.0
Klason Lignin	8.3

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Golden Exotics Limited, Asutuare
District or local community	Asutuare
Country	Ghana

Date(s) of sampling	19th February, 2014
Weather at site during the sampling	Cloudy with intermittent sunny breaks
Outside temperature	26ºC
Contextual aspects considered (rainfall etc)	None

Describe the process source from which the biowaste/bio-residue stem	The banana waste comes from processing of banana fruits for export
Category (field residue, farm or industry)	Industry – packaging at plantation

Brief site-specific description of the management of the biomass from which the sample is taken	Golden Exotics Limited is the largest banana plantation in Ghana. They produce banana for export to EU market and sold small amount in Ghanaian market. The rejected banana waste is pure and is produced throughout the year. The waste is generated as a result of rejected fruits which failed to meet the required quality for export. About 20 MT of banana waste is estimated at the plantation but this amount is being processed by the plantation for composting. Knives are used to trim off the rejected banana fruits.
Any visible environmental aspects seen at the site	none.
Present usage of the sampled biomass	The rejected banana waste fruits were being processed for composting.
Does biomass from which the sample is taken hold an economic or other value	Yes.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The rejected banana waste fruits were being processed for composting.
Purity	Pure
Colour	Green
Wet/dry/mixed	Wet
Particle size	3-4 cm
Type of storage at site	In piles outside the banana processing facility.

Weight of sample before drying and milling	10.4 kg
Weight dried sample	6.4 kg
Weight reduction	38%

Pictures

Figure 44: Banana stocks ready for quality check and packaging

Figure 45: Banana stocks that will be quality checked, banana bunches will then be packed for export

Figure 46: Water is used to clean and transport the rejected banana

Figure 47: The rejected fruit is taken to the compost where it is later used for soil treatment on the plantation.

Figure 48: Close-up of dried and milled sample of rejected banana

Cassava beer processing waste

General

Biomass material	Cassava Beer Processing Waste
Id code of sample	CABPW 2014-02-03 GH-Accra 1a Richard Bayitse
Responsible project partner	CSIR-GH

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ **Starch rich** **Lignocellulosic** ~~Nutrient rich~~
Results	see tables below

	Result [%]
Dry matter (DM)	97.6
Ash content (Ash)	0.94

	Mass – [% of DM]
Glucan	92.5
Xylan	2.6
Arabinan	2.7
Klason Lignin	2.1

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Avekpo, Ve Kolonu
District or local community	Ve Kolonu
Country	Ghana

Date(s) of sampling	28th January, 2014
Weather at site during the sampling	Clear and sunny
Outside temperature	28ºC
Contextual aspects considered (rainfall etc)	None

Describe the process source from which the biowaste/bio-residue stem	The cassava waste comes from processing of cassava tuber for beer brewing
Category (field residue, farm or industry)	Industry

Brief site-specific description of the management of the biomass from which the sample is taken	The cassava waste generated on site comes from processing of cassava tuber into cassava dough for brewing of beer. The waste is generated from stuck cassava dough in the extruder after daily processing. Before fresh product is extruded, the initial product extruded is discarded as waste. The waste is normally extruded into a polythene bag and dumped at a refuse damp near the processing plant. The waste generated daily is about 100 kg. The quantity varies according to their production level. Production is not done every day and is dependent on the request from the brewery and the availability of cassava tubers. Normally cassava tubers are less available in the dry season than the wet season because of difficulties in harvesting, which also affects production. The processing plant uses diesel powered generator as a source of energy. The site is a medium scale cassava processing facility which processes cassava for breweries.
Any visible environmental aspects seen at the site	The environmental aspect at the side is leachate from cassava processing which is channelled into the nearby bush
Present usage of the sampled biomass	none
Does biomass from which the sample is taken hold an economic or other value	no

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The cassava waste is stored in polythene material and dumped on a refuse dump created at the processing plant.
Purity	The cassava waste is pure and not mixed with any other material
Colour	Dirty White
Wet/dry/mixed	Wet
Particle size	0.1-0.5 mm
Type of storage at site	In an open landfill (refuse dump)

Weight of sample before drying and milling	30.4 kg
Weight dried sample	20.6 kg (The sample was wet before drying commenced)
Weight reduction	32%

Pictures

Figure 49: The cassava processing plant for cassava beer brewery

Figure 50: Sampling in progress

Figure 51: Inside the cassava beer processing plant

Figure 52: The cassava processing plant

Figure 53: Pile of cassava processing waste

Figure 54: Dried and milled sample of cassava beer processing waste

Cassava Peel collected at small-scale cassava mill

General

Biomass material	Cassava Peel collected at small-scale cassava mill
Id code of sample	CAP 2014-02-11 GH-Accra 1a Richard Bayitse
Responsible project partner	CSIR-GH

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ **Starch rich** **Lignocellulosic** ~~Nutrient rich~~
Results	see tables below

	Result [%]
Dry matter (DM)	89.7
Ash content (Ash)	6.43

	Mass – [% of DM]
Glucan	83.4
Xylan	2.3
Arabinan	2.3
Klason Lignin	1.9

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Ayigbe Town
District or local community	Bawjiase
Country	Ghana

Date(s) of sampling	31st January, 2014
Weather at site during the sampling	Cloudy but warm with intermittent sunny breaks
Outside temperature	28ºC
Contextual aspects considered (rainfall etc)	None

Describe the process source from which the biowaste/bio-residue stem	The cassava peel comes from processing of cassava tuber
Category (field residue, farm or industry)	Industry (small scale)

Brief site-specific description of the management of the biomass from which the sample is taken	Ayigbe Town at Bawjiase is noted for small scale cassava processing into gari and agbelima, which are all local foods. Cassava is brought to the processing facility mostly by women. They hand peel the cassava and store the cassava peels in sacks after daily processing for sale to animal farmers. They sometimes discard the excess into refuse dump if they do not have market for them. The cassava peels are normally mixed with some rejected cassava tubers and trimmed head and bottom of the tubers which normally contain fibre. Quantitative assessment is a bit difficult as they process daily what the equipment can handle per day as well as the demand from the market. I will estimate cassava peel generated at the facility as 1000 kg. The site is a small scale cassava processing facility which processes cassava daily
Any visible environmental aspects seen at the site	The environmental aspect at the side is leachate from pressed cassava dough.
Present usage of the sampled biomass	For feeding animals
Does biomass from which the sample is taken hold an economic or other value	Yes it is sold to animal farmers.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The cassava peels on site are mixture of fresh and old ones. Some are put in sacks ready for sale to prospective clients.
Purity	The cassava peel is pure and not mixed with any other material
Colour	Brownish at the back and dirty white on the surface
Wet/dry/mixed	Wet
Particle size	1-6 mm
Type of storage at site	They are put in sacks and stored under shade after a day's operation. The excess is left in small piles under the shade. It worth mentioning that, the peeling is done at the same place so they need space to do that, hence excess waste is sent to refuse dump.

Weight of sample before drying and milling	10.4 kg
Weight dried sample	6.9 kg
Weight reduction	33% Note: The cassava peel was sun dried first to remove excess water before drying at 60ºC for 24 hours. The sample was cleaned removing the skin and the fibrous material and weighed. The sample was dried again for 24 hours and re-weighed but there was no change in weight. The sample was put in polythene material and sealed.

Pictures

Figure 55: Small-scale cassava processing industry

Figure 56: To the right are the cassava tubers that are peeled by hand.

Figure 57: Pile of cassava peels that have manually been peeled off.

Figure 58: Close-up of untreated cassava peels

Figure 59: Close-up of dried and milled cassava peels, small scale processing

Figure 60: Cleaning and sorting of cassava peel at CSIR-GH labs

Cocoa pods - empty, collected at cocoa plantation

General

Biomass material	Cocoa pods - empty, collected at cocoa plantation
Id code of sample	CPOD 2014-02-07 GH-Accra 1a Richard Bayitse
Responsible project partner	CSIR-GH

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ Lignocellulosic **Nutrient rich**
Results	see tables below

	Result [%]
Dry matter (DM)	95.00
Ash content (Ash)	14.00

	Mass – [% of DM]
Glucan	
Xylan	
Arabinan	
Klason Lignin	33.90

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Cocoa Research Institute of Ghana, New Tafo
District or local community	New Tafo
Country	Ghana

Date(s) of sampling	30th January 2014
Weather at site during the sampling	Sunny, with patches of cloud
Outside temperature	24ºC
Contextual aspects considered (rainfall etc)	None

Describe the process source from which the biowaste/bio-residue stem	The cocoa pod is a waste generated after the beans are removed from the pod for fermentation and drying
Category (field residue, farm or industry)	Plantation residue (one spot)

Brief site-specific description of the management of the biomass from which the sample is taken	Cocoa Research Institute of Ghana (CRIG) is a research institute established to provide research support for cocoa growing and processing in the country. Different high yielding cocoa varieties are developed and analysed for quality. The institute receives substantial quantities of cocoa from both out growers and their research farms for analysis, hence large volumes of cocoa waste is generated on site and kept under shed. About 50 MT of cocoa pod is estimated to be found at the site and the pod is not contaminated with any foreign material. Knife is used to split open the pod to remove the beans. The main source of energy for generating the waste is human labour inputs.
Any visible environmental aspects seen at the site	There is no visible environmental aspects
Present usage of the sampled biomass	The ash is used for soap production
Does biomass from which the sample is taken hold an economic or other value	Yes the ash is sold to local soap manufacturers.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The cocoa pods are put in piles and are mixture of dry and fresh samples with majority being dried. They looked brownish black with some few yellowish patches. Some have patches of mold growing on them.
Purity	Not very pure because of the growth of mold.
Colour	Brownish black with yellow patches on some of them
Wet/dry/mixed	Mixed
Particle size	About 3 cm
Type of storage at site	Under roof

Weight of sample before drying and milling	7.9 kg
Weight dried sample	4.0 kg
Weight reduction	50%

Pictures

Figure 61: Collection point at the plantation for the empty cocoa pods

Figure 62: Empty cocoa pods

Figure 63: Sampling in progress

Figure 64: Dried and milled empty cocoa pod sample

Cow dung collected at cattle sheds

General

Biomass material	Cowdung collected at cattle sheds
Id code of sample	CD 2014-01-21 GH-Accra 1a Richard Bayitse
Responsible project partner	CSIR-GH

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ ~~Lignocellulosic~~ **Nutrient rich**
Results	see tables below

	Result [%]
Dry matter (DM)	93.40
Ash content (Ash)	29.00

	Mass – [% of DM]
Glucan	
Xylan	
Arabinan	
Klason Lignin	27.70

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Frafraha (CSIR-Animal Research Institute
District or local community	Adenta Municipality
Country	Ghana

Date(s) of sampling	10th February 2014
Weather at site during the sampling	Sunny, with clear clouds
Outside temperature	27ºC
Contextual aspects considered (rainfall etc)	None

Describe the process source from which the biowaste/bio-residue stem	The cowdung came from cattle droppings
Category (field residue, farm or industry)	Farm

Brief site-specific description of the management of the biomass from which the sample is taken	CSIR-Animal Research Institute is a research institute which undertake research on animals and animal products. Among the animals they research on are cows. They practice intensive and semi-intensive animal husbandry, in which they keep some of the cows in their kraals and feed them with fodder whiles others are left to graze in the field during the day, and kept in their kraal during the night. Cowdung from the kraals is scraped and deposited in piles at a designated place in the farm. 400 cows are kept in the farm and they produce about 8000 kg of cowdung daily. Some of the cowdung is used as manure in their fodder fields. Cowdung is generated throughout the year The cows are raised in well controlled environment with adequate pasture for feeding. They are brought back to their kraal everyday in the evening, where substantial amount of dung is produced
Any visible environmental aspects seen at the site	There is no visible environmental aspects
Present usage of the sampled biomass	According to the farm manager, some of the dung is used as manure för soil conditioning
Does biomass from which the sample is taken hold an economic or other value	Currently there is no economic value, but it is sometimes used as manure.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The cowdung was piled in a dump with the top looking dried. Portions of the dung appeared fresh than others, indicating deferent time of adding new pile of dung
Purity	The cowdung was pure with no other material
Colour	Brownish with slightly greenish tint in the fresh dung
Wet/dry/mixed	The top and the old pile was dry while the inner portion and new additions were wet, hence it can be described as mixed
Particle size	1-6 mm
Type of storage at site	Was dumped in an open space in pile

Weight of sample before drying and milling	20.1 kg
Weight dried sample	4.5 kg
Weight reduction	77%

Pictures

Figure 65: Cattle sheds

Figure 66: Sampling in progress from the heap of dung in connection to the cattle sheds

Figure 67: Samples of dung are taken to the labs for drying and milling

Figure 68: Weighing of fresh cow dung in CSIR-IIR Material Laboratory

Figure 69: Milling of the cowdung sample at the CSIR-GH labs

Figure 70: Dried and milled sample of cow dung from heap of dung outside cattle shed

Oil palm fruit bunch – empty, collected at palm oil mill

General

Biomass material	Oil palm fruit bunch – empty, collected at palm oil mill
Id code of sample	EFB 2014-02-11 GH-Accra 1a Richard Bayitse
Responsible project partner	CSIR-GH

Summary and chemical characteristics

Nutrient and/or sugar rich	Rich in simple sugars Starch rich Lignocellulosic ~~Nutrient rich~~
Results	(see tables below)

	Result [%]
Dry matter (DM)	89.60
Ash content (Ash)	5.10

	Mass – [% of DM]
Glucan	
Xylan	
Arabinan	
Klason Lignin	29.50

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Twifo Praso
District or local community	Twifo Praso
Country	Ghana

Date(s) of sampling	29th January 2014
Weather at site during the sampling	Warm with rainy clouds
Outside temperature	27ºC
Contextual aspects considered (rainfall etc)	None

Describe the process source from which the biowaste/bio-residue stem	The palm bunch (empty fruit bunch) is generated from processing of palm fruit bunch.
Category (field residue, farm or industry)	Industry

Brief site-specific description of the management of the biomass from which the sample is taken	Twifo Oil Palm Processing (TOPP) is one of the largest oil palm processing company in Ghana. The palm bunch (empty fruit bunch) is derived from processing of palm fruit bunch for oil production. The empty fruit bunch forms about 20 % of the total production. About 17-18 % of empty fruit bunch is generated during the peak season from February to April generating about 120-130 MT a day. During the lean season which span from August- October and January produced 43 MT and 70 MT respectively. The main energy used for generating this waste is both electrical and biomass to generate steam for the process.
Any visible environmental aspects seen at the site	Smoke from the plant chimney
Present usage of the sampled biomass	According to the production manager, the empty fruit bunch is used as mulch in their plantation
Does biomass from which the sample is taken hold an economic or other value	Currently there is no economic value, but it is used as mulch in their plantations

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The empty fruit bunch are put in plies on the factory before transporting to the plantations
Purity	100 % Pure
Colour	Brownish
Wet/dry/mixed	Semi dry
Particle size	About 20 cm
Type of storage at site	Was dumped in an open space in pile

Weight of sample before drying and milling	42.0 kg
Weight dried sample	37.2 kg
Weight reduction	11%

Pictures

Figure 71: Oil palm mill

Figure 72: transportation of the fruit bunches to the oil palm mill

Figure 73: Heap of empty oil palm fruit bunches

Figure 74: sampling of empty fruit bunches in progress

Figure 75: Size reduction of the sampled empty fruit bunches before drying.

