Bin2Bean

From Bio-waste to soil

D3.4 – Strategy to identify Critical Control Points (CCP) to monitor throughout the value chain

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BIN2BEAN project

D3.4 Strategy to identify Critical Control Points (CCC) to monitor throughout the value chain

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List of Acronyms

EC – European Commission
HACCP - Hazard Analysis and Critical Control Points; a preventive and systematic risk management approach

CCP - Critical Control Point; Process step at which a significant biological, chemical or physical hazard can be prevented, eliminated or reduced to an acceptable level through monitoring and control measures
CP - Control Point; Process step where monitoring or operational control is applied to support product quality and process management

Executive summary

The production of soil improvers from biowaste plays an important role in supporting nutrient recycling, circular economic objectives and sustainable soil management in Europe. At the same time, the safe and high-quality production of composts, digestates and other recycled fertilizing products require systematic risk management throughout the value chain, from biowaste collection to the final product.

This guideline was developed within the BIN2BEAN project to provide a harmonized and practical framework for identifying Critical Control Points (CCPs) and Control Points (CPs) in the production of soil improvers from biowaste. The guideline supports operators and other stakeholders in establishing HACCP-inspired quality management practices adapted to local processes and regulatory contexts.

The guideline covers the full production chain, including biowaste collection and reception, sorting and pre-treatment, composting and anaerobic digestion, maturation and storage, final processing, and final product quality control. It describes the main biological, chemical, and physical hazards associated with each process stage and provides practical guidance for monitoring, critical limits, corrective actions, traceability and documentation.

As part of the development process, a decision tree -based approach was created to support the systematic identification of CCPs and CPs. The approach was evaluated in BIN2BEAN Living Labs in Amsterdam, Egaleo and Hamburg through a validation survey involving biowaste management and soil improver production actors. The feedback confirmed that the decision tree is easy to use and highlighted the importance of input material quality management, particularly during biowaste sorting, collection and reception. The validation process also identified the need for clearer guidance on corrective actions, deviation management, monitoring practices and documentation, which were integrated into the final guideline.

The guideline is intended for soil improver producers, composting and anaerobic digestion operators, quality management personnel, laboratories, and other stakeholders involved in biowaste valorization. The approach can be adapted to different scales and local operational contexts and may support compliance with EU Fertilizing Products Regulation (EU 2019/1009), national quality assurance systems and other relevant standards.

1 Current EU requirements and quality management approach

The production and placing on the market of soil improvers from biowaste are regulated by EU and national legislation, including Regulation (EU) 2019/1009 on EU fertilizing products and relevant national quality assurance systems and standards. Operators are responsible for ensuring product safety, traceability and compliance throughout the production process.

Although no specific HACCP requirements exist for recycled fertilisers and soil improvers, a HACCP-inspired quality management approach can be applied to support systematic risk management and product safety. Such a system includes process description, raw material management, hazard assessment, identification of Critical Control Points (CCPs), monitoring procedures, corrective actions, documentation and verification.
The approach considers relevant biological, chemical and physical hazards at different process stages and defines suitable control measures and critical limits where needed. (1,2)

2 Biological, physical and chemical hazards in the production of soil improvers

The production of soil improvers from biowaste involves biological, physical, and chemical hazards that may affect product safety, quality, environmental performance and market acceptance (Table 1). Effective risk management requires that these hazards are identified, monitored and controlled throughout the production chain.

Physical hazards are mainly related to impurities and unwanted materials with incoming biowaste. Raw bio-waste can contain plastics, glass, metals, stones and other foreign objects. If not properly removed during sorting and pre-treatment, these materials may reduce product quality, damage equipment and limit the suitability of the final product for agricultural or horticultural use. Microplastics and visible plastic residues are a concern, particularly in mixed municipal biowaste streams. In addition, excessive dust or unsuitable particle size distribution may affect product handling, spreadability and occupational safety. (5)

Biological hazards concern microbiological safety and the presence of unwanted organisms. Inadequate hygienization may allow the survival of pathogenic microorganisms such as *Salmonella spp.* and *Escherichia coli*, which are commonly used as hygiene indicators in regulatory testing. Animal-derived pathogens or parasites can also remain viable if animal by-products are not treated under validated thermal conditions required by EU regulations (EC) N:o 1069/2009, and (EU) N:o 142/2011. Furthermore, weed seeds can survive in compost that has not reached sufficient temperatures, leading to their unintended spread in agricultural fields. (5, 7)

Chemical hazards include heavy metals, organic contaminants and nutrient-related risks. Heavy metals such as cadmium, lead, mercury, and nickel may enter the process through contaminated input material and accumulate in the final product. Organic contaminants,

including PAHs, PCBs, phthalates, and flame retardants, may also be present depending on the origin of the biowaste. Chemical risks may additionally arise from excessive salinity, high ammonium concentrations, or nutrient imbalances that can negatively affect plant growth or soil quality. (4)

Table 1. List of potential hazards, contaminants, and interfering materials in the process and the products.

