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# Open Innovation Test Bed for Developing Safe Nano-Enabled Bio-Based Materials And Polymer Bionanocomposites For Multifunctional And New Advanced Applications

**Deliverable D.3.7**
**Biomass availability in partner countries**

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## Deliverable fact sheet

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## Executive summary

The deliverable D3.7 reports relevant data related to task T3.1 “Biomass supply” of WP3 “Upgrading pilot lines for nano-additives and raw materials extraction” of the Bionanopolys project. Diverse commercial biomasses serve as raw materials and feedstock for the proposed processes in Bionanopolys, and relevant data regarding their availability is given in this report. Potentialities of using unconventional biomass such as phytoremediation biomass and agricultural waste streams are also considered for the aim of meeting circular economy goals.

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## Introduction

The Horizon Europe Bionanopolys project (www.bionanopolys.eu) is an initiative focused on developing advanced biomaterials using nanotechnology. The project aims to harness the potential of bio-nanocomposites to create innovative and sustainable solutions for various applications, ranging from packaging and textiles to cosmetics and pharmaceutics.

Biomaterials refer to materials derived from natural sources or synthesized using biological components. They possess unique properties that make them suitable for a wide range of applications and a pertinent substitute for fossil-based materials. The Bionanopolys project seeks to leverage emerging nano-scale applications to enhance the properties and performance of biomaterials such as strength, durability, biocompatibility, and functionality. Improving the scalability and cost-effectiveness of the manufacturing processes, ensuring safety and regulatory compliance, and optimizing the performance of biomaterials for specific applications are also addressed in the project by 14 active pilot plants.

In summary, Bionanopolys aims to drive advancements in various sectors by providing sustainable alternatives to conventional materials, reducing environmental impact, and enabling new functionalities starting from lignocellulosic biomass for the production of nanocellulose, nanofibers, cellulose nanocrystals and metal nanoparticles. In this context, a variety of conventional biomasses has been particularly selected for biomaterials production based on their suitability and the specific requirements for the intended application; also the potential use of unconventional biomass is presented.

# 1. Objectives

The present deliverable is related to biomass availability in the European countries in correspondence with the Bionanopolys project and aims at providing guidelines for industries regarding the supply of biomass and relevant data to promote the sustainable use of conventional and unconventional biomass in Europe. This is intended to establish a framework that will enable industries to identify and select appropriate biomass feedstocks for biomaterials production while ensuring that the sourcing of biomass is done in an environmentally sustainable process. The guidelines will provide information on the currently available biomass in Europe, the possible suppliers, and the potential utilizations of different types of biomass. This deliverable also aims to provide insights into the use of innovative technologies and circular practices for the production of biomass, such as phytoremediation biomass and/or using agricultural waste streams as resources.

## 2. Available biomass for bionanoproduction in Europe

**Lignocellulosic biomass** is a plant-based material composed of cellulose, hemicellulose and lignin and deployed in various applications due to its renewability, abundance, and biodegradability, which make it attractive for several industries. Cellulose, the main component of lignocellulosic biomass, is a polymer of glucose with high crystallinity; it is conventionally used in the paper and food industries, amongst others. Lignin is an aromatic macromolecule of high complexity and high calorific value, usually obtained as a by-product in the pulp and paper industry as black liquor and used for power generation through burning.

Even though lignocellulosic biomass has been industrially used for decades, recent developments seek to use it as a replacement for fossil resources in novel applications, increasing the sustainability of several sectors. For instance, cellulose can be transformed into nano-cellulose, which has high strength and is seen as a possible natural and bio-based additive for plastic matrices. Cellulose can also be spun into yarns and used in the textile industry while lignin can be an important source of chemicals. Finally, cellulose and hemicellulose can be hydrolyzed into sugars, which are important building blocks for the bioeconomy and can be transformed into biomaterials and chemicals.

*Softwoods* and *hardwoods* remain two of the largest conventional sources of lignocellulose for industrial applications, while **agricultural residues** and **energy crops** have been increasingly gaining attention as alternatives. In the Bionanopolys project, two *softwoods* (pine and spruce), one energy crop (miscanthus), one agricultural residue (wheat straw) and one hardwood biomass (beech) were characterized for their suitability for conversion. **Norway spruce** (*Picea abies*) and **miscanthus** (*Miscanthus giganteus*) were selected for bio-nanomaterials production due to their suitability for conversion (data included in Deliverable 3.1), high sugar content and their availability and eminent production. Nevertheless, the choice of biomass depends on its suitability for conversion and the specific requirements of the bioproduct being developed. Therefore, the other tested biomasses could also potentially be used and their availability is also described in the following sections.

## 2.1. Wood biomass availability

The statistical office of the European Union indicated that the total EU-27 forest area was estimated to be around 159 million hectares in 2020, which represented approximately 40% of the total land area of the member states[1]. Total wood production in the EU reached an estimated 507 million $m^3$ in 2021, with a 25.6 % increase compared to 2000[2].