Figure 76: Sample ready for analysis

Pig manure from pig rearing farm

General

Biomass material	Pig manure from pig rearing farm
Id code of sample	PM 2014-02-03 GH-Accra 1a Richard Bayitse
Responsible project partner	CSIR-GH

Summary and chemical characteristics

Nutrient and/or sugar rich	Rich in simple sugars Starch rich Lignocellulosic **Nutrient rich**
Results	see tables below

	Result [%]
Dry matter (DM)	95.20
Ash content (Ash)	39.70

	Mass – [% of DM]
Glucan	
Xylan	
Arabinan	
Klason Lignin	22.00

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Goviefe Farms
District or local community	Goviefe, near Kpeve
Country	Ghana

Date(s) of sampling	28th January, 2014
Weather at site during the sampling	Sunny, and hot
Outside temperature	28ºC
Contextual aspects considered (rainfall etc)	The Pig Manure was piled in small hips around the style and also dumped in a dug out pit.

Describe the process source from which the biowaste/bio-residue stem	The Pig manure came from Pig droppings
Category (field residue, farm or industry)	Farm (pig rearing)

Brief site-specific description of the management of the biomass from which the sample is taken	Goviefe farms is a privately own medium scale Pig farm. The pigs are kept in the style and provided with food. There are separate rooms for different sizes of pigs. The manure is scooped from the style every morning and dumped in a dug out which was full as at the time of visit. Excess pig manure was put in small hips dotted around the style in the nearby bush. About 10 tonnes of pig manure can be estimated on site The pigs are raised in well controlled environment with adequate feeding and cleaning. The farm has won best district farmer award for 2012 for good animal husbandry.
Any visible environmental aspects seen at the site	There is no visible environmental aspects
Present usage of the sampled biomass	There is no current use for the pig manure
Does biomass from which the sample is taken hold an economic or other value	Currently there is no economic value.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The pig manure was dumped in a dug out pit and also put in small piles around the pig farm.
Purity	The pig manure was pure with no other material
Colour	Brownish
Wet/dry/mixed	The old pile in the dugout pit was dry while the small piles were wet.
Particle size	1-4 mm
Type of storage at site	Was dumped in an open space and in pit and covered

Weight of sample before drying and milling	11,0 g
Weight dried sample	4,5 g
Weight reduction	59%

Pictures

Figure 77: Pig sheds

Figure 78: Inside the pig sheds

Figure 79: Sampling in progress. To the left sampling from collection pit and to the right collection from heap

Figure 80: Close-up of untreated sample of pig manure (to the right) and dried and milled sample of pig manure (to the left).

Poultry droppings collected at research institute

General

Biomass material	Poultry droppings
Id code of sample	PD 2014-06-19 GH-Accra 1a Richard Bayitse
Responsible project partner	CSIR-GH

Summary and chemical characteristics

Nutrient and/or sugar rich	Rich in simple sugars Starch rich Lignocellulosic **Nutrient rich**
Results	(see tables below)

	Result [%]
Dry matter (DM)	94.10
Ash content (Ash)	29.70

	Mass – [% of DM]
Glucan	
Xylan	
Arabinan	
Klason Lignin	

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Frafraha (CSIR-Animal Research Institute
District or local community	Adenta Municipality
Country	Ghana

Date(s) of sampling	19th June 2014
Weather at site during the sampling	Warm and cloudy
Outside temperature	87ºC
Contextual aspects considered (rainfall etc)	None

Describe the process source from which the biowaste/bio-residue stem	The poultry droppings came from poultry birds
Category (field residue, farm or industry)	Farm (poultry)

Brief site-specific description of the management of the biomass from which the sample is taken	CSIR-Animal Research Institute is a research institute which undertake research on animals and animal products. Among the animals they research on are poultry birds. The birds are kept in cooks and the droppings mixed with wood chips are scooped frequently and dumped in hips close by bush in an open. About 1 ton of droppings are available on site. Because the waste is kept in an open, rain can leach some of the droppings. The birds are raised in well controlled environment with adequate feeding.
Any visible environmental aspects seen at the site	There is no visible environmental aspects
Present usage of the sampled biomass	According to the farm manager, some of the poultry droppings is used as manure
Does biomass from which the sample is taken hold an economic or other value	Currently there is no economic value, but it is sometimes used as manure.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The poultry droppings were piled in a dump
Purity	The droppings were not pure. Mixed with wood chips and some few feathers. Feathers were removed from the collected sample before milling and sieved to get the final sample.
Colour	Brownish
Wet/dry/mixed	Semi dry
Particle size	1-7 mm
Type of storage at site	Was dumped in an open space in pile

Weight of sample before drying and milling	8.0 kg
Weight dried sample	7.5 kg
Weight reduction	6%

Pictures

Figure 81: The poultry dropping heap

Figure 82: Close-up of the poultry dropping biomass sampled

Figure 83: Sampling of poultry droppings in progress.

Figure 84: Dried and milled sample of poultry droppings

Rice bran collected at small rice mill

General

Biomass material	Rice Bran
Id code of sample	RB 2014-02-21 GH-Accra 1a Richard Bayitse
Responsible project partner	CSIR-GH

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** **Nutrient rich**
Results	see tables below

	Result [%]
Dry matter (DM)	90.30
Ash content (Ash)	14.50

	Mass – [% of DM]
Glucan	38.00
Xylan	12.30
Arabinan	3.60
Klason Lignin	19.60

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	London Boy - Asutuare
District or local community	Asutuare
Country	Ghana

Date(s) of sampling	19th February 2014
Weather at site during the sampling	Sunny, with few patches of cloud
Outside temperature	27ºC
Contextual aspects considered (rainfall etc)	None

Describe the process source from which the biowaste/bio-residue stem	Rice bran is a process waste generated after milling of paddy rice
Category (field residue, farm or industry)	Industry

Brief site-specific description of the management of the biomass from which the sample is taken	London Boy Mill is one of the small scale rice mills dotted at Asutuare. Rice bran is derived from paddy rice after milling. The bran is kept in 25 kg bags and stored for sale to prospective buyers. The quantity of rice bran generated depends on the amount of paddy milled. The availability of paddy is seasonal although they mill throughout the year. Production is increased during major season in August and minor season from January to May. Rice bran is about 95 % pure mixed with about 5 % of husk. About 18 MT of rice bran is stored in the store room. The main energy sources used is fossil fuel (Diesel). The rice milled here is not parboiled
Any visible environmental aspects seen at the site	no
Present usage of the sampled biomass	As animal feed
Does biomass from which the sample is taken hold an economic or other value	Yes it is sold to animal farmers.

Describe the basis of selection for taking sample from this specific site	The rice mill operates throughout the year

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The rice bran was packaged in 25 kg bags and stored
Purity	About 95 % pure
Colour	Brownish
Wet/dry/mixed	dry
Particle size	1-3 mm
Type of storage at site	Under roof

Weight of sample before drying and milling	41.9 kg
Weight dried sample to be stored/distributed	41.9 kg
Weight reductionto be stored/distributed	~0%

Pictures

Figure 85: Operation inside the London boy mil. Packing of the milled rice.

Figure 86: The paddy rice is dried in the sun outside the mill. The paddy will not need to be parboiled before it is milled.

Figure 87: Coning and quartering, and packing of the final sample.

Figure 88: Close up of final sample of rice bran Ghana.

KENYA

African Institute for Capacity Development (AICAD)

Andrew B. Gidamis (lead scientist)

Daniel Ndaka Sila

(Characterisation of samples done by Richard Bayitse and Xiaoru Hou)

Cabbage packaging from waste at food processing plant

General

Biomass material	Cabbage packaging from waste at food processing plant
Id code of sample	CW 2014-04-18 KN- Njoro 1a Sila
Responsible project partner	AICAD

Summary and chemical characteristics

Nutrient and/or sugar rich	Rich in simple sugars ~~Starch rich~~ Lignocellulosic **Nutrient rich**
Results	(see tables below)

	Result [%]
Dry matter (DM)	97.60
Ash content (Ash)	13.11

	Mass – [% of DM]
Glucan	
Xylan	
Arabinan	
Klason Lignin	15.10

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Njoro Canners Factory Ltd
District or local community	Molo, 25km from Nakuru
Country	Kenya

Date(s) of sampling	18th April 2014
Weather at site during the sampling	Sunny, no clouds
Outside temperature	About 26°C
Contextual aspects considered (rainfall etc)	It was a sunny day, no rain

Describe the process source from which the biowaste/bio-residue stem	The waste is generated from freshly harvested cabbages which are either dehydrated or sold as frozen mixed vegetables. The old, soiled and yellow looking leaves are manually removed and put in crates ready for disposal
Category (field residue, farm or industry)	Industry (vegetable packaging)

Brief site-specific description of the management of the biomass from which the sample is taken	Njoro Canners is situated 25km from Nakuru town, about 150m from the main gate of Egerton University. The factory processes dehydrated vegetables, frozen vegetables, spices, jams and marmalades, relishes and pickles among others. During vegetable processing, the old , diseased and spoiled cabbage leaves are plucked out from the cabbage head. The waste is put into crates that are stacked above each other for disposal in the late hours of the day. The amounts available on that day were approximately 1000kg, though operations run on daily basis. Production of vegetable waste is seasonal based on the seasonal planting of the crop. There are two seasons in a year, November – Jan and March to July every year. The waste comprises mostly of rejects: soiled, old yellowish leaves, diseased leave, and the cabbage stalk. The firm uses mostly firewood powered steam boilers located at each of the 5 processing lines. Hydroelectric power is used for lighting. Njoro Canners ha a high turnover of processed leafy vegetables either as dehydrated or frozen food material. The factory is located in the main agricultural basket area for Kenya producing large volumes of cabbages, carrots, kales among indigenous vegetables such as vegetable amaranth.
Any visible environmental aspects seen	No
Present usage of the sampled biomass	The waste is currently given to farmers as animal feed or for compost manure
Does biomass from which the sample is taken hold an economic or other value	Sold at a low cost to dairy farmers

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The sample was taken from crates of waste materials which had previously been plucked during cleaning and preparation of cabbage heads prior to processing.
Purity	The material was 100% cabbage
Colour	The sample contained mostly of green whitish leaves with occasional yellow patches.
Wet/dry/mixed	The samples were wet
Particle size	The sample comprised of whole cabbage leaves defoliated from the cabbage head
Type of storage at site	The sample was put in crates and stacked one after the other in a closed roofed area.

Weight of sample before drying and milling	63 kg
Weight dried sample	6.5 kg
Weight reduction	90%

Pictures

Figure 89: Reception and weighing bay at Njoro Canners at the Vegetable Dehydration Plant

Figure 90: A section of the crates in which the waste was put in

Figure 91: A close up of cabbage waste in a crate

Figure 92: Sampling of cabbage waste from crates

Figure 93: Oven drying of cabbages at department of Food Science and Technology Workshops, Kenya

Figure 94: Milling of dried cabbage waste using a hammer mill

Figure 95: A close up of dried cabbage in the feed Hopper

Figure 96: A close up of dry cabbage sample

Figure 97: Final sample after drying and milling

Cassava peels and trimmings processing plant

General

Biomass material	Cassava peels and trimmings from processing plant
Id code of sample	CPT 2014-04-21 KN- Mbuvo 1a Sila
Responsible project partner	AICAD

Summary and chemical characteristics

Nutrient and/or sugar rich

~~Rich in simple sugars~~
Starch rich
Lignocellulosic

~~Nutrient rich~~

Results

	Result [%]
Dry matter (DM)	97.10
Ash content (Ash)	5.01

	Mass – [% of DM]
Glucan	19.90
Xylan	8.10
Arabinan	8.20
Klason Lignin	20.00

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Mbuvo Commercial Village
District or local community	Kathonzweni, Makueni County
Country	Kenya

Date(s) of sampling	21st April 2014
Weather at site during the sampling	Sunny, no clouds
Outside temperature	About 29°C
Contextual aspects considered (rainfall etc)	It was a sunny day, no rain

Describe the process source from which the biowaste/bio-residue stem	The waste comprises mostly of cassava peels, diseased or over mature cassava root tubers
Category (field residue, farm or industry)	Industry

Brief site-specific description of the management of the biomass from which the sample is taken	Mbuvo Commercial Village is a community-based organization that consists of 10 self-help groups, and has a membership of 427, all from Makueni County in Kenya. Membership is drawn mostly from farmers who have interest in cassava farming. After 8 months of taking care cassava cuttings, cassava farmers in this area can harvest their produce. A number of value added products are available. Most of the products are flour based food products (Ugali, Chapati), chips or deep fried cassava tubers. Most of the waste is generated from the peeling of cassava. Diseased and over mature tubers are also discarded. After peeling, the waste is sun dried or damped directly in the farm to compost. The amounts available at the site were rather low since there was no processing on that day. Cassava waste can be found throughout the year since farmers' plant at different seasons. A crop becomes ready for harvesting after 8 months. A few farmers irrigate their farms. Most of the operations are powered using diesel engine. The choice of Mbuvo commercial village was inspired by the fact that the commercial village is involved in the whole value chain of cassava. The group forms a nucleus for improved cassava production but there is centralized processing and value addition among all the farmers. This group was picked due to its cooperative nature. In Jan 2014, the group planted 67,000 cassava cuttings to increase its productivity. The yield per hectare is approximately 40tonnes.
Any visible environmental aspects seen	No
Present usage of the sampled biomass	Cassava waste is basically used as compost manure or animal feed
Does biomass hold an economic value	No

