



## D1.4 - Barriers on BBF development

WP1, T1.2 European status and barriers on nutrient recovery technologies and bio-based fertilisers

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## Abbreviations

AA	Agricultural association
ABPR	Animal By-products Regulations
BBF	Bio-Based Fertiliser (economically prime important nutrient resource-based products)
CAPEX	Initial capital expenditure
CMC	Component Material Category (see Annex II to the FPR)
D	Deliverable
EU	European union
EWC	<a href="#">list of EWC codes</a>
F	Farmer
FM	Fertiliser manufacturer
FPR	The Fertilising Products Regulation ‘Regulation (EU) 2019/1009 of the European Parliament and of the Council of 5 June 2019 laying down rules on the making available on the market of EU fertilising products and amending Regulations (EC) No 1069/2009 and (EC) No 1107/2009 and repealing Regulation (EC) No 2003/2003
IEA	Integrated Environmental Authorisation
IWWTP	Industrial Waste Water Treatment Plant
MS	Member state
(MS)	Milestone
N	Nitrogen
NACE	<a href="#">List of NACE codes</a>
NR	Nutrient Recovery
NRT	Nutrient Recovery Technology
NTUA	National Technical University of Athens
OMPs	Organic micropollutants (Pharmaceutical residuals – addictive substances-pesticides)
OPEX	Total operational expenditure
P	Phosphorus
PAC	Powdered Activate Carbon
PAHs	Polycyclic aromatic hydrocarbons
PTEs	Potentially Toxic Elements (Zn, Cu, Ni, Pb, Cd, Cr, As, Tl or Hg)
PFC	Product Function Category (see Annex I to the FPR)
REACH	Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals, establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC, OJ L 396, 30.12.2006, p. 1–850.
UWWTP	Urban Waste Water Treatment Plant
WFD	Water Framework Directive
WP	Work package
WW	Waste Water
WWP	Waste Water Producer
WWT	Waste Water Treatment
WWTP	Waste Water Treatment Plant
WWTT	Waste Water Treatment Technology



## Executive Summary

The present deliverable includes the results of the work carried out within Task 1.2- ‘European status and barriers on nutrient recovery technologies and bio-based fertilisers’. It comprises the second deliverable of Work package (WP)1 – ‘Mapping current nutrient recovery balance in European WW treatment systems’. This deliverable completes D1.3 – ‘EU27 matrix for bio-based input streams and Nutrient Recovery (NR) technologies’, which targeted the study, mapping and evaluation of the current status in the European union (EU) matrix of the Bio-based input streams (Urban Waste water (WW), sewage sludge, food, Industrial WW and brine). The main results from the Task1.2 reported in this deliverable will be also input for the scheduled relevant Milestone is (MS)3 – ‘Identification of nutrient imbalances and NR technologies’. The means of verification is the *‘identification of at least 25 issues that should be tackled for BBF successful use’*. The target of task 1.2 is to study, map and evaluate the current status in the EU matrix that is described in D1.3, regarding:

- Bio-based input streams: Urban WW, sewage sludge, food, Industrial WW and brine (Table 3-9)
- NR technologies from bio-based input streams ([Section 3.1.1](#)).
- Economically prime important nutrient resource-based products (i.e. Bio-based fertilisers (BBFs)) (Table 4-20).

This was achieved through:

- reporting the identified preconditions and factors that drive or hamper the deployment of NR options in WW Treatment (WWT) facilities.
- allocating the lock-ins and barriers in the performance technologies targeting the synthesis of BBFs.
- allocating the lock-ins and barriers that hamper the final use of BBFs.

The methodology followed included two steps:

- i. firstly, an extended literature review about the factors that drive or hamper the deployment of NR options in WWT facilities (D1.3) and
- ii. secondly, a survey addressed to all the relevant stakeholders (D1.4).