Hazard category	Hazard / quality parameter	Why important
Physical	Plastics, metals, glass, stones	Quality and legal compliance, Environmental contamination and littering risk
Physical	Cross-contamination, machinery contamination, residual plastics/metals	Quality assurance and machinery lifespan
Physical	Dry matter / moisture content	Compostability and spreadability
Physical	Particle size	Mechanical properties and spreadability
Biological	Odour nuisance and microbial contamination	Process stability and prevention of environmental nuisance
Biological	Incomplete degradation and insufficient sanitisation	Hygiene and product usability
Biological	Pathogens: E. coli, Salmonella, Legionella	Regulatory compliance and user safety
Biological	Cross-contamination and biological hazards	Hygiene and environmental safety
Biological	New contamination and hygienic risks during storage	Product safety
Biological	Stability	Maturity and safe use
Biological	Organic matter (% oTS)	Soil improvement properties
Biological	Weed seeds and propagules	Prevention of weed spread and product usability
Chemical	Unstable pH and buffer capacity	Process balance
Chemical	Ammonia / H_2S	Process balance and occupational safety
Chemical	Heavy metals (Cd, Pb, etc.)	Legal limits and environmental contamination
Chemical	Antibiotic residues	Prevention of antibiotic resistance and food safety
Chemical	Organic contaminants (PAH, PCB, phthalates), etc.	Agricultural and environmental quality
Chemical	Nutrient content (NPK, trace elements)	Soil improvement effect
Chemical	C/N ratio	Maturity and nitrogen immobilisation assessment
Chemical	CEC (cation exchange capacity)	Nutrient retention capacity
Chemical	Mineralisation potential (NO_3-N/NH_4-N)	Control of nitrogen release
Chemical	EC (electrical conductivity)	Crop salt tolerance

3 Definition of Critical Control Points (CCP)

Critical Control Points (CCPs) are process steps where a significant biological, chemical or physical hazard can be prevented, eliminated or reduced to an acceptable level through

monitoring and control measures. The identification of CCPs is a central part of risk-based quality management in the production of soil improvers from biowaste.

The identification process begins with mapping the full production chain, including biowaste reception, pre-treatment, biological processing, storage and final product handling. At each stage, potential hazards and their significance are assessed together with the available monitoring and control measures. Not all process steps are CCPs; some may function as Control Points (CPs) supporting overall process quality and operational management.

Typical CCPs in biowaste treatment processes may include the acceptance and inspection of incoming biowaste, removal of physical contaminants during pre-treatment, temperature and retention time control during hygienization, monitoring of pH, moisture or process stability, and final product testing for pathogens, heavy metals or impurities (Table 1).

Each CCP should include a clearly defined hazard, suitable monitoring procedures, measurable critical limits or acceptance criteria, corrective actions in case of deviations, and appropriate documentation and verification practices. If monitoring results indicate that a critical limit is exceeded or process control is lost, corrective actions should be implemented to prevent unsafe or non-compliant material from entering the next process stage or the final product stream. Depending on the severity of the deviation, corrective measures may include reprocessing, additional treatment, restricted use of the product or batch rejection. (3)

4 Objectives and Scope

The production of soil improvers from biowaste is becoming increasingly important as part of nutrient recycling, circular economy strategies and sustainable soil management within the European Union. At the same time, the use of heterogeneous biowaste streams requires systematic quality management to ensure product safety, regulatory compliance and user confidence. (7,8)

The objective of this guideline is to provide a harmonized and practical framework that can be adapted to different local operational contexts for identifying Critical Control Points (CCPs), defining critical limits and supporting risk-based quality management in the production of soil improvers from biowaste. The guideline is based on HACCP-inspired principles and focuses on the identification, monitoring and management of biological, chemical and physical hazards throughout the production chain.

The guideline covers the full value chain from biowaste collection, reception and pre-treatment to biological treatment, maturation, storage, final processing and final product verification. It supports operators in identifying relevant process risks, implementing monitoring and corrective actions, improving traceability and documentation practices, and demonstrating product safety and quality.

The guideline is intended for composting and anaerobic digestion operators, soil improver producers, quality management personnel, laboratories, authorities and other stakeholders involved in biowaste valorisation and recycled fertilising products. The approach can be

applied in different operational scales and may support compliance with Regulation (EU) 2019/1009, national quality assurance systems and other relevant standards.

5 Methodology for developing the guideline

This guideline was developed within the BIN2BEAN project (WP3) as part of the work on improving the safety, quality, and market acceptance of soil improvers produced from biowaste. The development process built on previous WP3 tasks related to biowaste collection systems, process quality management, hazard identification, analytical methods, and soil improver performance assessment.

The work included a review of relevant EU legislation, standards, existing quality assurance approaches, and practical management methods related to composting, anaerobic digestion, and fertilising products made from organic waste. Biological, chemical, and physical hazards associated with different process stages were identified together with relevant monitoring parameters, critical limits, and possible corrective actions.

The development of the guideline was closely linked with BIN2BEAN Living Lab activities and interactions carried out throughout previous work packages and tasks. Living Labs in Amsterdam, Egaleo and Hamburg contributed practical knowledge related to local biowaste collection systems, treatment processes, quality management practices and end-user perspectives. Experiences, operational challenges and stakeholder feedback gathered during earlier BIN2BEAN activities supported the identification of relevant hazards, process stages and monitoring needs considered in this guideline and the related Decision Tree approach.

Based on this work, a draft guideline and Decision Tree approach were developed to support operators in identifying process-specific Critical Control Points (CCPs) and Control Points (CPs). The draft guideline and Decision Tree were reviewed internally within the project consortium and further refined through Living Lab validation activities. Validation was carried out through stakeholder testing and feedback collection in Amsterdam, Egaleo and Hamburg to evaluate the practical applicability of the Decision Tree approach under different local operational conditions.

A summary of the Living Lab validation survey and feedback is provided in Annex 1.