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The sample was sourced from a compost pit in a farm near the processing plant.
Purity	100% Cassava
Colour	Brown peels and white flesh. Flesh had dark marks for the aged ones
Wet/dry/mixed	The samples were wet
Particle size	The sample consisted of whole and diced cassava pieces of various sizes
Type of storage at site	Open disposal in a compost pit

Weight of sample before drying and milling	52.0kg
Weight dried sample	15.5kg
Weight reduction	70%

Pictures

Figure 98: Mbuvo Commercial Village at Kathonzweni, Makueni County

Figure 99: Cassava waste at the Mbuvo Commercial Village

Figure 100: A close up of cassava reject materials

Figure 101: A mobile chipper used for size reduction of the cassava waste materials

Figure 102: Cassava waste material that is being sun dried after chipping

Figure 103: Oven drying of cassava chips at the Food Science Workshop, JKUAT

Figure 104: Close-up of sample in the feed hopper of the mill

Figure 105: Cleaning a hammer mill in preparation for cassava milling

Figure 106: The inner part of the hammer mill used for milling

Figure 107: Dried and milled sample of the cassava trims and peels

Coffee husk from coffee mill

General

Biomass material	Coffee husk from coffee mill
Id code of sample	CH 2014-04-10 KN- Ruiru 1a Sila
Responsible project partner	AICAD

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** ~~Nutrient rich~~
Results	see tables below

	Result [%]
Dry matter (DM)	97.90
Ash content (Ash)	2.14

	Mass – [% of DM]
Glucan	32.60
Xylan	24.40
Arabinan	24.40
Klason Lignin	7.30

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Kofinaf Company Litd
District or local community	Ruiru, Kiambu County
Country	Kenya

Date(s) of sampling	10th April 2014
Weather at site during the sampling	Sunny, no clouds
Outside temperature	About 27°C
Contextual aspects considered (rainfall etc)	It was a sunny day, no rain

Describe the process source from which the biowaste/bio-residue stem	The waste is generated from husking of coffee beans before grading, classification and final packing
Category (field residue, farm or industry)	Industry

Brief site-specific description of the management of the biomass from which the sample is taken	Kofinaf Company Limited is located near Ruiru town about 10km from Thika road following the Kimbo exit. The company receives coffee beans from farmers. The silver lining protecting the coffee bean is removed by pressing the parchment coffee against a drum which expels the husk. Husks are separated from the coffee beans and the husk is blown out into an open land fill. The amount available during the day of sampling was about 5 tonnes. The husks are then put in gunny bags or loaded into trucks for sale as a source of energy. The amount varies largely based on the season of coffee production, the peak periods being November to February (main crop) and May – July (Fly crop). Coffee husk is generally used as a source of energy for firing brick kilns at Clay Works Kenya Ltd. Kofinaf is a well-organized coffee milling factory. There is a clear operation structure. Though they generate a lot of husk that could contribute to power generation internally, none is used for that purpose.
Any visible environmental aspects seen at the site	Dust
Present usage of the sampled biomass	Coffee husk is currently sold at a price Ksh 5.00/kg as a source of energy. A few SMEs use it for making coffee briquettes
Does biomass from which the sample is taken hold an economic or other value	See above

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	Freshly milled husk was a bit yellowish in color and was found in the middle of the landfill. However, the older material had lost their bright glossiness due to open storage.
Purity	The material was 100% coffee husk
Colour	The sample contained mostly of freshly milled coffee husk which was bright yellow
Wet/dry/mixed	The samples were dry
Particle size	The sample was a mixture of small particle sizes (powder) as well as whole expelled husk
Type of storage at site	Open air storage in a landfill was practiced

Weight of sample before drying and milling	12.0 kg
Weight dried sample	10.0 kg
Weight reduction	17%

Pictures

Figure 108: Gunny bags packaged with coffee husk ready for sale

Figure 109: Landfill at Kofinaf for disposing coffee husk as well as collection of husk for sale.

Figure 110: Collection of sample at the freshly expelled husk

Figure 111: Preparation of cones in readiness for sampling

Figure 112: Milling of coffee husks using a hammer mill

Figure 113: Dried and milled sample of coffee husk

Coffee pulp from coffee mill

General

Biomass material	Coffee pulp from coffee mill
Id code of sample	CP 2014-04-17 KN- Ruiru 1a Sila
Responsible project partner	AICAD

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** **Nutrient rich**
Results	(see tables below)

	Result [%]
Dry matter (DM)	96.10
Ash content (Ash)	10.00

	Mass – [% of DM]
Glucan	32.10
Xylan	20.20
Arabinan	20.20
Klason Lignin	26.70

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Kofinaf Company Litd
District or local community	Ruiru, Kiambu County
Country	Kenya

Date(s) of sampling	17th April 2014
Weather at site during the sampling	Sunny, no clouds
Outside temperature	About 27°C
Contextual aspects considered (rainfall etc)	It was a sunny day, no rain

Describe the process source from which the biowaste/bio-residue stem	The waste is generated after mechanically pulping coffee cherries to get parchment coffee
Category (field residue, farm or industry)	Industry

Brief site-specific description of the management of the biomass from which the sample is taken	Kofinaf Company Limited is located near Ruiru town about 10km from Thika road following the Kimbo exit. The company receives mature ripe coffee cherries from farmers. The cherries are mechanically pulped at the factory to produce parchment coffee. The pulp is then pumped through open channels into waste disposal area. It is kept under open storage and the amount available at the site during collection was rather low. The amount varies largely based on the season of coffee production, the peak periods being November to February (main crop) and May – July (Fly crop). Coffee pulp is generally is used a compost manure in the coffee farms. The main source of power is electricity.
Any visible environmental aspects seen at the site	A lot of water is used in the process There is a large amount of solid organic waste at the site
Present usage of the sampled biomass	Coffee pulp is currently being use for compost manure in the neighbouring coffee farms
Does biomass from which the sample is taken hold an economic or other value	No

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	Freshly removed coffee pulp was piled into heaps in each collection tank before final transfer into an open landfill
Purity	The material was 100% coffee pulp
Colour	The sample was mostly red, with a few orange and green cherries
Wet/dry/mixed	The samples was wet
Particle size	The sample was the size of coffee bean
Type of storage at site	Open air storage in a landfill was practiced

Weight of sample before drying and milling	55.0 kg
Weight dried sample	6.7 kg
Weight reduction	88%

Pictures

Figure 114: Coffee pulp in disposal tanks

Figure 115: Drying coffee pulp in a solar dryer at 70’C

Figure 116: A close up of the samples in the dryer

Figure 117: Close-up of the final dried and milled sample of coffee pulp

Flower waste from greenhouse plantations

General

Biomass material	Flower waste from greenhouse plantations
Id code of sample	FW 2014-04-29 KN- Juja 1a Sila
Responsible project partner	AICAD

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** ~~Nutrient rich~~
Results	see tables below

	Result [%]
Dry matter (DM)	96.40
Ash content (Ash)	6.83

	Mass – [% of DM]
Glucan	
Xylan	
Arabinan	
Klason Lignin	21.00

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Penta Flowers Juja
District or local community	Juja, Kiambu County
Country	Kenya

Date(s) of sampling	29st April 2014
Weather at site during the sampling	Sunny, no clouds
Outside temperature	About 28°C
Contextual aspects considered (rainfall etc)	It was a sunny day, no rain

Describe the process source from which the biowaste/bio-residue stem	The waste largely comprises of reject flowers obtained after sorting and grading cut flower. It consists of twigs, leaves and the floral part. Most of what was found on the collection site was rose flowers.
Category (field residue, farm or industry)	Greenhouse

Brief site-specific description of the management of the biomass from which the sample is taken	Penta flower farm is located about 8km from Thika highway in Juja area, Kiambu county. The company specializes on exporting intermediate open roses into the European markets. It currently grows roses under 25ha of greenhouses for export on fresh basis. The farm is rapidly expanding within Juja and Thika area. It uses greenhouse technology for continuous production of the flower cuttings. It employs many people from the neighborhood. After picking, the flowers are transported to the main plant where they are sorted and graded. Reject materials are piled into a heap which eventually is disposed next to the factory in open bins. There is a large open damping site near the factory with piles of dry flowers. The amount of accumulated waste available is massive, and it increases every day with additional waste coming from the plant. The farm is irrigated so production is done throughout the year. Hydroelectric power from the national grid is used for lighting and cold storage where need be. The flowers are transported using reefers to the airport for shipping.
Any visible environmental aspects seen	The plant processes about 60,000 flower stems /day and this generates alot of waste
Present usage of the sampled biomass	The waste is composted for manure or red worms are used to degrade the material to form vermi-compost that is used for fertilisation purposes
Does biomass from which the sample is taken hold an economic or other value	No

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The sample comprised of freshly harvested rose flower reject materials heaped in huge piles.
Purity	100% Cut flowers
Colour	Green leafed stems with carnations of various colors
Wet/dry/mixed	The samples were wet
Particle size	The sample consisted mainly of about 30cm of rose flower stems with attached carnations
Type of storage at site	Open disposal in a compost pit.

Weight of sample before drying and milling	42.0 kg
Weight dried sample	7.5 kg
Weight reduction	82%

Pictures

Figure 118: A section of the Green houses used for planting flower at Penta Flowers at Juja

Figure 119: Rejected flowers

Figure 120: A Pile of fresh Rose flowers that were rejects for the day

Figure 121: Flower waste in the back of the greenhouses

Figure 122: Greenhouse solar dryer used for predrying of flours (temperature 45-50^{o}C at peak hours)

Figure 123: Close-up of sample inside trays in the solar dryer

Figure 124: Milling of flowers in tractor driven hammer mill

Figure 125: Solar drying of milled flowers, this also constitutes the form of the final sample

Open Market vegetables waste

General

Biomass material	Open Market vegetables waste
Id code of sample	PMW 2014-05-16 KN- Limura 1a Sila
Responsible project partner	AICAD

Summary and chemical characteristics

Nutrient and/or sugar rich	Rich in simple sugars ~~Starch rich~~ Lignocellulosic **Nutrient rich**
Results	see tables below

	Result [%]
Dry matter (DM)	90.40
Ash content (Ash)	10.29

	Mass – [% of DM]
Glucan	
Xylan	
Arabinan	
Klason Lignin	19.90

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Open air market at Limura road
District or local community	Nairobi
Country	Kenya

Date(s) of sampling	16th May 2014
Weather at site during the sampling	Sunny, no clouds
Outside temperature	About 27°C
Contextual aspects considered (rainfall etc)	It was a sunny day, no rain

Describe the process source from which the biowaste/bio-residue stem	The waste largely comprises of plant material waste obtained mainly from fruits and vegetable, maize combs, beans and peas
Category (field residue, farm or industry)	Market waste

Brief site-specific description of the management of the biomass from which the sample is taken	City Park Market is mainly a fresh fruits and vegetable market located in Parklands area of Nairobi, opposite Agakhan hopsital. It occupies approximately a 3 acre piece of land. The market is controlled by the city council. The vendors at the market sort out agricultural waste from various crops and dispose them off in an open landfill ready for collection by the city council. Up to 5 tonnes of fresh and putrefied waste was available at the time of collection. There is no seasonal variability since the market is open throughout the year. The waste comprises all of kinds of waste, some at a very advanced state of rotting while some is in fresh state. The main source of energy at the market is electricity from the national grid. *Note from sampling:* A self tour was done by talking to the vendors in the market and assessing the type of products they sale and how they dispose off their waste. After establishing a rapport with the opinion leaders at the site, sampling began. A random sampling procedure was applied, where up to a maximum of 5kg of waste was collected from 18 vendors at the market. Samples contained a mixture of all kinds of plant waste.
Any visible environmental aspects seen at the site	The solid waste is a major pollution hazard for the area. Leachate percolates in the drainage stream on the side of the disposal landfill
Present usage of the sampled biomass	Fresh waste is collected by street boys for animal feed, the city council does not use it.
Does biomass from which the sample is taken hold an economic or other value	No

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The sample comprised of a mixture of agricultural waste at different stages of rotting The quality of the waste varies greatly from vendor to vendor. A lot needs to be done to separate agricultural waste from other kinds of waste.
Purity	90% Agricultural waste
Colour	It ranged from green for leafy vegetables, red (fruits) and most of the rotten sample was dark
Wet/dry/mixed	Mixed sample of dry and wet materials
Particle size	A broad range of waste materials
Type of storage at site	Open disposal in a compost pit

Weight of sample before drying and milling	90.0 kg
Weight dried sample	11.7 kg
Weight reduction	87%

Pictures

Figure 126: A close up on some of the vegetables and fruits exhibited for sale in City Park Market

Figure 127: Inside the market and the vendor stalls

Figure 128: Inside the market and the vendor stalls

Figure 129: Waste Disposal area at City Park Market- embedded are street boys collecting waste for animal feed (pig)

Figure 130: Sampling in progress

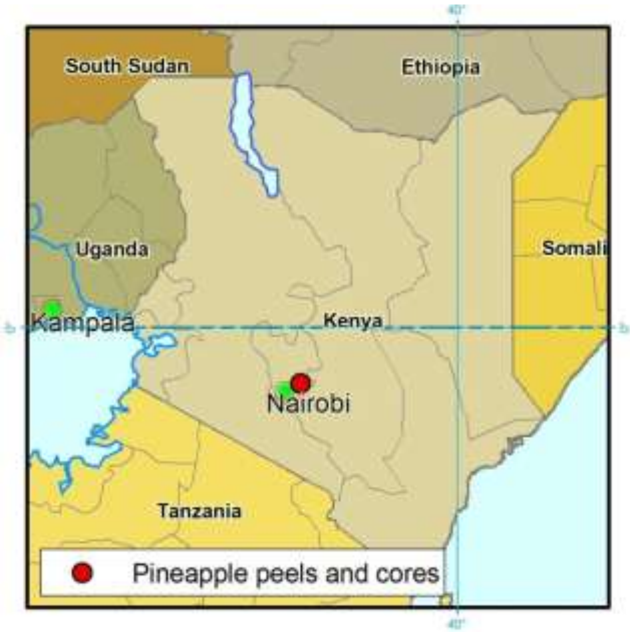
Figure 131: Sorting of waste before drying at JKUAT