For this survey, National Technical University of Athens (NTUA), in co-operation with CARTIF Technology Centre and the assistance and corrective suggestions by WalNUT stakeholders, prepared questionnaires derived from a literature review of previous relevant surveys and a specialised web-based research on EU matrix built sites (e.g. Fertilisers Europe (Fertilizers Europe, 2022), Registration, Evaluation, Authorisation and restrictions of Chemicals for fertilisers (REACH for fertilizers, 2022)).

A unique questionnaire was prepared for each of the following target groups, to facilitate and ensure a response of high value:

- ✓ WW (Urban WW, sewage sludge, food, Industrial WW and brine) producers.
- ✓ WWT plant managers/operators.
- ✓ Bio-based fertilisers Manufacturers (FM).
- ✓ Bio-based fertilisers End-users (Farmers, Agricultural Associations (AA)).
- ✓ Technology providers (TP).
- ✓ Policy makers.

The questionnaire for each stakeholder was also subdivided based on whether they have had previous experience with Nutrient Recovery.

The responses have been gathered in four groups and processed systematically.

- First group: WW producers (Urban WW, sewage sludge, food, Industrial WW and brine) have been grouped with those of WW treatment plant managers/operators



- Second group: Bio-based fertilisers Manufacturers have been grouped with Bio-based fertilisers End-users (Farmers, Agricultural Associations)
- Third group: Technology providers.
- Fourth group: Policy makers (no responses available, so far).

The results of this study are reported in this deliverable in seven sections:

In [Section 1](#), the Purpose, scope and target group, the Contribution partners and any Relation to other activities in the project, are described.

In [Section 2](#), the first attempt to define [Bio-based fertilisers](#) in the context of the WalNUT project sets the basis for the interaction with the stakeholders. In [Section 3](#), the quantitative and qualitative results of the responses from WWP and WWTP and their assessment are presented. Accordingly, in [Section 4](#) and [Section 5](#) the quantitative and qualitative results of the responses from BBF end-users (fertiliser manufacturers, farmers and agricultural associations) and technology providers are shown. In [Section 6](#), the conclusions are gathered and presented. The questionnaires for each stakeholder group are presented in [Annex I](#).

Initially, the interviews were supposed to be paper-based, completed by each of the WalNUT partners, to avoid any misunderstandings due to different languages. The interviewees of their choice would remain anonymous. During this process, a number of partners suggested that it would be more manageable to complete the WalNUT surveys [online](#). The questionnaires were uploaded online using Google forms. During this attempt, the challenges that should be overcome are listed below:

- Lack of Bio-based fertilisers definition to set the basis of interaction ([Section 2.1](#))
- Transition in Reg. (EU) 2019/1009 ([Section 2.1](#))
- Inclusive content (Diversity was recognised in the needs and abilities of WalNUT stakeholders. A representative example is that regardless of Reg. (EU) 2019/1009, in France, STRUvite, Biochar and Incineration ash are not allowed to be used as BBFs after treatment. Usually, sewage sludge and sludge composts are spread locally, sometimes up to a few hundreds of km
- Identification of the target group in which fertiliser manufacturers should be included (BBF end-users)
- Significance of interviewee's response
- Replacement of terms (i.e. 'pollutants') with positive terms (i.e. 'not valorised nutrients'). This of course applies in the cases when the application of a BBF is not hazardous for the soil.
- Transformance of Paper-based interviews of selected stakeholders to Web-based surveys (Google forms)
- GDPR issues with WalNUT project interviews.

The conclusions that have been drawn after the assessment of the responses, are gathered at the end of each relevant section.

- ❖ WWP, IWWTP and UWWTP: [Barriers](#), [Measures](#), [Motives](#)
- ❖ Fertiliser manufacturers: [Barriers](#), [Motives](#)
- ❖ Farmers and agricultural associations: [Barriers](#), [measures and motives](#)
- ❖ Technology providers: [Barriers](#), [Motives](#).