### 2.1.1. Softwoods

Softwood trees, such as pine, spruce, and fir, are typically fast-growing and widely available in Europe, conferring a plentiful source of biomass. The strength and durability of softwoods make them suitable for structural applications, but they are also commonly used in the pulp and paper industry due to their long fibers. Owing to these characteristics, two softwood biomass were selected by the Bionanopolys project: **spruce** and **pine**.

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[1]European Forest Institute, 2020. https://efi.int/forestquestions/q1

[2]Eurostat 2022. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Wood_products_-_production_and_trade#Wood-based_industries. Accessed in 03/07/2023

**Spruce** is a versatile and valuable tree species that has many potential uses in various industries across Europe. Its availability and use may vary depending on factors such as local market demand, forest management practices, and environmental regulations. According to the Eurostat 2021 statistics on **spruce** production, trade and industrial wood specifically for pulpwood, split and other industrial exportations, **Germany** was the largest exporter of spruce, exporting annually around 1.4 million $m^3$, followed by Belgium (0.6 million $m^3$), Norway (0.5 million $m^3$), and Austria (0.3 million $m^3$)[3].

**Pine** is another softwood tree species that is widely available in Europe, particularly in **Poland**, **Norway**, **Lithuania**, **Spain** and **Sweden,** with respective annual production of 0.9 million $m^3$, 0.5 million $m^3$, 0.5 million $m^3$, 0.3 million $m^3$, and 0.2 million $m^3$ [4]. It is used in different industries, including construction, paper manufacturing, and packaging.

### 2.1.2. Hardwoods

Hardwoods have been also opted for industrial applications in which oak, maple, and beech are distinguished with complex chemical composition, being a source of valuable biomaterials and chemicals used in the production of adhesives, coatings, pharmaceuticals, and other industrial applications.

**Beech** is a hardwood tree species that is available mainly in Croatia, Germany, Romania and France. In 2021, the annual export production under bark in **Croatia** was 0.56 million $m^3$, also in **Germany** (0.5 million $m^3$), **Romania** (0.4 million $m^3$) and **France** (0.15 million

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[3] Eurostat 2023. https://ec.europa.eu/eurostat/databrowser/bookmark/8333e112-44ec-474c-8678-90002d395767?lang=en. Accessed in 12/07/2023

[4] Eurostat 2023. https://ec.europa.eu/eurostat/databrowser/bookmark/31bb2cab-f0ba-474e-bc71-0781c3ced5a6?lang=en. Accessed in 12/07/2023

m$^3$)[5]. It is used in multiple industries, including furniture, flooring, and construction materials.

### 2.1.3. Sustainability of available wood biomass

The Forest Stewardship Council certification is consistently followed in Europe to ensure **sustainable and responsible forest management practices**, including those related to pine, beech and spruce production. Also, The EU Timber Regulation sets out requirements for the sourcing and trade of timber to respect legislations and sustainability.

## 2.2. Miscanthus availability

Energy crops, such as switchgrass, **miscanthus** and red canary grass, have proven potential for biomaterials production. Their availability varies depending on the geographical location, climate, land availability, and local agricultural practices. Thanks to its high cellulose content, **miscanthus** (*Miscanthus* spp.) is a popular biomass crop in Europe, grown primarily in **Germany**, the **UK**, and **France**.

As an emerging crop, only a few numbers are available regarding its annual production. In 2020, miscanthus production in England was 83 000 tonnes (dry matter) with over 1200 ha of land currently used for its cultivation in the UK[6]. In France, more than 4500 ha of land is covered by miscanthus crops[7]. Additionally, in Germany, around 4500 ha of

[5] Eurostat 2023. https://ec.europa.eu/eurostat/databrowser/bookmark/f00cf227-f329-433d-8032-f01b4852afa9?lang=en. Accessed in 12/07/2023.

[6] United Kingdom Department for environment, food and rural affairs, 2021. https://www.gov.uk/government/statistics/area-of-crops-grown-for-bioenergy-in-england-and-the-uk-2008-2020/section-2-plant-biomass-miscanthus-short-rotation-coppice-and-straw. Accessed in 12/07/2023.

[7] Brancourt-Hulmel, M., Höfte, H. (2022). https://doi.org/10.1007/s12155-022-10480-8

agricultural land is given for the cultivation of miscanthus[8]. Miscanthus yields can vary depending on several conditions, such as climate, harvest time, and management practices. In Europe, yields are reported to range from 10 to 50 $t.ha^{-1}.y^{-1}$ (dry matter)[9]; therefore, France and Germany are expected to annually produce between 90 000 to 450 000 t (dry matter) of miscanthus.

## 3. Biomass suppliers

Following the Bionanopolys project goals and requirements for sustainable lignocellulosic feedstocks, relevant suppliers across Europe were identified and are given in Table 1.

The suppliers identified in Table 1 are established suppliers in the market, so their prices are expected to be competitive. A new stakeholder wishing to source biomass from these companies will need to make a supply contract with them, at which point it is expected that price negotiations can be carried out depending on the volumes of biomass to be sourced.