6 Critical Control Points of process stages

6.1 Biowaste collection and reception

The collection and reception of biowaste are among the most critical stages for ensuring the quality and safety of soil improvers. The quality of incoming materials directly affects the effectiveness of subsequent treatment processes and the quality of the final product.
Physical impurities such as plastics, glass, metal objects, and stones are commonly detected in separately collected biowaste and may remain in the process if not effectively removed during reception and pre-treatment (Table 2). Incoming biowaste may also contain chemical contaminants or biological hazards depending on the origin and quality of the input material.

Monitoring practices at this stage may include visual inspections, sampling procedures, supplier verification, and documentation of contamination levels. Acceptance criteria should be clearly defined for different input materials, and batches exceeding established quality limits should be rejected, redirected to additional pre-treatment or handled through other corrective measures. (5)

6.2 Sorting and pre-treatment

Sorting and pre-treatment ensure that only suitable materials enter composting or anaerobic digestion processes. Effective source separation and pre-treatment significantly influence the safety, quality and usability of the final product. Incoming biowaste may contain physical contaminants such as plastics, metals, glass, stones and other foreign materials that can reduce product quality, interfere with processing equipment and prevent compliance with regulatory or product-specific quality requirements. Depending on the origin of the input material, the material may also contain microplastics or other contaminants requiring additional control measures.

Monitoring and control practices at this stage may include visual inspections, sampling, manual sorting, mechanical separation and documentation of contamination levels. The effectiveness of pre-treatment processes should be regularly verified to ensure that contaminants are adequately removed before biological treatment.

Acceptance criteria and operational limits should be clearly defined for incoming materials and pre-treated fractions. If contamination levels exceed acceptable limits, corrective actions may include additional sorting, reprocessing, diversion to another treatment process or rejection of the batch. All significant deviations and corrective measures should be documented to support traceability and process verification. (5)

6.3 Composting and anaerobic digestion process

Composting and anaerobic digestion are biological treatment processes used to decompose and stabilize organic matter, reduce biological hazards, and produce safe and high-quality soil improvers or digestates. Effective process control is essential to ensure process efficiency, hygienisation, product stability, and compliance with quality requirements. Key process parameters include temperature, moisture content, retention time, aeration, pH and process stability, all of which influence microbial activity and treatment efficiency. In composting processes, maintaining sufficient temperature and retention time is essential to ensure adequate hygienisation and degradation of organic matter and reduction of pathogens and weed seeds. In anaerobic digestion processes, monitoring of pH, alkalinity, ammonia, and hydrogen sulfide is important for maintaining biological stability, methane production efficiency, and operational safety.

Monitoring procedures may include continuous or regular measurements, process records, and verification of operating conditions throughout the active treatment phase. Stability indicators such as oxygen uptake rate (OUR), gas production parameters, or other maturity indicators may also be used to assess process performance and material stability.

Critical limits and operational target values should be defined for relevant process parameters. If monitoring indicates that process conditions fall outside acceptable limits, corrective actions may include adjusting aeration, moisture or input material composition, extending processing time, remixing material, modifying feeding practices or reprocessing the batch. Monitoring results, deviations, and corrective actions should be documented to ensure traceability and verification of process performance. (5, 7)

6.4 Maturation and storage

After the active composting or anaerobic digestion phase, the material enters the maturation and storage stage, where the stabilization of organic matter continues and the quality of the final product is maintained before use or distribution. This stage is also important for the further decomposition of organic matter and the reduction of the C/N ratio to a level suitable for stable and mature soil improvers. Proper management of this stage is important for preventing recontamination, maintaining product stability and ensuring consistent product quality. Key monitoring parameters during maturation and storage may include temperature, moisture content, odor, and product stability (Table 2). Inadequate storage conditions may lead to renewed microbial activity, anaerobic conditions, odor formation and nutrient losses. In addition, insufficient separation of treated and untreated materials may increase the risk of cross-contamination.

Storage areas and handling practices should be designed to minimize contamination from external sources, pests, machinery or untreated materials. Clear procedures should be established for batch identification, storage duration and the separation of different material streams to support traceability and quality management. If monitoring indicates deviations from defined storage or maturation conditions, corrective actions may include additional aeration, turning, moisture adjustment, extended maturation time or reprocessing of the material. All significant deviations, monitoring results and corrective measures should be documented to support verification and product release decisions. Effective maturation and storage practices contribute to product stability, safe handling and the consistent quality of soil improvers before final use or placing on the market. (4, 5)

6.5 Sieving and final processing

Sieving and final processing are important process stages for ensuring that the final product meets the intended quality, safety and usability requirements. These stages are used to break up oversized particles, reduce remaining impurities and unwanted materials, while improving the consistency and handling properties of the product. Potential risks at this stage include the presence of plastics, metals, stones or other foreign materials, unsuitable particle size distribution, excessive salinity or insufficient product stability (Table 2). Depending on the input material and process, additional risks related to chemical contaminants or product quality deviations may also need to be considered.

Monitoring procedures may include sieve analysis, visual inspections, electrical conductivity measurements and verification of product stability and physical quality. The functionality and cleanliness of screening and processing equipment should also be regularly checked to minimize cross-contamination and maintain process performance. Critical limits or acceptance criteria should be defined for relevant quality parameters and impurity levels. If

the product does not meet the required criteria, corrective actions may include re-screening, additional processing, blending with conforming material, restricting the intended use of the product or rejection of the batch. Monitoring results, deviations and corrective actions should be documented to support traceability and final product verification. (5)

6.6 Final Product

Before placing the product on the market or applying it to soil, the final product should be verified to ensure that it meets relevant regulatory, safety and quality requirements. Final product control is essential for confirming that the production process has been effective and that the product is suitable for its intended use. Key quality and safety parameters may include microbiological quality, heavy metal concentrations, visible impurities, nutrient content, stability, organic matter content, particle size distribution and electrical conductivity (Table 2). Depending on the input material, process and intended use of the product, additional chemical or agronomic parameters may also require assessment.