In [Section 6](#), the conclusions after the inspection of all the gathered information have been categorised regarding:

- ✓ the [spread of Nutrient Recovery awareness](#)
- ✓ the [preconditions and factors that drive or hamper the deployment of NR WWT facilities](#)
- ✓ the [lock-ins and barriers in the performance technologies targeting the synthesis of BBFs](#)
- ✓ the [lock-ins and barriers that hamper the final use of BBFs](#)
- ✓ the [supply-demand of BBFs](#)
- ✓ the [WW value chain symbiosis](#).



With the goal of spreading awareness about Nutrient Recovery, the WalNUT surveys will be accessible on the WalNUT project site until the completion of the project. Any deviation from the conclusions that have been drawn will be incorporated in the [Portal of the WalNUT platform](#) (D1.5), and published on the site of the [WalNUT project](#).

**Keywords:** Nutrient Recovery awareness, Bio-based fertilisers, farmers, agricultural associations.



# 1 Introduction

## 1.1 Purpose, scope and target group

The objectives to be achieved after the completion of the WalNUT stakeholders survey, the export of the qualitative and quantitative data and the accompanying analysis of the interviews are:

- to address the identified pconditions and factors that drive or hamper the deployment of Nutrient Recovery (NR) options by waste water (WW) producers ([Section 3.4](#)) and in WW Treatment (WWT) facilities ([Section 3.5](#)).
- to allocate the lock-ins and barriers that hamper the synthesis of Bio-based fertilisers (BBFs) ([Section 3.6.1](#)), the use of recovered nutrients as substitutes for fossil-based ones ([Section 3.6.2](#)), and the use of BBFs from End-user perspective ([Section 3.6.3](#)).
- to involve Policy makers in closing the WW circle ([Section 3.6.4](#)).
- to allocate the lock-ins and barriers that technology providers need to overcome in the recovery of economically prime important nutrient resource-based products ([Section 3.7](#)).

The scope of this work is to assist the stable expansion of nutrient recovery from WW and use of recovered nutrients as bio-based fertilising products. The target is to ease or even eliminate the listed bottlenecks to successful NR implementation by proactively planning resource recovery routes. Rather than interpreting bottlenecks as barriers to the implementation of resource recovery routes, they should be seen as starting points for WWT plants (WWTP) process design and management strategies.

The scope of this work has inevitably been expanded towards the mapping of bio-based input streams Table 3-5 Nutrient Recovery technologies Table 3-6 along with nutrient removal trains from bio-based input streams (Table 3-11) and Economically prime important nutrient resource-based products (i.e. BBFs). (In Table 4-16, the profile of Fertiliser manufacturers (FMs) is presented. The commercial fertilising end-products (BBFs) FMHungary handles is of biochar and high qty compost from clean solid biowaste sources only that have been Certified according to 36/2006 FVM degree (HU) and EU 2019/1009 CMC3 and CMC14. The aforementioned certifications provide the sources with the “End-of-waste Status”. ‘End of Waste Status’ refers to the status of a waste material that meets requirements to no longer be classified as waste but as resource for new production processes.

The target group is the whole added value supply chain (problem owners, technology providers, intermediate users) that are the ones to also share information with respect to the waste generators; the companies managing WW; the applied treatment methods; the technology providers for the production of bio-based products, as well as the companies that are interested in buying the BBFs in order to sell them to the end users. Moreover, end users voices will be heard from this series of interviews. Last but not least, policy makers (national, regional and local authorities) will have the opportunity to explore via this deliverable the potential and the available alternatives for the management of WW streams in the context of circular economy. So far, all NR value chain actors have not been sufficiently influential on policy makers to tackle all bottlenecks to the same extent.



## 1.2 Contribution partners

In Table 1 the contribution of each WalNUT stakeholder is described.