Figure 132: Sample separated based on ease of decay and plant source

Figure 133: Milling of the sample using a tractor driven hammer mill

Figure 134: Dried and milled sample of market biowaste

Pineapple peels and used cores from processing



General

Biomass material	Pineapple peels and used cores from processing industry
Id code of sample	PPC 2014-05-03 KN- Thika 1a Sila
Responsible project partner	AICAD

Summary and chemical characteristics

Nutrient and/or sugar rich	**Rich in simple sugars** ~~Starch rich~~ **Lignocellulosic** ~~Nutrient rich~~
Results	see below

	Result [%]
Dry matter (DM)	97.80
Ash content (Ash)	2.53

	Mass – [% of DM]
Glucan	53.10
Xylan	6.40
Arabinan	6.50
Klason Lignin	4.40

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Thika town
District or local community	Thika
Country	Kenya

Date(s) of sampling	3rd May 2014
Weather at site during the sampling	Sunny, no clouds
Outside temperature	About 25°C
Contextual aspects considered (rainfall etc)	It was a sunny day, no rain

Describe the process source from which the biowaste/bio-residue stem	The waste is generated during the peeling and removal of cores from whole pineapples in the process of canning pineapple pieces and juice extraction.
Category (field residue, farm or industry)	Industry

Brief site-specific description of the management of the biomass from which the sample is taken	Delmonte Kenya Ltd is a food processing company that operates cultivation, production, canning of pineapple products. The company produces canned pineapple pieces, juice concentrates and ready to drink juices. The company head office is located approximately around 10km from Thika town and has extensive pineapple growing land. It has a processing capacity of about 1500tonnes of pineapples per day. Most of the operations in the company are automated. After peeling and core removal, the by products are conveyed to a number of mills where they are shredded and squeezed for maximum juice removal. The pressed cake is then transported to waiting trucks for sale either as animal feed or for compost manure preparations. Production is done throughout the year by strategically staggering the planting of the material. During off rain seasons, irrigation farming is embraced. The company produces large amounts of waste during the days of production. The main source of energy is a steam boiler which is fired with furnace oil. The company has intention of investing in clean energy development systems to facilitate their own operations and export the excess energy into the national grid.
Any visible environmental aspects seen at the site	No
Present usage of the sampled biomass	Most of the pomace is sold directly as animal feed . The excess is treated and send back to the farm as compost manure.
Does biomass from which the sample is taken hold an economic or other value	Yes, 1 tonne is sold at Ksh. 900 at the factory

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The sample was taken from moving conveyor belts as they were being directed to waiting trucks either for sale or for composting There is also a waste linked to the harvest of the pineapple. These stocks are according to the site manager left at the farmers and burned after every four years (ratoon crop).
Purity	The material was 100% pineapple waste For each of the waste lines (peel or core), 5 kg of sample was collected at intervals 5 minutes between each batch until approximately 40 kg was obtained from the moving conveyor belt. The samples were taken to JKUAT for drying. Once dry, the pineapple peels were homogeneous-ly mixed with the core at equal volumes before milling.
Colour	Pineapple cores were green with patches of cream yellow while the cores were cream yellow to white
Wet/dry/mixed	The samples were wet
Particle size	The sample consisted of diminuted pineapple waste which had earlier been macerated and pressed
Type of storage at site	The waste was channelled to waiting trucks

Weight of sample before drying and milling	80.0 kg
Weight dried sample	11.9 kg
Weight reduction	85%

Pictures

Figure 135: Pineapple reception area: Pineapples being offloaded from trucks

Figure 136: A section of Pineapple peel conveyor belt

Figure 137: Pineapple core coming out after the press

Figure 138: Waste discharge area: Trucks being loaded with pineapple waste

Figure 139: Sampling at the pineapple peel conveyor belt

Figure 140: Four samples consisting of pineapple peel (greenish) and pineapple core (whitish) waste

Figure 141: A close up of pineapple core waste (to the left) and close up of pine-apple peel waste (to the right).

Figure 142: Dried and milled final sample of mixed core and peels pineapple processing waste

Sisal decortications processing waste

General

Biomass material	Sisal decortications processing waste
Id code of sample	SDW 2014-04-15 KN- Nakuru 1a Sila
Responsible project partner	AICAD

Summary and chemical characteristics

Nutrient and/or sugar rich	Rich in simple sugars Starch rich Lignocellulosic **Nutrient rich**
Results	see tables below

	Result [%]
Dry matter (DM)	95.20
Ash content (Ash)	8.17

	Mass – [% of DM]
Glucan	
Xylan	
Arabinan	
Klason Lignin	17.90

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Athinai Sisal Factory
District or local community	Nakuru
Country	Kenya

Date(s) of sampling	15th April 2014
Weather at site during the sampling	Sunny, no clouds
Outside temperature	About 26°C
Contextual aspects considered (rainfall etc)	Sisal processing was ongoing: the fresh and old solid and liquid waste was heaped in one place. Workers were removing the solid waste for further processing

Describe the process source from which the biowaste/bio-residue stem	The waste was collected from a sisal factory which operates all year round in Kabarak. The factory has subcontracted sisal farmers who grow the crop all year round at staggered rate to ensure all year round supply
Category (field residue, farm or industry)	Industry

Brief site-specific description of the management of the biomass from which the sample is taken	The waste is obtained from a land fill in a sisal factory at Athinai. The plant decorticates about 3.5 tonnes of sisal per day of which the liquid and solid waste are channelled directly to a land fill about 100m from the processing plant. There was a high volume of waste available at the site > 40 tonnes, based on the estimated amounts on the site. Once in the landfill the solid waste is separated from the liquid waste and sun dried. After attaining moisture content below 15%, it is then baled and put in a well-ventilated building from where it is sold to interested clients. Processing of sisal takes place all year round. The factory has subcontracted farmers within the same vicinity to plant and manage the crop. This makes it a suitable area because of its socio-economic importance. Visually , the waste mostly comprises of fibrous material with a lot of organic matter attached on it from the leaves
Any visible environmental aspects seen at the site	The disposal site is soggy in the middle. The working conditions at the site are not good.
Present usage of the sampled biomass	The waste is currently used for animal feed, manure, as holding materials for buildings, as fillers for sofa set making
Does biomass from which the sample is taken hold an economic or other value	The sisal waste is sold to any willing buyer.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The sample was taken from a heap of sisal waste located about 100m from the main decorticating plant. The mill is served with sisal which is grown in the neighboring area. Once it grows to the required maturity , the leaves of the plant are harvested and transported using tractors to the factory from which they are processed into fibre, dried, brushed, graded and baled ready for sale. The waste comprises of old and new material heaped in a landfill. Solid materials are pulled out of the disposal channel to reduce the amount of water on them, spread on grass and sun dried until the moisture content is 15%. The sample was collected from freshly decorticated sisal waste in the middle of the land fill.
Purity	The material is pure sisal waste
Colour	Freshly decorticated material is green but turns brownish after drying
Wet/dry/mixed	The sample was very wet
Particle size	Fibrous and intertwined into a mesh which was difficult to separate
Type of storage at site	The sample is found in a landfill next to the decorticator. After drying the sample is kept under a roofed area for sale

Weight of sample before drying and milling	68.0 kg
Weight dried sample	7.5 kg
Weight reduction	89%

Pictures

Figure 143: Athinai Sisal factory. The channel is where the watery residue from pressing the sisal is transported for disposal.

Figure 144: Athinai Sisal Factory in Nakuru- Finished product being dried

Figure 145: Sisal from the farm being delivered to the Factory for decortication

Figure 146: Sisal decortication process

Figure 147: Landfill for disposing sisal waste

Figure 148: Fresh sisal waste after decortication

Figure 149: Removal of solid waste from the waste delivery channel for sampling

Figure 150: Close-up of the sisal biowaste, fresh in the disposal channel to the right and slightly dried on the left

Figure 151: Bales of the treated biowaste from the sisal processing ready for sale

Figure 152: Bales of the final sisal product ready for sale

Figure 153: Drying of sisal waste in an electric assisted solar dryer (70^oC)

Figure 154: Milling the sisal processing biowaste with a hammer mill

Figure 155: Dried and milled sisal processing biowaste

Sugarcane Bagasse from sugar mill

General

Biomass material	Sugarcane Bagasse
Id code of sample	SB 2014-04-28 KN- Mumias 1a Sila
Responsible project partner	AICAD

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** ~~Nutrient rich~~
Results	see below

	Result [%]
Dry matter (DM)	96.40
Ash content (Ash)	5.05

	Mass – [% of DM]
Glucan	
Xylan	
Arabinan	
Klason Lignin	22.80

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Mumias Sugar Company Ltd
District or local community	Mumias
Country	Kenya

Date(s) of sampling	28th April 2014
Weather at site during the sampling	Sunny, no clouds
Outside temperature	About 27°C
Contextual aspects considered (rainfall etc)	It was a sunny day, no rain

Describe the process source from which the biowaste stem	The waste is generated from crushing of sugarcane to produce juice which is crystallized into brown sugar
Category (field residue, farm or industry)	Industry

Brief site-specific description of the management of the biomass from which the sample is taken	Mumias Sugar is a the leading producer of brown sugar in Kenya and it has diversified its operations into electricity production and ethanol. The company has a capacity to produce 34MW of electricity of which 26MW is exported to the national grid. It also has the capacity to produce 24 million liters of water and 22 million litres of Ethanol annually. The Factory is supplied with cane from both the Nucleus Estate and from the indigenous Out grower farmers. On maturing the cane is harvested either manually or mechanically and transported to the site for sugar production (core business). It is then milled and the juice extracted. The solid waste (bagasse) is heaped into large mountains of waste at a moisture content of 50%. This is utilized for firing of steam boilers which are used in the generation of electricity for local use and export. A large volume of bagasse is produced daily. The plant has the capacity to mill 360tonnes/hr of sugarcane of which bagasse is 37% the weight of un-milled cane. Most of the energy used in the industry is generated internally from the steam engines which are fired using bagasse. Additional bagasse is bought from neighboring sugar factories to increase the feedstock for energy production. It is the only sugar factory in Kenya which generates its own electricity from sugar waste and exports the excess electricity to the national grid.
Any visible environmental aspects seen	No
Present usage of the sampled biomass	Most of the bagasse is used for firing of boilers which are used for generation of electricity
Does biomass from which the sample is taken hold an economic or other value	Yes, the extra power produced by burning bagasse is sold to Kenya Power and Lightening Company, which is fed to the local electricity grid. Mumias sugar could serve as a good example to other companies' in terms of implementing waste management. They have turned what would have been a menace to income.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The sample was taken found in large heaps and had a moisture content of about 50%. It was stored under a roofed area without walls
Purity	The material was 100% bagasse
Colour	The sample was brown in colour
Wet/dry/mixed	The samples semi wet.
Particle size	The sample comprised of a diverse range of particle sizes
Type of storage at site	The bagasse is stored under a roofed storage area in big heaps. The area was not confined in walls. It is from here where it is taken to the boiler rooms as a source of energy

Weight of sample before drying and milling	16.0 kg
Weight dried sample	9.6 kg
Weight reduction	40%

Pictures

Figure 156: An outside view of Mumias Sugar Factory indicating steam exhausting from the company

Figure 157: A section of the heap of Bagasse at Mumias Sugar Factory

Figure 158: A pilot plant solar dryer equipped with an electric heating coil to supplement solar energy

Figure 159: A close of bagasse samples in the solar dryer

Figure 160: Bagasse milling using a tractor driven hammer mill

Figure 161: A close up of the finished product after milling of bagasse

MOROCCO

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Mohammed Belmakki

Banana crop residues from greenhouses

General

Biomass material	Banana crop residues from greenhouses
Id code of sample	CRB 2013-07-08 MA Menasra 1a BELMAKKI
Responsible project partner	IAV – Morocco

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** **Nutrient rich**
Results	see tables below

	Result [%]
Dry matter (DM)	94.29
Ash content (Ash)	14.69

	Mass – [% of DM]
Glucan	19.00
Xylan	7.37
Arabinan	3.53
Klason Lignin	24.17

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Menasra
District or local community	MoulayBouselham
Country	Morocco

Date(s) of sampling	08 July 2013
Weather at site during the sampling	Sunny, clear sky
Outside temperature	About 33 °C
Contextual aspects considered (rainfall etc)	Sample collection was made on the leaves, stems and fruits after harvest within plastic greenhouses. It should be noted that the leaves are starting to become more or less dry. The sampling was made form a flat surface.

Describe the process source from which the biowaste/bio-residue stem	Sampling was conducted at a farm where the main production is the banana. This farm is spread over an area of 8.7 haunder plastic greenhouse.
Category (field residue, farm or industry)	Field residue (plantation)

Brief site-specific description of the management of the biomass from which the sample is taken	The source of the biowaste feedstock that is the sample is residues of banana cultivation in greenhouses. These residues are comprised of leaves, pseudo-stem and discarded fruit. After harvest, bananas are placed in ripening where they undergo treatment with controlled conditions of temperature and humidity. The volume of biomass is estimated on the basis of 5 tonnes /hectare/year for leaves and 3 tons/hectare/year for pseudo-stem. Thus, the annual volume of crop residues banana at this farm is about 70 tonnes /hectare. The banana fruits are collected and sold separately. The common practice for crop residues in the area is that farmers leave the ground all the plant mass produced by the banana itself (pseudo stem and leaves) for mulching (cover the soil to reduce weed growth). In the case of diseased plants, they must be disposed off greenhouses. Irrigation of this farm is done by localized system which operates by means of a diesel pump installed in a pit. The access to the area is facilitated by the existence of a well-developed road network. The area where the farm origin of the samples is characterized by the production of bananas. Seasonal variations in banana cultivation are not important and that through the use of greenhouses that ensure continuity production throughout the year.
Any visible environmental aspects seen	Nothing to report
Present usage of the sampled biomass	Crop residues are left on the ground to form mulch against weediness in the greenhouse.
Does biomass from which the sample is taken hold an economic or other value	The biomass sampled is used in the process of production of banana.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	Leaves, pseudostem and banana fruits are left on the ground inside the greenhouse without being collected. These plant materials are more or less dry. Some leaves are green (see the picture below).
Purity	Pure, no other materials found.
Colour	yellowish green
Wet/dry/mixed	Mixed
Particle size	Sample with variable particle diameters (more than 0.5 meter)
Type of storage at site	Left on the ground

Weight of sample before drying and milling	5.3kg
Weight dried sample	4,3 Kg
Weight reduction	19%

Pictures

Figure 162: Inside the banana greenhouse

Figure 163: The greenhouse ground from which the sample was collected

Figure 164: Sampling in progress

Figure 165: Lab work – weighing the banana crop residue sample

Figure 166: Dried and milled sample of crop residue from banana greenhouses.