Monitoring and verification procedures may include laboratory analyses, sampling programs, visual inspections and review of process and batch documentation. Sampling and testing practices should be based on relevant standards, regulatory requirements and risk-based quality management principles. Acceptance criteria and critical limits should be clearly defined for relevant product parameters. If the final product does not meet established requirements, corrective actions may include additional treatment, reprocessing, restricting the intended use of the product or rejection of the batch. Product release decisions should be based on documented monitoring and analytical results together with traceable batch information. (5, 8)

Table 2. Critical Control Points in different biowaste process stages. The presented limits are indicative examples; additional national or product-specific requirements may apply.

Stage of the process	Potential hazards	Critical Control Point (CCP)	Monitoring measures	Critical Limits	Corrective actions
Household sorting and collection of bio-waste	plastic, glass, metal, chemical residues, biological risks	CCP: Source separation and contamination control	Visual inspection of collected waste, public reporting systems	Max. 5g/kg contamination by weight (dry matter); max. 2.5 g/kg plastics of dry matter >2 mm (EU 2019/1009, from July 2026)	Direct feedback to households; public awareness campaigns; rejection of highly contaminated batches; economic incentives or sanctions depending on local regulation
Biowaste collection and reception	Heavy metals, pesticides, plastics, pathogens	CCP1: Raw material acceptance criteria and sampling	Sampling and lab analysis (e.g. ICP-OES), supplier verification	Heavy metals < legal thresholds, plastic < 0.5%, no hazardous waste	Reject batch, trace source, notify supplier
Sorting and pre-treatment	Foreign objects (glass, metal, plastic), contamination	CCP2: Mechanical separation, visual inspection	Manual sorting, metal detectors, visual control	>99 % of particles <40 mm, minimal foreign objects	Re-sort, remove contaminants, adjust process
Composting process	Insufficient temperature/time → pathogen survival	CCP3: Temperature-time control (e.g. 55°C for 2 weeks)	Continuous temperature monitoring, compost logs	Minimum 55°C for 14 days (or regional equivalent)	Extend composting time, remix pile, check aeration
Composting process	Incorrect moisture content and pH	CCP4: Moisture and pH control	moisture and pH measurement	Moisture content between 40-65 %, pH 6.0-8.0	Adjust moisture and pH
Maturation and storage	Unstable compost, nitrogen immobilization, phytotoxins	CCP5: Compost maturity and stability testing	Respiration test, NO3/NH4 ratio	NO3/NH4 > 1, NH4 < 0.4 g/kg, OUR < 10 mmol/kg OM/h	Extend curing phase, reprocess or reject batch
Sieving and final processing	Particle size, Elecctrical conductivity	CCP6: Final product quality control	Sieve analysis, EC testing	EC: ± 75 % relative deviation of the declared value	Rescreen, dilute with conforming compost, reprocess or reject
Final product	Pathogens	CCP7: E. coli and Salmonella testing	Microbial assays	Pathogens absent	Re-sanitation or reject the batch
Final product	Heavy metal concentrations	CCP8: Final product acceptance criteria and sampling	Legal/product specific limits	Heavy metals < legal thresholds	Limit use to non-agricultural areas or reject
Final product	stability, phytotoxicity	CCP9: Final product acceptance	Oxygen uptake rate	OUR < 25 mmol/kg OM/h	Extend maturation or limit application

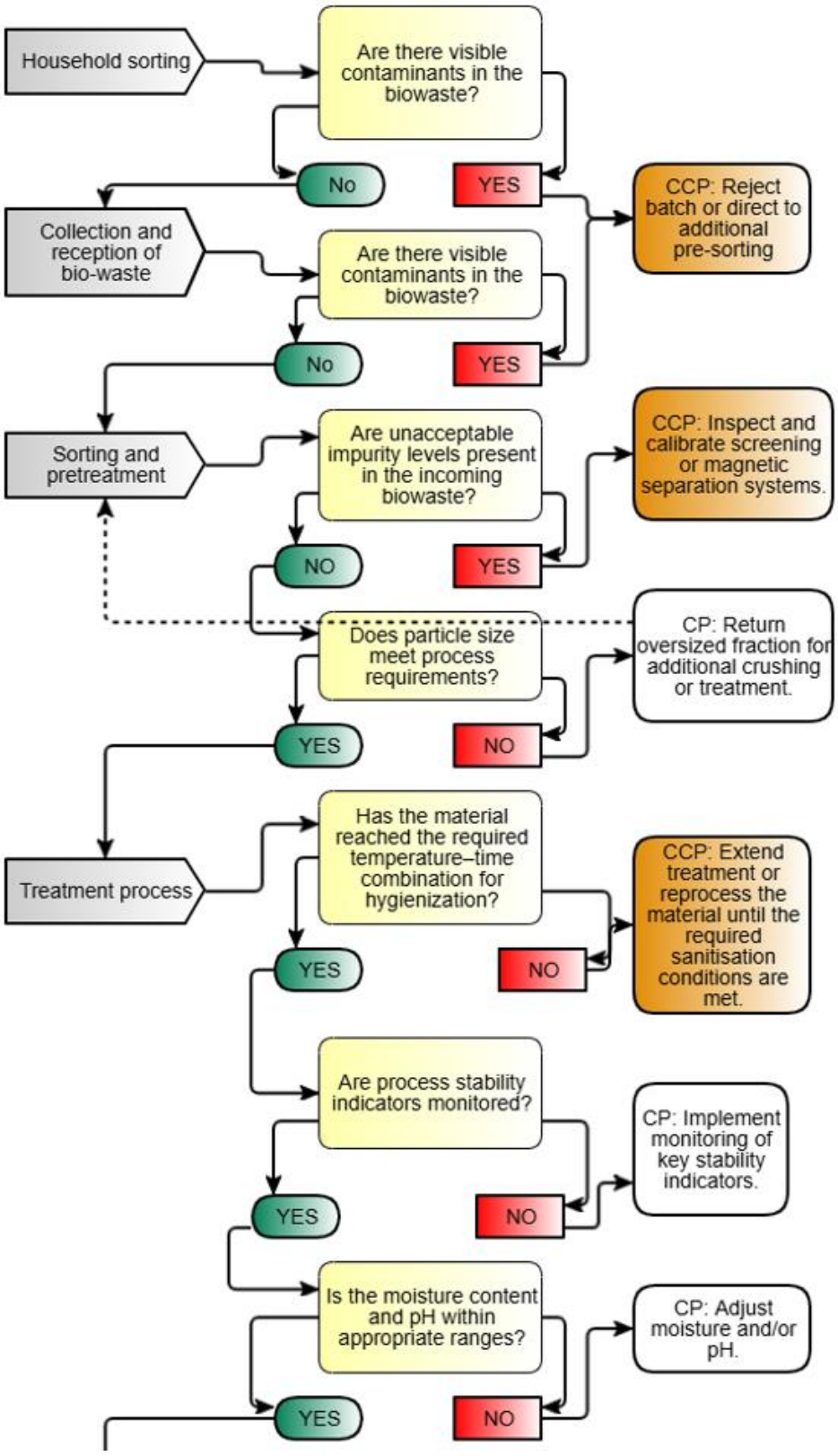
7 Decision Tree for Identifying Critical Control Points in Soil Improver Production