Table 1: Contribution of partners

Partner	Contribution
NTUA	Literature review, Web- and paper-based surveys, Preparation of surveys Upload of surveys to Google forms EU funded WalNUT Project Horizon 2020 Interviews ( <a href="mailto:walnutinterviews@gmail.com">walnutinterviews@gmail.com</a> ), Interview of selected stakeholders such as farmers, converters, consumers and legislators,
CARTIF	Suggestions in the preparation of the surveys, Revision of surveys, Extensive explication of the whole added value supply chain, Feedback by CE-TAQUA, VEOLIA and ITACYL.
APCA [CA17, CA34]	Interview of selected stakeholders such as farmers, converters, consumers and legislators,
3R	Suggestions in the preparation of the surveys, Detailed presentation of the whole added value supply chain, Interviews of selected stakeholders such as farmers, converters, consumers and legislators
UGent	, Interview of selected stakeholders such as farmers, converters, consumers and legislators, Feedback by AQUAFIN
ICONS	Introductory text and Figure in the publication of the surveys in the WalNUT site

## 1.3 Relation to other activities in the project

In Table 2 any relation to tasks in other WalNUT WPs is presented with the accompanying description.

Table 2: Relation to other activities in the project

Task	Description
WP6 (Tasks 6.1 & 6.2)	The preparation of policy makers' survey predefined the work that needed to be done in Task 6.1. The responses that were gathered assist the implementation of Task 6.2 that is policy recommendations for regulatory, market and user acceptance of BBFs from WW.
WP7 (Tasks 7.1 and 7.3)	Facilitation of Literature study and analysis of business cases related to NR from WW cycles in Task 7.1. Via the interviews of the stakeholders, past and current initiatives at EU level aiming at creating circular and sustainable technologies for NR were identified to help propose an exploitation plan in Task 7.3.
WP8 (Task 8.1)	The online platform will contribute to serve as a communication and dissemination tool.



## 2 Setting the basis of the WalNUT surveys

### 2.1 Definition of Bio-based fertiliser

To set the basis of the WalNUT surveys, the primary target was to provide the interviewees with a definition of Bio-based fertilisers (BBFs).

The proposed definition in WalNUT D1.3 – EU27 matrix for bio-based input streams and NR technologies (p. 46-47) is: Bio-Based Fertilisers (BBFs) are fertilisers that contain macro- (NPK) and/or micro - nutrients that derive from Nutrient Recovery practices on Bio-based input streams (Urban WW, sewage sludge, food, Industrial WW and brine) in order to replace fossil – based nutrients or they are economically prime important nutrient resource-based products that derive from the valorisation of Bio-based input streams. These products will be discussed extensively in Sections [3](#) and [4](#).

This preliminary definition was used to inform partners and stakeholders in recovering nutrient rich products from WW to be used for fertilisation purposes.

Another approach could have been that BBFs are fertilising products, or a component to be used in the production of (Tailor-Made) fertilisers, that derive from biomass-related resources. With the completion of time, the proposed definition in WalNUT D4.1 – Good experimental practice protocol (and Lexicon) (p.10) for Bio-based fertiliser is: *‘Fertiliser derived from the nutrient recovery and re-use (NRR) technologies (physical, thermal, chemical and/or biological, excluding anaerobic digestion and liquid-solid separations) to biomass-related residues or side-streams, in order to improve their fertiliser efficiency’*.

Reg (EU) 2019/1009 defines ‘fertilising products’ as a substance, mixture, micro- organism or any other material, applied or intended to be applied on plants or their rhizosphere, or on mushrooms or their mycosphere, or intended to constitute the rhizosphere or mycosphere, either on its own or mixed with another material, for the purpose of providing the plants or mushrooms with nutrient or improving their nutrition efficiency.

According to the EIP-AGRI Focus Group (EIP-AGRI Focus Group, 2017) *“Biobased fertilisers” are defined as organic or organo-mineral fertiliser products derived from renewable biomass-related resources rather than synthetic products which require fossil resources for their production (including anaerobic digestion’*.

A novel BBF has been defined as a BBF produced by processes beyond simple biogas digestion of animal manures and simple composting. The processes involved in producing novel BBFs can e.g. be drying, pelletizing or mineral extraction (Wester-Larsen , Müller-Stöver, & Salo, 2022).