[8] German Federal ministry for economic affairs and climate change 2022. https://www.german-energy-solutions.de/GES/Redaktion/EN/News/2022/20220927-biomass-windflowers.html. Accessed in 12/07/2023.
[9] Ben Fradj et al., 2020. https://doi.org/10.1016/j.indcrop.2020.112281

**Table 1. List of biomass suppliers in Europe (non-exhaustive)**

| Supplier | Country | Contact information | Offered services |
|---|---|---|---|
| **STORA ENSO** | Finland | staffan.torssell@storaenso.com<br>(+39) 471610121<br>www.storaenso.com | **Spruce, pine, beech** |
| **DANUBIA WOOD TRADING GMBH** | Austria | office@danubiawood.com<br>(+43) 15851813<br>www.danubiawood.com | **Spruce, pine, miscanthus** |
| **BRUNING GROUP** | Germany | mail@bruening-group.de<br>(+49) 429378940<br>www.bruening-group.com | **Pine, beech, miscanthus** |
| **ROTTNEROS** | Sweden | info@rottneros.com<br>(+46) 27062000<br>www.rottneros.com | **Spruce, pine** |
| **HOLZ PICHLER AG SPA** | Italy | info@holz-pichler.com<br>(+39) 471610121<br>www.xtimber.com | **Spruce, pine** |
| **SODRA** | Sweden | jens.hallendorff@sodra.com<br>(+46) 722351029<br>www.sodra.com | **Spruce, pine, beech** |
| **SASUPRA** | Lithuania | darius@sasupra.lt<br>(+370) 62238355<br>www.sasupra.lt | **Spruce** |
| **Ersnt Fish** | Germany | m.kicinski@ernstfisch.de<br>(+49) 2952971729<br>ernstfisch.de | **Spruce** |
| **BALTWOOD** | Latvia | info@baltwood.eu<br>(+371) 20367109<br>www.baltwood.eu | **Spruce, pine** |
| **Cradle crops** | Netherlands | info@cradlecrops.com<br>(+31) 624669672<br>cradlecrops.nl | **Miscanthus** |

## 4. Potential use of unconventional biomass

The circular economy gained attention in last years as a sustainable and resource-efficient alternative to the linear "take-make-dispose" model. In a circular economy, materials and resources are maintained in use through recycling, reusing, and regenerating processes. One promising avenue for advancing circular economy goals is the utilization of unconventional biomass, such as agricultural residues and biomass produced in contaminated sites (henceforth called phytoremediation biomass). Such unconventional biomass can address issues related to the use of conventional biomass such as land use change, soil degradation, and potential competition with food production. Moreover, by valorizing these unconventional biomass resources, we can **reduce the extraction and consumption of virgin materials**, **minimizing the associated environmental impacts**.

## 4.1. Phytoremediation biomass

**Phytoremediation,** the use of plants to extract, degrade, or immobilize pollutants from the environment, offers a unique opportunity to transform contaminated sites into valuable biomass resources. Plants employed in phytoremediation processes are capable of accumulating pollutants within their tissues, thereby cleaning the environment while simultaneously generating biomass that can be repurposed. By harnessing phytoremediation biomass, which may include plant residues, roots, or harvested biomass from contaminated sites, we can redirect these materials from being discarded or treated as waste towards productive and sustainable applications.

In Europe, around 2.5 million contaminated sites are registered, amounting to more than 550 million ha of contaminated land[10]. Several projects tested the potential use of phytoremediation biomass issued from different plant species such as **spruce**, **miscanthus**, **poplar, willow, and hemp** for different applications (e.g. NanoRetox, New-C-Land, phytoSudoe, Phytomine), including nanoparticles, biocomposites, textile and nanocatalysts. The New-C-Land project, for instance, developed a tool for guiding the use of contaminated sites for non-food biomass cultivation in Belgium and France: https://sitesforbiomass.eu/. For the Bionanopolys project, **hemp** issued from

[10] Panagos et al., 2013. https://doi.org/10.1155/2013/158764

phytoremediation is being tested as feedstock for the production of polyhydroxyalkanoates (**PHAs)**.

## 4.2. Agricultural residues

**Agricultural residues**, such as straw, husks, and stalks, are often researched as feedstock for producing nanoproducts and bio-based nanomaterials. In Europe agricultural waste is increasingly being explored for various industrial applications. A report of EU-Cordis indicates that approximately 700 million tonnes of agricultural waste is being generated annually in Europe among 1346 million tonnes worldwide[11]. The ever-growing amount of agricultural residues has become a major concern throughout the whole world. Strategies for their processing and value-added reuse are needed to enable a sustainable utilization of feedstocks and reduce the environmental burden. Due to their composition with various beneficial ingredients, these subproducts can be valorized by different techniques leading to economic and environmental advantages.

## Conclusion

Several feedstocks are available for producing nanocomposites from bio-based sources with a supply chain already well-established for the conventional sources such as wood biomass. Even though there are regulations that ensure a sustainable production of such woody biomass, for increased sustainability it is important to consider unconventional sources of biomass such as agricultural wastes and phytoremediation biomass to

[11]Cordis 2021. https://cordis.europa.eu/article/id/410208-sustainable-food-waste-reduction-solutions-bolster-our-bioeconomy. Accessed in 12/07/2023.

increase the availability of biomass for the bioeconomy without increasing the use of agricultural land for the production of materials.