Beet pulp – dried, from processing industry

General

Biomass material	Beet pulp – dried, from processing industry
Id code of sample	DBP2014-03-01 MA Zemamra 1a BELMAKKI
Responsible project partner	IAV – Morocco

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** ~~Nutrient rich~~
Results	see below

	Result [%]
Dry matter (DM)	88.54
Ash content (Ash)	5.23

	Mass – [% of DM]
Glucan	24.51
Xylan	7.99
Arabinan	16.25
Klason Lignin	16.00

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Warehouse on a farm of beet in Zemamra
District or local community	Zemamra center
Country	Morocco

Date(s) of sampling	01 March 2014
Weather at site during the sampling	Cloudy sky
Outside temperature	About 18 °C
Contextual aspects considered (rainfall etc)	Pulp was placed either in bulk or in bags stacked within a magazine for storing.

Describe the process source from which the biowaste/bio-residue stem	Sampling was carried out in a magazine for storing dry beet pulp in a farmer.
Category (field residue, farm or industry)	Industrial process

Brief site-specific description of the management of the biomass from which the sample is taken **At least these should be included:** **- What is the origin** **-how is biowastekept at site** **- Assessment of amounts available at site** **-seasonal changes in availability** **-qualitative assessment of amounts**	After harvesting sugar beets, the processing unit COSUMAR in Zemamra receives the roots of this culture for the extraction of sugar. The rest of the roots namely the dry pulps are isolated and collected as by-products. These pulps are returned to farmers who subsequently use it as feed for livestock or the marketing intermediaries. The rate of pulp production is about 60 kg per tonne of pulp treated roots. The total amount of dry pulp produced at the plant is about 57,600 tons. It is noted that the pulp does not stay in the factory because the contract between farmers and COSUMAR requires that these by-products are returned to farmers with a cost of 182 US$ per ton. Beet cultivation is spread over the period from May to July. Thus, the transformation of roots started at the end of July. Dried beet pulp is generally produced in August but remain stored in farmers and marketers all year. At the warehouse where we conducted sampling, the amount stored pulps was about 8 tons.
Any visible environmental aspects seen at the site	Nothing to report.
Present usage of the sampled biomass	Dried beet pulp are used as animal feed especially that the region of Doukkala is an area known for its milk production which leads to a high demand for this by-product.
Does biomass from which the sample is taken hold an economic or other value	Dried beet pulps are sold 3.5 DH per kilo equivalent to 0.42 US$ per kilo.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	Very dry sample in pellet form.
Purity	Sample pure.
Colour	Brown
Wet/dry/mixed	Dry
Particle size	granule size is approximately 3 cm
Type of storage at site	In heaps

Weight of sample before drying and milling	58.0 kg
Weight dried sample	51.3 Kg
Weight reduction	12%

Pictures

Figure 167: Milling operation of sample

Figure 168: Dried and milled sample of dried beet pulp

Figure 169: Close-up of dried and milled sample of dried beet pulp

Cattle manure collected from open air piles

General

Biomass material	Cattle manure collected from open air piles
Id code of sample	CMN 2013-07-03 MA Kenitra 1a BELMAKKI
Responsible project partner	IAV – Morocco

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ ~~Lignocellulosic~~ **Nutrient rich**
Results	see tables below

	Result [%]
Dry matter (DM)	93.88
Ash content (Ash)	20.02

	Mass – [% of DM]
Glucan	27.61
Xylan	18.06
Arabinan	2.51
Klason Lignin	24.14

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Five small livestock farms at 6 km from the city of Kenitra
District or local community	Kénitra
Country	Morocco

Date(s) of sampling	03 July 2013
Weather at site during the sampling	Sunny, clear sky
Outside temperature	About 32 °C
Contextual aspects considered (rainfall etc)	Sampling of manure was operated in the summer when the ambient temperature was 32° C. Cattle manure was found in heaps at the five farms.

Describe the process source from which the biowaste/bio-residue stem	Sampling was conducted at five cattle livestock farms where the average number of livestock is about 8 cows per farm.
Category (field residue, farm or industry)	Farm

Brief site-specific description of the management of the biomass from which the sample is taken	In the Sampled farm, manure is placed in a heap after recovery from the barn. The manure will be stored for a minimum period of six months before being used as a soil amendment to avoid burning the roots of plants, in particular because of the urine The amount of manure produced is estimated at 200 kg per week.
Any visible environmental aspects seen at the site	Nothing to report
Present usage of the sampled biomass	Manure is used as a soil amendment.
Does biomass from which the sample is taken hold an economic or other value	The biomass sampled can be sold in large quantities.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	the sampled was fresh manure (urine and faeces) mixed with bedding (straw)
Purity	Mixed with straw.
Colour	Brown
Wet/dry/mixed	wet
Particle size	Sample with variable particle diameters
Type of storage at site	In heaps

Weight of sample before drying and milling	25.2 kg
Weight dried sample	4,8 Kg
Weight reduction	81%

Pictures

Figure 170: The dung pile from which sample was taken

Figure 171: Dung pile where sample was taken

Figure 172: Dung pile where sample was taken

Figure 173: Dung pile where sample was taken

Figure 174: Dung pile where sample was taken

Figure 175: Close-up of untreated sample – photo taken sampling site (before drying and milling

Figure 176: manure samples in a 10-liter

Figure 177: Preparing the mixed sample

Figure 178: Preparing the mixed sample

Figure 179: Dried and milled sample of cattle manure (close-up of final sample to the right)

Faba bean crop residues collected at cultivation site

General

Biomass material	Faba bean crop residues collected at cultivation site
Id code of sample	FAB2013-07-13 MA Khemisset 1a BELMAKKI
Responsible project partner	IAV – Morocco

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** ~~Nutrient rich~~
Results	

	Result [%]
Dry matter (DM)	96.09
Ash content (Ash)	4.63

	Mass – [% of DM]
Glucan	16.75
Xylan	9.33
Arabinan	3.97
Klason Lignin	15.01

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Farm production of faba bean in region of Khemisset
District or local community	El Khemisset
Country	Morocco

Date(s) of sampling	13 July 2013
Weather at site during the sampling	Cloudy sky
Outside temperature	About 28 °C
Contextual aspects considered (rainfall etc)	Sample collection was made on the leaves, stems and roots after harvest. The sampling was made form a flat surface.

Describe the process source from which the biowaste/bio-residue stem	Sampling was conducted at a farm where the main production is cereals and legumes. This farm is spread over an area of 3.6 ha. The area reserved for faba bean is 1.2 ha.
Category (field residue, farm or industry)	Field residue (plantation)

Brief site-specific description of the management of the biomass from which the sample is taken	The source of the biowaste feedstock is the residues of faba bean cultivation. These residues are comprised of leaves and stems. The grains of faba bean are collected and sold separately. The harvest is done mechanically by the use of combine. The quantity of biomass is estimated on the basis of 2.7 tons /hectare/year for crop residues. Thus, the annual volume this residues at this farm is about 3.2 tonnes. The common practice for crop residues in the area is that farmers leave on the ground all the plant mass produced after harvest (root, stem and leaves) to play to enrich the soil. No irrigation system used. The access to the area is facilitated by the existence of a well developed road network. The area where the farm origin of the samples is characterized by the production of cereals and legumes.
Any visible environmental aspects seen at the site	Nothing to report.
Present usage of the sampled biomass	Soil amendment.
Does biomass from which the sample is taken hold an economic or other value	The biomass sampled is used in the process of production of other crop.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	Leaves and stem are left on the ground without being collected. These plant materials are more or less dry.
Purity	Pure, no other materials found.
Colour	yellow
Wet/dry/mixed	mixed
Particle size	Sample with variable particle diameters (more than 20 cm)

Weight of sample before drying and milling	10.4 kg
Weight dried sample	3.3 Kg
Weight reduction	68%

Pictures

Figure 180: Milling operation of sample

Figure 181: Final sample after preparation

Figure 182: Final sample after preparation, close-up

Figure 183: HPLC system used for strong acid hydrolysis

Maize crop residues collected at field

General

Biomass material	Maize crop residues collected at field
Id code of sample	MAI 2013-10-13 MA Bouderbala 1a BELMAKKI
Responsible project partner	IAV – Morocco

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** ~~Nutrient rich~~
Results	(see tables below)

	Result [%]
Dry matter (DM)	94.97
Ash content (Ash)	5.32

	Mass – [% of DM]
Glucan	34.21
Xylan	17.51
Arabinan	3.01
Klason Lignin	21.30

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Farm production of maize in Bouderbala
District or local community	El Hajeb
Country	Morocco

Date(s) of sampling	13 October 2013
Weather at site during the sampling	Cloudy sky
Outside temperature	About 26 °C
Contextual aspects considered (rainfall etc)	Sample collection was made on the leaves and stems after harvest The sampling was made form a flat surface.

Describe the process source from which the biowaste/bio-residue stem	Sampling was conducted at a farm where the main production is cereals. This farm is spread over an area of 4.5 ha. The area reserved for corn is 2 ha.
Category (field residue, farm or industry)	Field residue

Brief site-specific description of the management of the biomass from which the sample is taken	The source of the biowaste feedstock that is the sample is residues of maize cultivation. These residues are comprised of leaves and stems. The grains of maize are collected and sold separately. The volume of biomass is estimated on the basis of 5 tonnes /hectare/year for crop residues. Thus, the annual volume this residues at this farm is about 12.5 tonnes. The farmers use this crop residues for livestock feed. Irrigation of this farm is done by surface irrigation system which operates by means of a diesel pump. The access to the area is facilitated by the existence of a well developed road network. The area where the farm origin of the samples is characterized by the production of cereals and olives.
Any visible environmental aspects seen at the site	Nothing to report.
Present usage of the sampled biomass	Livestock feed.
Does biomass from which the sample is taken hold an economic or other value	The use of such residues reduces the cost of feeding livestock.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	Leaves and stem are left on the ground without being collected. These plant materials are more or less dry.
Purity	Pure, no other materials found.
Colour	green
Wet/dry/mixed	mixed
Particle size	Sample with variable particle diameters (more than 20 cm)
Type of storage at site	Left on the ground

Weight of sample before drying and milling	11.3 kg
Weight dried sample	3.6 Kg
Weight reduction	68%

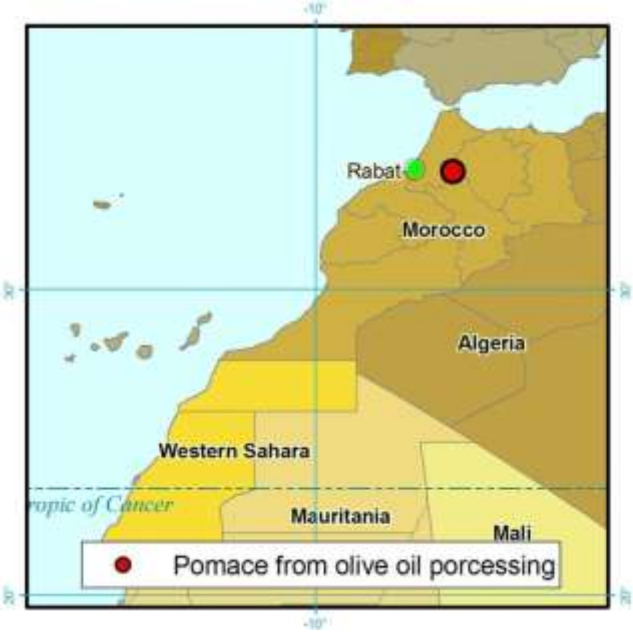
Pictures

Figure 184: Maize field

Figure 185: Final sample after preparation

Figure 186: Final sample after preparation - close-up

Olive pomace from olive oil processing



General

Biomass material	Olive pomace from olive oil processing
Id code of sample	OLP2014-03-09 MA Meknès 1a BELMAKKI
Responsible project partner	IAV – Morocco

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** ~~Nutrient rich~~
Results	see tables below

	Result [%]
Dry matter (DM)	94.30
Ash content (Ash)	2.26

	Mass – [% of DM]
Glucan	15.75
Xylan	10.49
Arabinan	5.80
Klason Lignin	27.56

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Crushing unit of olive in Meknès
District or local community	Meknès
Country	Morocco

Date(s) of sampling	09 March 2014
Weather at site during the sampling	Cloudy sky
Outside temperature	About 16 °C
Contextual aspects considered (rainfall etc)	Olive pomace was placed either in bulk stacked within a magazine for storing inside the plant.