A decision tree can be used as a practical tool to support the systematic identification of Critical Control Points (CCPs) and Control Points (CPs) in the production of soil improvers from biowaste. The purpose of the decision tree is to help operators evaluate process-related hazards, determine where control measures are needed and define suitable monitoring and corrective actions for different process stages. The decision tree approach is based on a sequence of questions related to the significance of identified hazards, the availability of preventive or control measures, the possibility of monitoring the process step and the potential impact of process deviations on product safety or quality. The approach supports consistent decision-making and helps distinguish CCPs from general operational control points.

The assessment should be carried out separately for each relevant process stage, including biowaste reception, pre-treatment, biological treatment, maturation, storage, and final product handling (Fig. 1). The evaluation should consider biological, chemical, and physical hazards together with process-specific operational conditions, input material characteristics and the intended end use of the product. When applying the decision tree, operators should evaluate whether a significant hazard may occur at the process stage and whether the hazard can be prevented, eliminated or reduced through process control measures. The assessment should also consider whether suitable monitoring procedures and measurable critical limits or acceptance criteria can be established, and whether possible deviations can be effectively corrected before the material reaches the next process stage or the final user.

If loss of control at a process stage may compromise product safety, quality or regulatory compliance, the stage may be identified as a CCP. Process stages that primarily support operational management or product quality without being critical for safety may be classified as CPs. The decision tree should be used together with process descriptions, monitoring plans, documentation procedures and relevant regulatory requirements. The identified CCPs and CPs should be regularly reviewed and updated whenever process conditions, input material, technologies or regulatory requirements change. The following decision tree (Fig. 1, and Table 3) provides an example of a practical approach for identifying CCPs and CPs in biowaste treatment and soil improver production processes.

Figure 1. Key questions and Decision Tree for CCP identification.