Describe the process source from which the biowaste/bio-residue stem	Sampling was carried out in a magazine for storing olive pomace in the form of bulk.
Category (field residue, farm or industry)	Industrial process residue

Brief site-specific description of the management of the biomass from which the sample is taken.	The farmers near the city of Meknes transport their harvested olives to several crushing plants which is located in this area. After crushing, the farmers recover oil but the processing residues as pomace remained in the crushing unit. The production rate of pomace at the sampled unit is around 50 kg of pomace per 100 kg of olive fruit treated. The quantities of pomace generated are stored in bulk in order to be subsequently sold to industrial intermediates. Olive harvesting is spread over the period from November to January. Thus, the transformation of olive started at the end of November. At the site where we conducted sampling, the amount stored of pomace was about 20 tons.
Any visible environmental aspects seen at the site	Nothing to report.
Present usage of the sampled biomass	The pomaces are either sold to other industrial units that specialize in the extraction of pomace oil or as combustible to boilers
Does biomass from which the sample is taken hold an economic or other value	Pomace olive are sold 81 US$ per ton.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	Pomace in the form of homogeneous mass of variable size
Purity	Sample pure.
Colour	Brown
Wet/dry/mixed	Wet
Particle size	granule size is approximately 30 cm
Type of storage at site	In heaps

Weight of sample before drying and milling	13.2 kg
Weight dried sample	8.1 kg
Weight reduction	39%

Pictures

Figure 187: Sample of olive pomace before preparation

Figure 188: Weighing of sample

Figure 189: Reading the results from the HPLC analysis

Figure 190: Dried and milled sample of olive pomace.

Orange pulp from orange juice processing

General

Biomass material	Orange pulp from orange juice processing
Id code of sample	ORP2014-03-30 MA Kenitra 1a BELMAKKI
Responsible project partner	IAV – Morocco

Summary and chemical characteristics

Nutrient and/or sugar rich

~~Rich in simple sugars~~
~~Starch rich~~
Lignocellulosic

~~Nutrient rich~~

Results

	Result [%]
Dry matter (DM)	90.30
Ash content (Ash)	4.17

	Mass – [% of DM]
Glucan	18.53
Xylan	9.03
Arabinan	6.71
Klason Lignin	18.47

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Production unit of orange juice in Kenitra (CITRUMA)
District or local community	Kenitra
Country	Morocco

Date(s) of sampling	30 March 2014
Weather at site during the sampling	Cloudy sky
Outside temperature	About 19 °C
Contextual aspects considered (rainfall etc)	Nothing to report.

Describe the process source from which the biowaste/bio-residue stem	Sampling was carried out from a large storage bin orange pulp.
Category (field residue, farm or industry)	Field residue (plantation)

Brief site-specific description of the management of the biomass from which the sample is taken	After receiving the oranges, they go through several steps such as washing and sorting before reaching the juicing machines. Once pressed, these fruits are emptied of liquid (juice) which is the final product after packaging. Thus, this process generates large quantities of orange pulp, up to 50% of the amount of processed orange. It should be noted that the capacity of this plant is about 300 tons per day. Thus, the production period is five months, which gives an amount of pulp produced in the order of 22,500 tons. In this unit a part of the pulp is valorised by drying process producing pellets for feeding livestock. Pulps are pressed and heated, a natural solvent is recovered. This molasses is added to the paste dried and used as feed for cattle in the form of pellets.
Any visible environmental aspects seen at the site	Nothing to report.
Present usage of the sampled biomass	Orange pulps are used as animal feed especially in the region of Gharb which is an area known for its milk production which leads to a high demand for this by-product.
Does biomass from which the sample is taken hold an economic or other value	Pellets from pulp are sold as by-product.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	Sample very wet
Purity	Sample pure.
Colour	orange and yellow
Wet/dry/mixed	Wet
Particle size	Particle size more than 5 cm
Type of storage at site	In bulk

Weight of sample before drying and milling	26.0 kg
Weight dried sample	6.5 Kg
Weight reduction	75%

Pictures

Figure 191: sample before drying

Figure 192: Dried and milled sample of orange pulp

Sugarcane crop residues collected at field

General

Biomass material	Sugarcane crop residues collected at field
Id code of sample	SCT 2013-07-05 MA Belksiri 1a BELMAKKI
Responsible project partner	IAV – Morocco

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** ~~Nutrient rich~~
Results	see tables below

	Result [%]
Dry matter (DM)	94.24
Ash content (Ash)	6.25

	Mass – [% of DM]
Glucan	35.68
Xylan	20.61
Arabinan	2.81
Klason Lignin	21.72

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Farm production of sugarcane in Belksiri
District or local community	Mechraa Belksiri
Country	Morocco

Date(s) of sampling	05 July 2013
Weather at site during the sampling	Cloudy sky
Outside temperature	About 32 °C
Contextual aspects considered (rainfall etc)	Sample collection was made on the leaves and stems after harvest. It should be noted that the leaves are starting to become more or less dry. The sampling was made form a flat surface.

Describe the process source from which the biowaste/bio-residue stem	Sampling was conducted at a farm where the main production is the sugarcane. This farm is spread over an area of 4.8 ha.
Category (field residue, farm or industry)	Field residue

Brief site-specific description of the management of the biomass from which the sample is taken **At least these should be included:** **- What is the origin** **-how is biowastekept at site** **- Assessment of amounts available at site** **-seasonal changes in availability** **-qualitative assessment of amounts**	The source of the biowaste feedstock that is the sample is residues of sugarcane cultivation. These residues are comprised of leaves and the part of stems not collected. The canes collected by mechanical harvesting is intended for the sugar factory called SURAC and located at Mechraa Belksiri. This unit is specialized in the production of sugar cane. The volume of biomass is estimated on the basis of 12 tonnes /hectare/year for crop residues. Thus, the annual volume this residues at this farm is about 58 tonnes. The farmers use this crop residues for livestock feed. Irrigation of this farm is done by aspersion system which operates by means of a diesel pump. The access to the area is facilitated by the existence of a well developed road network. The area where the farm origin of the samples is characterized by the production of sugarcane. The cultivation of sugar cane begins in January and lasts for a period of six months depending on weather conditions.
Any visible environmental aspects seen at the site	Nothing to report.
Present usage of the sampled biomass	Livestock feed.
Does biomass from which the sample is taken hold an economic or other value	The use of such residues reduces the cost of feeding livestock.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	Leaves and stem are left on the ground without being collected. These plant materials are more or less dry.
Purity	Pure, no other materials found.
Colour	yellow
Wet/dry/mixed	mixed
Particle size	Sample with variable particle diameters (more than 20 cm)
Type of storage at site	Left on the ground

Weight of sample before drying and milling	7.5 kg
Weight dried sample	2.9 Kg
Weight reduction	61%

Pictures

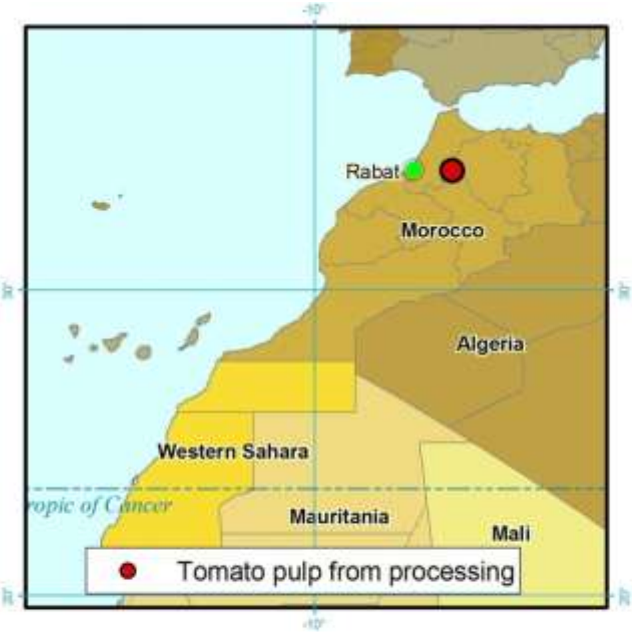
Figure 193: Picture of feedstock site from which the sample was taken

Figure 194: The sugarcane field residues sampled

Figure 195: Dried and milled sample of sugarcane crop residue

Figure 196: HPLC system used for strong acid hydrolysis

Tomato pulp from tomato processing



General

Biomass material	Tomato pulp from tomato processing
Id code of sample	TMP2014-07-15 MA Meknes 1a BELMAKKI
Responsible project partner	IAV – Morocco

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** ~~Nutrient rich~~
Results	see tables below

	Result [%]
Dry matter (DM)	95.18
Ash content (Ash)	4.09

	Mass – [% of DM]
Glucan	15.10
Xylan	8.47
Arabinan	5.29
Klason Lignin	22.43

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Unit processing of fruits and vegetables in Meknes called Les Con-serves de Meknès / AICHA
District or local community	Meknes
Country	Morocco

Date(s) of sampling	15July 2014
Weather at site dur-ing the sampling	Cloudy sky
Outside temperature	About 34 °C
Contextual aspects considered (rainfall etc)	Nothing to report.

Describe the process source from which the biowaste/bio-residue stem	Sampling was carried out from a large storage bin tomato pulp.
Category (field resi-due, farm or industry)	Industry

Brief site-specific description of the management of the biomass from which the sample is taken.	The production of tomato concentrate is achieved by seeding following the washing operation and a cold grinding before heating according to the degree of staining. The sieving and refining next come to separate the pulp from the skins, seeds and coarse fragments. It should be noted that the capacity of this plant is about 2000 tons per day. The production of pulp produced is about 200 tons/day.
Any visible environ-mental aspects seen at the site	Nothing to report.
Present usage of the sampled biomass	Pulps are used as by-product.
Does biomass from which the sample is taken hold an eco-nomic or other value	Pulps are sold as by-product.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	Sample very wet
Purity	Sample pure.
Colour	red
Wet/dry/mixed	Wet
Particle size	Particle size more than 5 cm
Type of storage at site	In bulk

Weight of sample before drying and milling	21.0 kg
Weight dried sample	5.3 Kg
Weight reduction	75%

Pictures

Figure 197: The untreated tomato pulp waste (to the left), dried and milled sample of tomato pulp (to the right)

SOUTH AFRICA

Council for Scientific and Industrial Research – South Africa (CSIR-SA)

Konanani Rashamuse (lead scientist)
Kgama Mathiba
Bruce Sithole
Neville Tawona

Banana fruits - ripe, rejected at packaging site

General

Biomass material	Banana fruits - ripe, rejected at packaging site
Id code of sample	SA-LV-BAF-DM-150513
Responsible project partner	CSIR-ZAR

Summary and chemical characteristics

Nutrient and/or sugar rich	**Rich in simple sugars** *(glucan value should possibly be higher)* **Starch rich*** ~~Lignocellulosic~~ ~~Nutrient rich~~
Results	see below

	Result [%]
Dry matter (DM)	88.18
Ash content (Ash)	6.90

	Mass – [% of DM]
Glucan	39.11
Xylan	0.56
Arabinan	0.43
Klason Lignin*	11.52

* in this case Acid Insoluble Material

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Zedpro (Pty) Ltd in Levubu, Limpopo Province of South Africa
District or local community	Makhado Municipality, Vhembe district
Country	South Africa

Date(s) of sampling	12 March 2013
Weather at site during the sampling	Sunny, Dry weather
Outside temperature	37°C
Contextual aspects considered (rainfall etc)	The sample was collected towards the end of summer season, with the temperature generally ranging between 30-37 ^{o}C

Describe the process source from which the biowaste/bio-residue stem	At the site there were three possibilities to pick biowaste; i) the whole banana, ii) the peels and iii) only the fruit. In this sample it is only the fruit that was taken. The banana fruit that was picked was ready to be disposed for compost product.
Category (field residue, farm or industry)	Industry (packaging)

Brief site-specific description of the management of the biomass from which the sample is taken	The sample used was a combination of rotten and poor grade whole banana which was ready to be disposed for compost product. Tons of this waste samples are produced daily during summer and Autumn season. (Difficult to actually give a number) Natural sun light is as energy input process for compositing of these wastes. The site where the sample was taken is both a banana farm and Banana Packaging site.
Any visible environmental aspects seen at the site	None
Present usage of the sampled biomass	Compositing
Does biomass from which the sample is taken hold an economic or other value	Compost if often sold at a certain price and some of the compositing is applied during the ploughing season.

Describe the basis of selection for taking sample from this specific site	Banana generally is a very rich carbohydrates and the waste derived from such crop offer a potential feedstock for further bioprocessing and value addition.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The sample is often piled in a specific designated area on daily basis during harvesting and processing and then taken to a compositing site on weakly basis.
Purity	Often the biowaste in question is often contaminated with banana pseud-stems.
Colour	Grey –yellow and brown depending on how long it has been kept
Wet/dry/mixed	Mixed (semi-dry)
Particle size	< 3mm
Type of storage at site	Open space

Weight of sample before drying and milling	2.0 kg
Weight dried sample	1,7 kg Particles range between 0.3 - 1 mm (60.0%) Particle size range 0.125 – 0.3 (27.8%) - This material was more dense and compact than the banana peels
Weight reduction	14%

Pictures

Figure 198: Banana stocks ready for quality control and packaging

Figure 199: Rejected bananas

Figure 200: Close-up of the untreated banana fruit sample

Figure 201: Dried and milled sample of banana fruits

Banana peels from rejected fruits at packaging site

General

Biomass material	Banana peels from rejected fruits at packaging site
Id code of sample	SA-LV-BPEEL-DM-150513
Responsible project partner	CSIR-ZAR

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** **Nutrient rich**
Results	see tables below

	Result [%]
Dry matter (DM)	87.81
Ash content (Ash)	16.45

	Mass – [% of DM]
Glucan	35.41
Xylan	0.63
Arabinan	1.11
Klason Lignin*	12.76

* in this case Acid Insoluble Material

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Zedpro (Pty) Ltd in Levubu, Limpopo Province of South Africa
District or local community	Makhado Municipality, Vhembe district
Country	South Africa

Date(s) of sampling	12 March 2013
Weather at site during the sampling	Sunny, Dry weather
Outside temperature	37°C
Contextual aspects considered (rainfall etc)	The sample was collected towards the end of summer season, with the temperature generally ranging between 30-37 °C

Describe the process source from which the biowaste/bio-residue stem	At the site there were three possibilities to pick biowaste; i) the whole banana, ii) the peels and iii) only the fruit. In this sample only the peel was taken. The sample used was the peel fraction of the rejected Banana which was ready to be disposed for compost production.
Category (field residue, farm or industry)	Industry (packaging)

Brief site-specific description of the management of the biomass from which the sample is taken	The sample used was a combination of rotten and poor grade whole banana which was ready to be disposed for compost product. Tons of this waste samples are produced daily during summer and Autumn season. (Difficult to actually give a number) Natural sun light is as energy input process for compositing of these wastes. The site where the sample was taken is both a banana farm and Banana Packaging site.
Any visible environmental aspects seen at the site	None
Present usage of the sampled biomass	Compositing
Does biomass from which the sample is taken hold an economic or other value	Compost if often sold at a certain price and some of the compositing is applied during the ploughing season.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The sample is often piled in a specific designated area on daily basis during harvesting and processing and then taken to a compositing site on weakly basis.
Purity	Often the biowaste in question is often contaminated with banana pseud-stems.
Colour	Grey –yellow and brown depending on how long it has been kept
Wet/dry/mixed	Mixed (semi-dry)
Particle size	< 3mm
Type of storage at site	Open space

Weight of sample before drying and milling	2.0 kg
Weight dried sample	1.7 KG - Banana peels Particles range between 0.3 - 1 mm (65.4%) Particle size range 0.125 – 0.3 (19.2%)
Weight reduction	14%

Pictures

Figure 202: Rejected bananas

Figure 203: Close-up of the banana peels

Figure 204: Dried and milled sample of banana peels

Cattle manure collected at pasture land

General

Biomass material	Cattle Manure collected at pasture land
Id code of sample	SA-LG-CMW-DM-130813
Responsible project partner	ETM South Africa

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ ~~Lignocellulosic~~ **Nutrient rich**
Results	

	Result [%]
Dry matter (DM)	93.16
Ash content (Ash)	31.20

	Mass – [% of DM]
Glucan	14.61
Xylan	8.58
Arabinan	1.51
Klason Lignin*	25.01

* in this case Acid Insoluble Material

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Luganda Grazing Land
District or local community	EThekwini Municipality
Country	South Africa

Date(s) of sampling	13 August 2013
Weather at site during the sampling	Sunny, Dry weather
Outside temperature	25°C
Contextual aspects considered (rainfall etc)	The cattle manure was dry because it had stayed in the grazing land for more than five days. Fresh manure is obtained mostly in the mornings.

Describe the process source from which the biowaste/bio-residue stem	The process from which the sample is taken is a small scale grazing land in the south part of Pinetown, KwaZulu Natal. Subsistence farmers herd their cattle in the grazing land frequently when the grass is palatable to the livestock.
Category (field residue, farm or industry)	Farm (sample from the pasture)

Brief site-specific description of the management of the biomass from which the sample is taken	The cattle manure comes from the subsistence farmers herds during times when the grass is green. The cattle spend three quarters of the day in the area and hence produce considerable amounts of dung. Fresh dung, if required in that state, can be obtained in the morning, before the heat dries up the manure. An average herd, consisting of 20 cattle, produces an estimated 40kg of dung per day. It was noted however than the farmers frequent the grazing land at particular times of the year, from August to December. Hence the supply of the biomass is not consistent all year round.
Any visible environmental aspects seen at the site	None
Present usage of the sampled biomass	None
Does biomass from which the sample is taken hold an economic or other value	None

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The sample was taken from the dung droppings around the grazing land. The grazing land spans an area equivalent to 100m by 100m square. The cattle manure is however sparsely distributed over the whole area hence 10 different locations spanning the whole area were selected at random to obtain the subsamples.
Purity	The cattle manure was mixed with some few strands of grass and in some few cases undigested components were visible.
Colour	Grey -dirty green
Wet/dry/mixed	Mixed (semi-dry)
Particle size	< 3mm
Type of storage at site	Open space

Weight of sample before drying and milling	0.90 kg
Weight dried sample	0.83 kg
Weight reduction	7%

Pictures

Figure 205: The pasture where samples were collected.

Figure 206: Untreated sample of cattle dung, South Africa

Figure 207: Dried and milled sample of dung (pasture)

Fruit and vegetable waste collected at packaging industry

General

Biomass material	Fruit and vegetable waste collected at packaging industry
Id code of sample	SA-VL-FVW-DM-120813
Responsible project partner	ETM South Africa

Summary and chemical characteristics

Nutrient and/or sugar rich	**Rich in simple sugars** **Starch rich** ~~Lignocellulosic~~ **Nutrient rich**
Results	see tables below

	Result [%]
Dry matter (DM)	86.62
Ash content (Ash)	9.54

	Mass – [% of DM]
Glucan	22.49
Xylan	1.44
Arabinan	1.70
Klason Lignin*	13.43

* in this case Acid Insoluble Material

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	MF Produce, Verulum
District or local community	EThekwini Municipality, KwaZulu-Natal
Country	South Africa

Date(s) of sampling	12 August 2013
Weather at site during the sampling	Sunny
Outside temperature	28°C
Contextual aspects considered (rainfall etc)	Windy conditions sometimes prevail. Rain is prevalent all year round. High temperatures are common especially in the summer seasons.

Describe the process source from which the biowaste/bio-residue stem	The process from which the sample is taken is a fruit & vegetable packaging centre. The waste material is generated during packaging for supply to retail shops and/or supermarkets.
Category (field residue, farm or industry)	Industry

Brief site-specific description of the management of the biomass from which the sample is taken	The source of the biowaste feedstock that is the sample is the fruit & vegetable waste residues generated at the MF produce centre. The waste material comes from nearby farmers who sell their green and fresh produce for supply to retail shops, wholesalers and supermarkets like Shoprite and Checkers [SA Supermarkets] The fruit & vegetable waste comprises of green vegetable leaves (e.g cabbage and lettuce), butternuts, and green paper. These materials come in different percentages with vegetables comprising more than 80%. Total volume rate of waste produced is on average 1 ton per day. The fruit & vegetable material are delivered from the farms onto the central point – the fresh produce market. The material is graded for packaging and the waste material collected and stored in rectangular plastic crates for disposal. The waste material is disposed of onto farm lands to serve as soil improvers, irrespective of the freshness of the material. There is no other use for the waste residues. Production of waste is almost constant all year round. There are large trucks for transportation of the waste material away from the site. The fresh produce market is located in a town called Verulum, about 27km north of Durban, and a dust road branches from the freeway to the area. The area is connected to the national electricity grid.
Any visible environmental aspects seen	None
Present usage of the sampled biomass	Used as a soil improver in its fresh state as a way of disposal.
Does biomass from which the sample is taken hold an economic or other value	Not at the moment. According to the manager, they would welcome anyone willing to collect the waste away from the site.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The fruit and vegetable residues are collected in rectangular crates *separately* depending on type. This made it easier to obtain a "homogeneous" mix since the percentage abundance of each individual constituent is known thus a representative sample followed the same distribution. An onsite-operator provided the details of the relative amounts and assisted with the mixing. It should be noted that the nature of the waste mixture of different vegetables and some fruit material introduces variability if another location has to be chosen for comparison purposes. Probably in future research, use of only vegetable material should be considered to reduce variability in waste composition.
Purity	The individual constituents (fruits and vegetables) are homogeneous and clean. No other materials were found mixed.
Colour	Green and yellow mostly.
Wet/dry/mixed	Mixed
Particle size	5-15cm
Type of storage at site	Temporary (Max 1 day) under roof

Weight of sample before drying and milling	1.00 kg
Weight dried sample	0.85 kg
Weight reduction	15%
Notes/remarks on the final sample	The final sample had a pleasant aroma attributed to the presence of fruit material.

Pictures

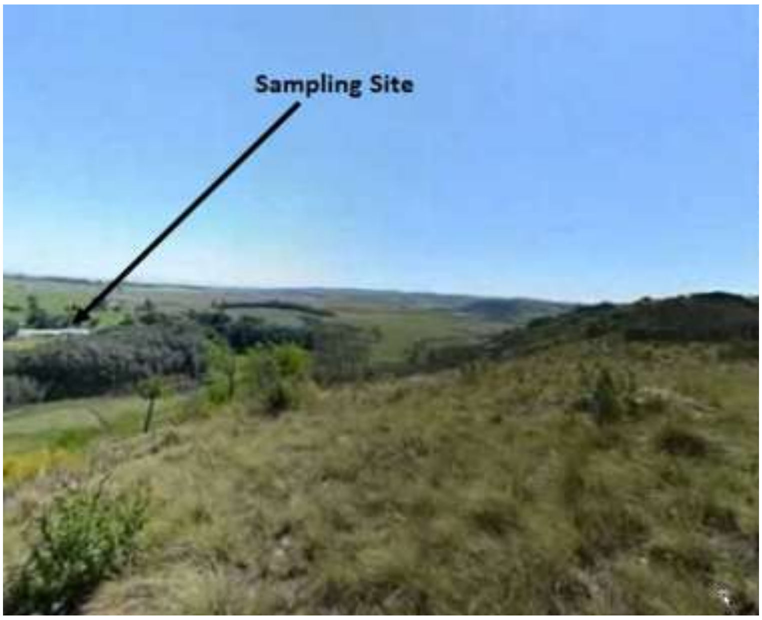


Figure 208: Site from which the sample was collected

Figure 209: Bags of the biowaste sampled (to the left), close-up of the untreated sample of fruit and vegetable waste (to the right)

Figure 210: Dried and milled sample of fruit and vegetable waste

Garden Waste at waste collection point

General

Biomass material	Garden Waste at waste collection point
Id code of sample	SA-GV-GDW-DM-230813
Responsible project partner	ETM – South Africa

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** **Nutrient rich**
Results	see tables below

	Result [%]
Dry matter (DM)	90.31
Ash content (Ash)	10.75

	Mass – [% of DM]
Glucan	18.87
Xylan	5.60
Arabinan	2.98
Klason Lignin*	37.12

* in this case Acid Insoluble Material

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Glanville Garden Refuse Site
District or local community	eThekwini Municipality
Country	South Africa

Date(s) of sampling	23 August 2013
Weather at site during the sampling	Sunny, no clouds
Outside temperature	27°C
Contextual aspects considered (rainfall etc)	High temperatures usually prevail in the summer seasons.

Describe the process source from which the biowaste/bio-residue stem	The process from which the sample is taken is a Durban Solid Waste (DSW) refuse site located within a residential suburb.
Category (field residue, farm or industry)	Collection site for garbage

Brief site-specific description of the management of the biomass from which the sample is taken	Residents from the nearby suburbs bring in garden refuse generated from maintaining the properties. Woodlands, Yellowwood Park, Mobeni Heights. The garden refuse is stored in 5,5m3 steel skips Average volume of refuse brought at the site is 100m3 per day Available September to June Slight drop off in July & August(winter) The waste feedstock consists of shrub branches, twigs and mostly dried plant leaves with the latter contributing more than 50%.
Any visible environmental aspects seen at the site	None, garden waste is brought in during the day and removed via compactor on the same day
Present usage of the sampled biomass	Goes to Landfill
Does biomass from which the sample is taken hold an economic or other value	Does not have any value at this time but there is a potential for composting or waste to energy (pyrolysis)

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The material was unloaded from the storage skips to enable sampling. The general workers assisted with this task with the help of Municipality trucks. The sample was then drawn from this material.
Purity	The sample was not very pure; some soil is embedded between the waste materials.
Colour	Generally brown color
Wet/dry/mixed	Dry
Particle size	5-15cm (not uniform particle size)
Type of storage at site	Stored in the open in steel skips.

Weight of sample before drying and milling	0.80 kg
Weight dried sample	0.72 kg
Weight reduction	11%
Notes/remarks on the final sample	The final sample was very dry, however it also exhibited a “dusty” nature.

Pictures

Figure 211: Garden waste collection point

Figure 212: Containers containing the garden waste sampled

Figure 213: Dried and milled sample of garden waste

Maize bran from maize mill

General

Biomass material	Maize Bran from maize mill
Id code of sample	SA-NZ-MZ-DM-031013
Responsible project partner	CSIR-ZAR

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ **Starch rich** **Lignocellulosic** ~~Nutrient rich~~
Results	see tables below

	Result [%]
Dry matter (DM)	91.22
Ash content (Ash)	3.92

	Mass – [% of DM]
Glucan	46.53
Xylan	10.81
Arabinan	8.23
Klason Lignin*	1.73

* in this case Acid Insoluble Material

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Nzhelele Milling
District or local community	Dzananani Area, Vhembe district
Country	South Africa

Date(s) of sampling	03 October 2013
Weather at site during the sampling	Sunny, Dry weather
Outside temperature	37°C
Contextual aspects considered (rainfall etc)	The sample was collected towards the beginning of spring season in South Africa

Describe the process source from which the biowaste/bio-residue stem	The sample collected was maize bran provided courtesy of Nzhelele Milling.
Category (field residue, farm or industry)	Industrial residue

Brief site-specific description of the management of the biomass from which the sample is taken	Nzhelele milling is a small commercial milling company. Depending on the season the milling plant does not operate throughout the year The sample was collected on our behalf prior collection. There are two types of maize bran available – smooth and rough. The sample here is the rough type.
Any visible environmental aspects seen at the site	None
Present usage of the sampled biomass	Animal feed
Does biomass from which the sample is taken hold an economic or other value	Yes, The actual biomass is used for food production

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The access to the site was provided, however on the day of site visit the mill was not operation.
Purity	The Maize bran also contained residual starch
Colour	Yellowish appearance
Wet/dry/mixed	dry
Particle size	0.3-0.5 mm
Type of storage at site	Because of a high demand from local livestock farms the bran is often sold as soon as it is available.