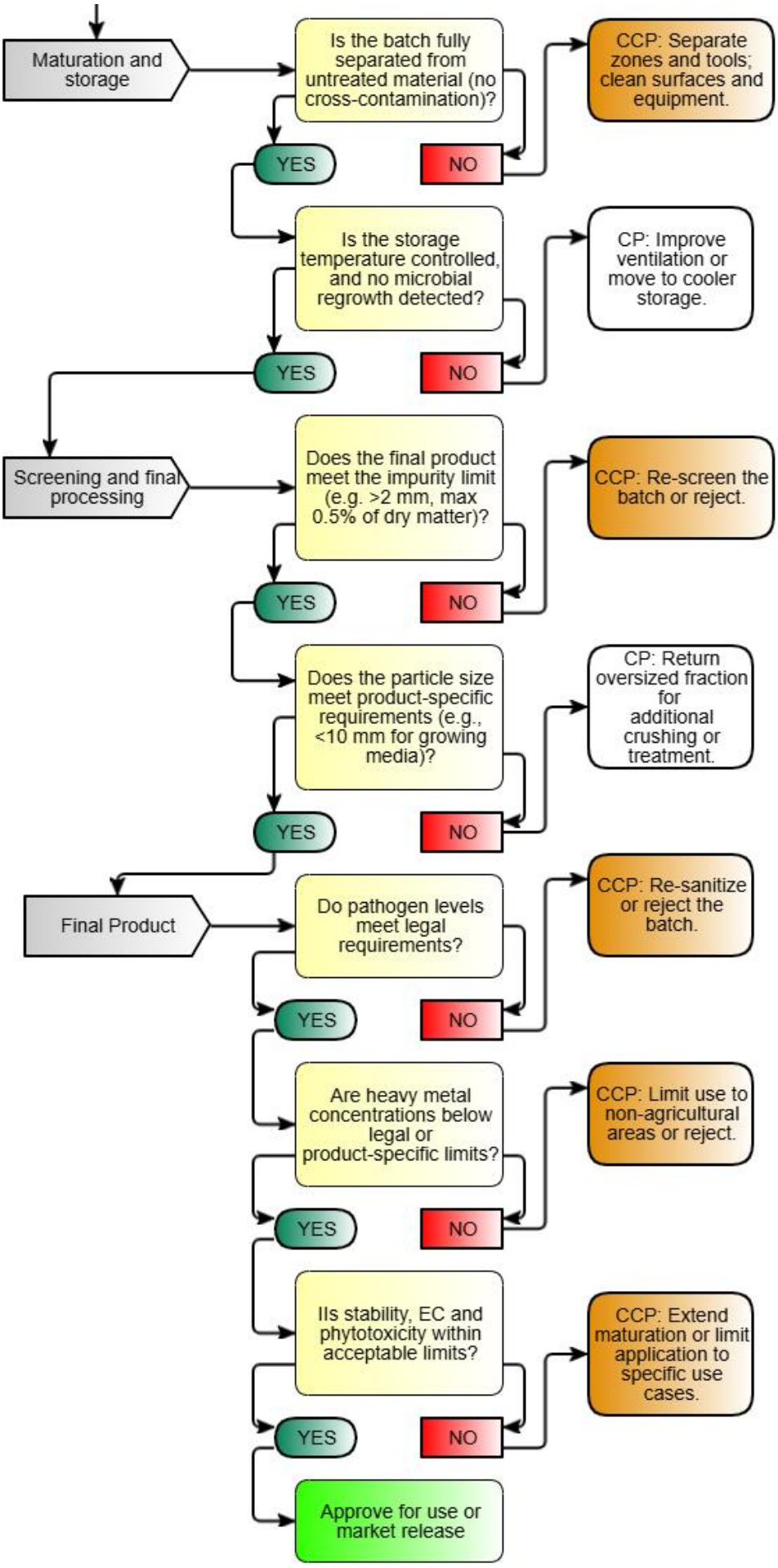

Maturation and storage
Is the batch fully separated from untreated material (no cross-contamination)?
CCP: Separate zones and tools; clean surfaces and equipment.
YES
NO
Is the storage temperature controlled, and no microbial regrowth detected?
CP: Improve ventilation or move to cooler storage.
YES
NO
Screening and final processing
Does the final product meet the impurity limit (e.g. >2 mm, max 0.5% of dry matter)?
CCP: Re-screen the batch or reject.
YES
NO
Does the particle size meet product-specific requirements (e.g., <10 mm for growing media)?
CP: Return oversized fraction for additional crushing or treatment.
YES
NO
Final Product
Do pathogen levels meet legal requirements?
CCP: Re-sanitize or reject the batch.
YES
NO
Are heavy metal concentrations below legal or product-specific limits?
CCP: Limit use to non-agricultural areas or reject.
YES
NO
IIs stability, EC and phytotoxicity within acceptable limits?
CCP: Extend maturation or limit application to specific use cases.
YES
NO
Approve for use or market release

Table 3. Decision tree and corrective actions for CCP/CP identification.

Process stage	Key question	YES	NO	CCP / CP
Biowaste reception	Are visible contaminants present in incoming biowaste?	Direct material to pre-sorting or additional inspection	Continue to next process step	CCP
Sorting and pre-treatment	Are unacceptable impurity levels present after pre-treatment?	Continue additional separation or reprocessing	Continue process	CCP
Pre-treatment	Does particle size meet process requirements?	Continue process	Return oversized fraction for crushing or treatment	CP
Treatmet process/ hygienization	Has the required temperature–time combination for hygienization been achieved?	Continue process	Extend treatment or reprocess material	CCP
Treatment process/ monitoring	Are process stability indicators monitored?	Continue monitoring	Define monitoring practices based on process risks	CP / CCP depending on process
Composting process	Are moisture content and pH within target ranges?	Continue process	Adjust process conditions	CP
Composting process	Is aeration or turning adequately controlled?	Continue process	Improve aeration or turning frequency	CP
Maturation and storage	Is cross-contamination between treated and untreated material prevented?	Continue storage	Separate material streams and clean equipment	CCP
Storage	Is storage temperature controlled?	Continue monitoring	Improve ventilation or storage conditions	CP
Screening and final processing	Does the final product meet impurity limits?	Continue to final product approval	Re-screen or reject batch	CP / CCP depending on severity
Screening and final processing	Does particle size meet product-specific requirements?	Continue process	Return material for additional treatment	CP
Final product	Do pathogen levels meet legal requirements?	Continue documentation	Re-sanitize or reject batch	CCP
Final product	Are heavy metal concentrations below legal limits?	Continue documentation	Restrict use or reject batch	CCP
Final product	Are stability, EC, nutrient content and phytotoxicity within acceptable limits?	Product approved	Extend maturation, restrict use, reprocess or reject	CCP

8 Practical considerations for CCP management

The decision tree and CCP/CP approach presented in this guideline provide a practical framework for identifying and managing biological, chemical and physical risks in the production of soil improvers from biowaste. Effective implementation requires that the approach is adapted to local operational conditions, input materials, treatment technologies and regulatory requirements. Different operational environments may involve different types of biowaste streams, collection systems, processing technologies and quality challenges. The composition and contamination level of separately collected household biowaste may differ significantly from food industry side streams, park and garden waste or catering waste. As a result, the identified CCPs, monitoring procedures, critical limits and corrective actions may vary between facilities and regions.