Weight of sample before drying and milling	10.0 kg
Weight dried sample	9.0 kg
Weight reduction	10%

Pictures

Figure 214: The mill where the maize bran comes out from the mill

Figure 215: The maize bran collected in a sack

Figure 216: Close-up of untreated maize bran sample

Saw dust sourced from sawmill

General

Biomass material	Saw dust sourced from sawmill
Id code of sample	SA-NZ-SD-DM-120813
Responsible project partner	CSIR-ZAR

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** ~~Nutrient rich~~
Results	see tables below

	Result [%]
Dry matter (DM)	93.52
Ash content (Ash)	0.62

	Mass – [% of DM]
Glucan	47.52
Xylan	7.40
Arabinan	0.18
Klason Lignin*	34.40

* in this case Acid Insoluble Material

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Fondwe wood processing
District or local community	Thulamela municipality
Country	South Africa

Date(s) of sampling	12 August 2013
Weather at site during the sampling	Sunny, Dry and windy weather
Outside temperature	37°C
Contextual aspects considered (rainfall etc)	The sample was collected towards the beginning of spring season and of Autumn season

Describe the process source from which the biowaste/bio-residue stem	The sample collected was a Saw dust provided courtesy of Fondwe wood processing.
Category (field residue, farm or industry)	Industry

Brief site-specific description of the management of the biomass from which the sample is taken	The company in question could not grant us access to the plant but they were actually happy to provide us with a 50 kg of Saw Dust sample.
Any visible environmental aspects seen at the site	None
Present usage of the sampled biomass	As part of compositing and providing shelter surface for the chicken farmers
Does biomass from which the sample is taken hold an economic or other value	Yes, The actual biomass is used for wood production that is utilised in for paper and furniture making. The Saw dust is rich in cellulose, xxulan and lignin provides an ideal feedstock for biotechnology conversion to value added extraction and it also contain a considerable amount of plant proteins and fats

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	Access to the site was restricted
Purity	The sample only composed saw dust
Colour	brownish appearance
Wet/dry/mixed	dry
Particle size	1-3 mm
Type of storage at site	Sample were stored in piles with the plant

Weight of sample before drying and milling	0.50 kg
Weight dried sample	0.47 kg (the sample was dry)
Weight reduction	7%

Pictures

Figure 217: Close-up of sample

Soya bean field residues collected at field

General

Biomass material	Soya Bean field residues collected at field
Id code of sample	SA-MH-SYW-DM-200813
Responsible project partner	ETM – South Africa

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** **Nutrient rich**
Results	see below

	Result [%]
Dry matter (DM)	93.93
Ash content (Ash)	30.67

	Mass – [% of DM]
Glucan	14.31
Xylan	3.12
Arabinan	4.81
Klason Lignin*	26.04

* in this case Acid Insoluble Material

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Mariannhill Soya Research Centre
District or local community	EThekwini Municipality
Country	South Africa

Date(s) of sampling	20 August 2013
Weather at site during the sampling	Sunny, no clouds
Outside temperature	27°C
Contextual aspects considered (rainfall etc)	The site is at a hilly location and no trees are around to act as wind breaks. Wind becomes a nuisance considering the light soya waste which is temporarily stored there.

Describe the process source from which the biowaste/bio-residue stem	The process from which the sample is obtained is the Soya bean research centre located in Mariannhill Pinetown. The soya bean is grown at the site during the periods March to June and the whole process occur onsite.
Category (field residue, farm or industry)	Field residue

Brief site-specific description of the management of the biomass from which the sample is taken	The source of the biowaste feedstock is soya stalks and leaves of the bean plant excluding the seeds. The soya waste is produced from the research centre where it is grown in the period from March to June, only once per year. In terms of volume distribution, it was ascertained that the stalks and the plant leaves were of equal contribution. The total waste produced in 2013 was 5m3. Projections from the manager pointed to an increase in the production rate, where it was estimated that in the 2014 season, 10m3 of waste could be produced and the latter amount to be doubled in 2015. As mentioned, the availability of the waste is seasonal and not constant throughout the year. The material is kept temporarily under a shade; however it is ploughed back in the land to save as a soil improver as it supposedly exhibits good compost characteristics. The site is connected to the national electricity grid for energy requirements.
Any visible environmental aspects seen at the site	None
Present usage of the sampled biomass	Used as a soil conditioner on the site fields.
Does biomass from which the sample is taken hold an economic or other value	None

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The sample was taken from the pile of soya waste material at the temporary storage place. There are a few contract workers that manage the soya operations. After harvesting, the seeds are separated from the parent plant, which is then regarded as waste material to be ploughed back into the soil at an appropriate time.
Purity	The soya waste heaps are almost pure, with very little amounts of dry grass
Colour	Grey
Wet/dry/mixed	Very dry
Particle size	10-15cm
Type of storage at site	In piles/heaps

Weight of sample before drying and milling	0.80 kg
Weight dried sample	0.73 kg
Weight reduction	9%

Pictures

Figure 218: Scenery of the area where the sample was taken.

Figure 219: Close-up of the biomass that constitutes the sample.

Figure 220: Close-up of the dired and milled sample of soya bean field residues

Sugarcane bagasse sourced from sugar mill

General

Biomass material	Sugarcane Bagasse sourced from sugar mill
Id code of sample	SA-DUR-MM-DM-050913
Responsible project partner	CSIR-ZAR

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** ~~Nutrient rich~~
Results	(see tables below)

	Result [%]
Dry matter (DM)	95.85
Ash content (Ash)	5.64

	Mass – [% of DM]
Glucan	65.81
Xylan	5.89
Arabinan	0.13
Klason Lignin	18.09

* in this case Acid Insoluble Material

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Sugar milling research institute
District or local community	EThekwini municipality , Kwazulu natal
Country	South Africa

Date(s) of sampling	05 September 2013
Weather at site during the sampling	Sunny, Dry weather
Outside temperature	37°C
Contextual aspects considered (rainfall etc)	The sample was shipped to us towards the beginning during the first week of September 2013

Describe the process source from which the biowaste/bio-residue stem	The sample collected was a sugar cane bagasse provided courtesy of SMRI.
Category (field residue, farm or industry)	Industry

Brief site-specific description of the management of the biomass from which the sample is taken	The company in question shipped the sample to us instead of us actually sampling the site. The sugarcane bagasse sample provides an ideal feedstock for biotechnology value added extraction and it also contain a considerable amount of hemicellulose and phenolic acids.
Any visible environmental aspects seen at the site	None
Present usage of the sampled biomass	The sample is burnt for energy production
Does biomass from which the sample is taken hold an economic or other value	Yes, The bagasse is used for energy purposes. The actual biomass (sugar cane) is used for food production

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	Sample was shipped to us instead of us actually sampling on the site
Purity	The bagasse did not contain any residual simple sugars
Colour	Greshish-black appearance
Wet/dry/mixed	dry
Particle size	3-6
Type of storage at site	Sample is used for heat energy production

Weight of sample before drying and milling	0.50 kg
Weight dried sample	0.48 kg
Weight reduction	4%

Pictures

Figure 221: The sugarcane bagasse studied

Figure 222: Close-up of final sample

Water hyacinth from water stream

General

Biomass material	Water Hyacinth from water stream
Id code of sample	SA-IN-WHW-DM-160813
Responsible project partner	ETM – South Africa

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** **Nutrient rich**
Results	see tables below

	Result [%]
Dry matter (DM)	93.94
Ash content (Ash)	30.68

	Mass – [% of DM]
Glucan	14.32
Xylan	3.13
Arabinan	4.82
Klason Lignin*	26.04

* in this case Acid Insoluble Material

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Mlazi River Intake area
District or local community	EThekwini Municipality
Country	South Africa

Date(s) of sampling	16 August 2013
Weather at site during the sampling	Partly cloudy
Outside temperature	24°C
Contextual aspects considered (rainfall etc)	

Describe the process source from which the biowaste/bio-residue stem	The process source from which the biowaste residue comes from is the uncontrolled overgrowth of the water hyacinth in Umlazi River around the Intake area.
Category (field residue, farm or industry)	Biomass found naturally in nature (water)

Brief site-specific description of the management of the biomass from which the sample is taken	The water hyacinth basically grows uncontrollably in most parts of the river due to the nutrient-rich water of the Umlazi river. This can be attributed to the eutrophication phenomena. There was no accurate was of quantifying the amount of water hyacinth at the river site. The water hyacinth weed is generally perennial in nature. Efforts have been made by Umngeni Water Treatment Company in Durban to reduce the amounts of water hyacinth but it continues to be problematic in the untreated areas.
Any visible environmental aspects seen at the site	None
Present usage of the sampled biomass	None. It is an undesired weed.
Does biomass from which the sample is taken hold an economic or other value	No.

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	The sample was taken from the river bank where the water hyacinth grows. At the time of sampling, the water hyacinth covered almost an area equivalent to 40% of the river width, that is from the river bank inwards.
Purity	Very pure
Colour	Green
Wet/dry/mixed	Wet
Particle size	5-15cm
Type of storage at site	Naturally grows. No storage

Weight of sample before drying and milling	3.00 kg
Weight dried sample	0.35 kg (Sample contained lots of water hence during the drying process the sample mass decreased drastically.)
Weight reduction	88%

Pictures

Figure 223: Water hyacinths at the water stream

Figure 224: Close-up of water hyacinths

Figure 225: Close-up of dried and milled sample of water hyacinths

Wheat bran sourced from mill

General

Biomass material	Wheat bran sourced from mill
Id code of sample	SA-PW-WB-DM-050913
Responsible project partner	CSIR-ZAR

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ **Starch rich** **Lignocellulosic** ~~Nutrient rich~~
Results	(see tables below)

Results

	Result [%]
Dry matter (DM)	89.09
Ash content (Ash)	5.73

	Mass – [% of DM]
Glucan	34.78
Xylan	10.59
Arabinan	7.18
Klason Lignin*	9.25

* in this case Acid Insoluble Material

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	FoodCorp
District or local community	Tshwane Municipality, Pretoria
Country	South Africa

Date(s) of sampling	05 September 2013
Weather at site during the sampling	Sunny, Dry weather
Outside temperature	37°C
Contextual aspects considered (rainfall etc)	The sample was collected towards the beginning of spring, season

Describe the process source from which the biowaste/bio-residue stem	The sample collected was wheat bran provided courtesy of Food Corp company.
Category (field residue, farm or industry)	Industry residue

Brief site-specific description of the management of the biomass from which the sample is taken	The company in question could not grant us access to the plant but they were actually happy to provide us with wheat bran sample. The wheat bran sample provides an ideal feedstock for biotechnology value added extraction and it also contain a considerable amount of starch that can be fermented to ethanol.
Any visible environmental aspects seen at the site	None
Present usage of the sampled biomass	Animal feed
Does biomass from which the sample is taken hold an economic or other value	Yes, The actual biomass is used for feed

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	Access to the site was restricted
Purity	The bran also contained residual starch
Colour	White/brownish appearance
Wet/dry/mixed	dry
Particle size	0.3-1mm
Type of storage at site	Sample were stored in piles with the plant

Weight of sample before drying and milling	10.0 kg
Weight dried sample	8.8 kg Wheat Bran A: VM (308)417 78% of particles range between 0.3 - 1 mm (ex Food corp, Pta West)
Weight reduction	12%

Pictures

Figure 226: Close-up of dried and milled sample of wheat bran

Wood bark sourced from paper and pulp industry

General

Biomass material	Wood Bark sourced from paper and pulp industry
Id code of sample	SA-MM-WBW-DM-200913
Responsible project partner	ETM – South Africa

Summary and chemical characteristics

Nutrient and/or sugar rich	~~Rich in simple sugars~~ ~~Starch rich~~ **Lignocellulosic** ~~Nutrient rich~~
Results	see tables below

	Result [%]
Dry matter (DM)	94.32
Ash content (Ash)	6.23

	Mass – [% of DM]
Glucan	22.55
Xylan	3.14
Arabinan	2.88
Klason Lignin*	48.37

* in this case Acid Insoluble Material

Glucan is the sum of starch and cellulose

Details of the site and present use of the feedstock

Site name	Mondi Merebank Mill
District or local community	EThekwini Municipality
Country	South Africa

Date(s) of sampling	20 September 2013
Weather at site during the sampling	Partly cloudy, no rain
Outside temperature	26°C
Contextual aspects considered (rainfall etc)	

Describe the process source from which the biowaste/bio-residue stem	The process from which the sample is taken is a large commercial scale paper manufacturing plant/mill. The bark comes from the pre-processing of wood.
Category (field residue, farm or industry)	Industry

Brief site-specific description of the management of the biomass from which the sample is taken	The pre-processing of wood before paper manufacturing involves debarking the wood using a debarking machine. The bark removed from the wood is then collected as residue and stored for other uses.
Any visible environmental aspects seen at the site	
Present usage of the sampled biomass	Bark is used as a compost feedstock and is sometimes burnt for energy production (steam)
Does biomass from which the sample is taken hold an economic or other value	

Details linked to the biomass sampled

Brief description of the biowaste sampled (as found on-site)	A truckload of bark was obtained from the mill. This is a huge plant in which various paper making operations are in progress. For this reason there was not enough space within the mill to perform the sampling hence the reason we were offered a truckload of the bark feedstock which was transported to the ETM Northdene R&D hub for the sampling process.
Purity	Very pure, only bark was present
Colour	Reddish-brown
Wet/dry/mixed	Dry
Particle size	5-10cm
Type of storage at site	Under roof

Weight of sample before drying and milling	1.00 kg
Weight dried sample	0.96 kg
Weight reduction	4%

Pictures

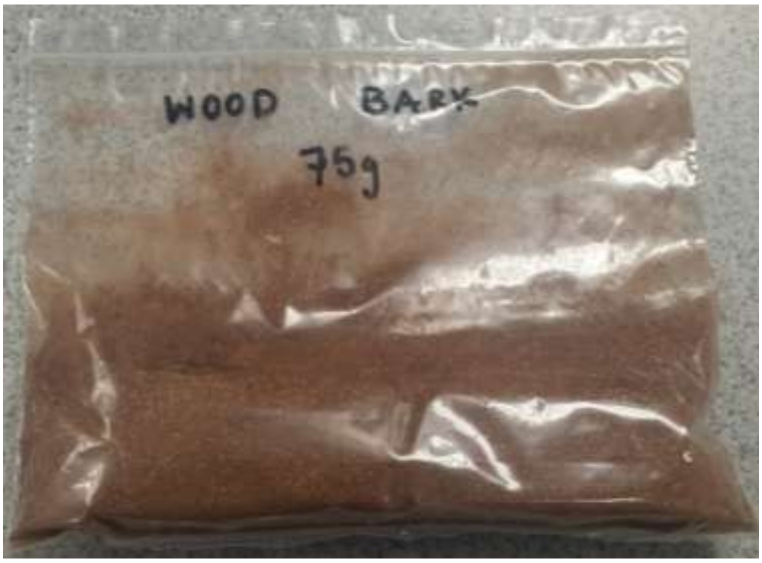


Figure 227: Dried and milled sample of wood bark, South Africa