When applying the decision tree, operators should ensure that process descriptions, responsibilities, monitoring procedures and corrective actions are clearly defined and regularly updated. Particular attention should be paid to biowaste sorting, collection and reception, as the quality of incoming materials strongly influences process performance and final product quality. The effectiveness of a HACCP-based or HACCP-inspired system depends on systematic monitoring, practical control measures and consistent documentation. Monitoring procedures should remain practical and proportionate to the scale and complexity of the operation. Smaller facilities may apply simplified monitoring approaches, while larger or more complex treatment systems may require more detailed process control, analytical testing and traceability systems.

The identified CCPs and CPs should be regularly reviewed, especially when input materials, technologies, operating conditions or legal requirements change. Staff training, internal communication and clear responsibilities are important to ensure consistent implementation of monitoring and corrective actions. Special attention should be given to contamination management, hygienization efficiency, prevention of cross-contamination, storage conditions and final product verification. In addition to supporting regulatory compliance, consistent quality management improves product safety, market acceptance and user confidence in soil improvers derived from biowaste. The decision tree should be used as a flexible support tool rather than as a fixed checklist. The framework can be replicated and adapted in different local contexts by selecting process-specific monitoring parameters, critical limits and corrective actions that reflect local operational conditions, available technologies and intended product use.

8.1 Adaptation to local operational contexts

In cities and regions where separately collected household biowaste and urban organic waste streams form a major part of the input material, such as Amsterdam, particular emphasis should be placed on source separation quality, contamination monitoring, acceptance criteria and effective pre-treatment practices to reduce physical impurities such as plastics, glass and metals.

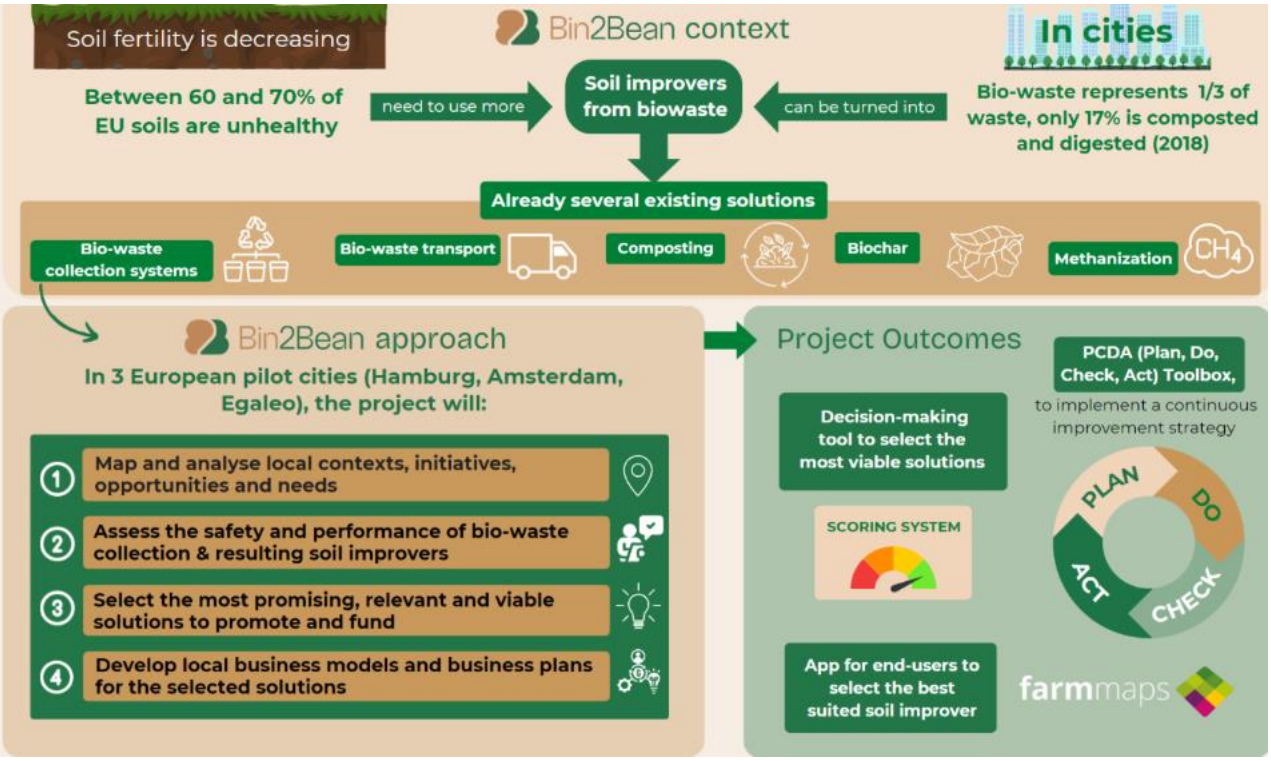
In cities where biowaste collection and treatment systems are still under development, such as Egaleo, the priority may be the establishment of systematic monitoring, documentation

and HACCP-inspired management practices. Although the input material may be relatively clean, clear operational procedures, traceability systems, corrective actions and staff responsibilities are important to support the gradual development of consistent process management practices.

In regions where biowaste treatment systems and quality management procedures are already well established, such as Hamburg, the framework may support the review and harmonization of existing monitoring and documentation practices. The Decision Tree approach may also provide additional support for communication between stakeholders, comparison of operational practices and adaptation to future regulatory changes or new input material streams.

About Bin2Bean

Bin2Bean is a research-action project, co-funded by the European Commission under the Mission Soil, which aims to optimise the performance of bio-waste collection and transformation into soil improvers. It started in September 2023 and will last 3 years.



Bin2Bean collaborates with 3 City-Region Living Labs (*Amsterdam*, *Egaleo*, *Hamburg*), which have different states of progress and levels of experience on the topic, to implement a series of activities:

1. **Map local contexts**, in terms of state-of-progress, existing initiatives, needs, material and monetary flows.

2. **Design a tailored evaluation framework** to demonstrate the safety, environmental and socio-economic performance of bio-waste collection systems and soil improvers.

3. **Develop a scoring system**, fed by data from the evaluation framework, to help cities select the most effective and market-ready solutions adapted to their context.

4. **Develop tailored and viable business and/or community models** for the highest scored solutions, according to stakeholders' willingness-to-adopt.

5. **Draft local, national and EU policy roadmaps**, including waste charging policies and citizen awareness campaigns.

All this will feed into a **PDCA (Plan, Do, Check, Act) toolbox**, enabling any city-region to create a continuous improvement loop towards effective bio-waste recycling and regenerative soil systems.

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Annex 1: Decision Tree survey – summary report

The survey was conducted in the Living Labs to assess whether a decision tree–based questionnaire supports soil improver producers in identifying their own Critical Control Points (CCPs) and Control Points (CPs), and in compiling a site-specific CCP/CP list. The survey was implemented as a Webropol questionnaire between 7 and 26 April 2026. A total of six responses were received (n=6): two from the Netherlands (Amsterdam), two from Greece (Egaleo), and two from Germany.

Background information

Respondents primarily worked in biowaste collection, reception and pre-treatment, composting, anaerobic digestion, and/or final product quality management. The assessed input materials included household biowaste, restaurant biowaste, food industry side streams, and park/garden waste.

The final products were used in agriculture, landscaping/green infrastructure, consumer products, and municipal/urban applications. Products were mainly used locally, but some respondents reported distribution at the national level and in other EU countries and outside the EU. In addition to national legislation, operations were guided by EU legislation (EU 2019/1009) and various quality management systems, certifications and/or HACCP-based procedures.

Biowaste reception and pre-treatment

All respondents reported that visible impurities are always present in incoming biowaste. In addition, half of the respondents indicated that impurities may still be present after processing. Regarding particle size, half of the respondents stated that the material does not always meet the target (< 60 mm). In such cases, the material is routed to reprocessing, diverted to another process, or the batch is not accepted. However, some responses indicated that clear and consistent procedures for handling deviations were not in place.

When contamination is detected, the most common action is manual removal of impurities or routing the batch to reprocessing. In some cases, the batch is not accepted at all, or a clear operating procedure is lacking.

Process control

Half of the respondents worked with composting, one respondent with anaerobic digestion, and two with both processes. Among process stability indicators, the most commonly monitored parameters were ammonia (NH_3) and alkalinity/buffering capacity. Moisture content and pH were reported to be within target values in half of the responses. Aeration was monitored automatically in half of the responses.

Maturation, storage and final processing

Based on almost all responses, cross-contamination was prevented, and batches were kept separated. However, three respondents reported that storage temperature is not measured. Three respondents also reported that final product requirements/thresholds (e.g., limits for visible impurities or particle size requirements such as <10 mm for substrates) are not met in their process or product.

Final product

Most respondents assessed that pathogen levels remain within limits. Half of the respondents reported that heavy metal concentrations are below the limit values. In addition, half indicated that final product stability is within limits and that phytotoxicity is at an acceptable level. Visible impurities were assessed by four respondents. Nutrient content was analyzed by five respondents, and electrical conductivity (EC) by four respondents.

Risk management, support needs and feedback

Four respondents reported using a HACCP-based risk management plan or a similar approach (e.g., a risk management plan linked to specific equipment or process stages). Most respondents identified household biowaste sorting, as well as its collection and reception, as the most significant risk factors affecting final product quality. Respondents expressed a need for support across several areas, particularly in defining critical limits, monitoring practices, traceability and documentation, corrective actions, and use of the decision tree.

All six respondents found the decision tree easy to use. Regarding perceived usefulness, one respondent considered it useful, three were neutral, and two did not consider it useful. When asked whether they already use a similar tool or a HACCP-based approach for identifying critical points, one responded yes, three partly, and two no (or were unsure).

Overall summary and conclusions

The Living Lab survey results indicate that the decision tree questionnaire is user-friendly, as all respondents found it easy to use. The responses also confirm that key risks and bottlenecks in control are concentrated particularly in biowaste sorting, collection and reception, where impurities are systematically observed. This indicates that the guidance should prioritize input material quality management and early stages of the value chain.

The results highlight variation in CCP/CP management practices. While some operators reported clear acceptance criteria and corrective actions (e.g., batch rejection, reprocessing), others reported unclear procedures, particularly regarding deviations related to particle size and contamination. This indicates a need to describe more clearly, minimum requirements and practical examples of corrective actions for different scenarios.

For final product control, several respondents reported using analytical monitoring (pathogens, heavy metals, visible impurities, nutrients, EC, stability), but not consistently across all cases. Respondents requested support especially for defining critical limits, monitoring, traceability and documentation, and corrective actions.

Although the decision tree was perceived as easy to use, its added value was rated as neutral by some respondents. To better support decision-making, the tool should be complemented with a short explanation of how the branching logic proceeds and why specific questions appear, and an end section summarizing the key identified CCP/CP candidates and proposed next steps for the respondent. Overall, the decision tree provides a solid starting point for CCP/CP identification, but its effectiveness can be improved by clarifying deviation management and adding a clear summary of outcomes.

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