The BBFs of a sister project ‘FERTIMANURE’ (The project’s response—Fertimanure, 2023) are defined as *“obtained through a physical, thermal/thermo-chemical, chemical, and/or biological processes for the treatment of manure or digestate that result into a change in composition due to a change in concentration of nutrients and their ratios compared to the input material(s) in order to get better marketable products providing farmers with nutrients of sufficient quality”*. However, just separation of manure in a solid and liquid fraction (as first processing step) is excluded. These products are not conceived as a BBF, although they are valuable sources to supply nutrients on agricultural land.



## 2.2 Existing surveys and new approach

NPK and micronutrients that are present above the legal disposal limits are nutrients that have not yet been valorised. Recovering materials from waste streams in accordance with generally accepted criteria gives a positive association with the materials as they are not any longer labelled as waste but as new and safe-to-use products.

Value can be created if the interests of all stakeholders, including business partners, end users and policy makers, are integrated into the planning process, and applications with unique selling propositions are found.

The most ideal candidate to get that surplus of nutrients and specific waste types that can be approved as fertiliser goods is nutrient-deficient arable land. The disposal limits are to be made even stricter in order to make compliance with nutrient recovery practices an alluring option. This is due to the depletion of mineral ores, the expensive purification processes required as a result of the accumulation of cadmium and uranium during the consumption of the ores, the nutritional needs of the continuously growing global population, and the impoverishment of soil composition.

The viability of the recovered nutrients as commercially sold products is currently limited. As an example, in the case of the estimated struvite price, it depends not only on the Nutrient Recovery technology and the concentration on the bio-based input stream but also on the Mg source (magnesite, magnesium sulphate/chloride/oxide), the Mg content and the Mg/P ratio. This factor does not only depend on the market demand and the product quality but also on governmental policies that control struvite as a BBF.

Fertiliser Manufacturers in Europe are actively working on the development of fertilising products to facilitate precision farming. This attempt targets both the enhanced uptake of NPK and micronutrients by plants and the restriction of nutrient losses to water bodies and the air. Farmers have expressed their skepticism towards innovative products (such as slow release or concentrated fertilisers) because they are applied less frequently and/or in small dosages on the soil. Therefore, the same skepticism is expected by farmers when introduced to BBFs, as defined above.

Kehrein et al., (Kehrein, et al., 2020) published a critical review on nutrient and other sources recovery from municipal WWTPs. Their work focused on ‘*market supply potentials, technologies and bottlenecks*’. In recent studies (Preisner, et al., 2022), (Tur-Cardona, et al., 2018), (Srivastava, Vaish, Singh, & Singh, 2020), (Mini-paper – End-user requirements for recycled and biobased fertiliser products, 2022), bio-based fertilisers’ end – users are presented to be preoccupied with the accumulative effect of organic micro pollutants, potentially toxic elements (as heavy metals), poly aromatic hydrocarbons, pharmaceutical residuals, hormones, illicit drugs, microbiological pathogens etc., that can be present in the bio-based input streams, on the soil, the food crops and the food chain. Interviewees were asked to share any national / regional policy framework they have to comply with so as to avoid the indiscriminate valorisation of urban WW, sewage sludge, food, industrial WW and brine.

In Figure 2-1 a map (Fertilizers Europe, 2022) of EU-MS major fertiliser plants is presented. This map was used as a guide for the mapping of fertiliser manufacturers so as to approach them and complete the WalNUT survey. Unfortunately, the feedback from this approach was not sufficient for a representative display of the barriers for the utilisation of WW-based fertilising products, and Fertiliser manufacturers were contacted on behalf of WalNUT stakeholders.





Figure 2-1: Graph of EU-MS major fertiliser plants (Fertilizers Europe, 2022)

In the WalNUT surveys, attention was been paid on locating and interviewing NR practitioners. Therefore, the questionnaires were also sent to the contacts registered in the publically accessible databases presented in the context of WalNUT D1.3. In the cases when an actor has attempted to apply NR, but their effort was discontinued, they were asked to mention how/why their attempt was blocked (Sections 3.3.1 and 3.4.1).

The steps for the implementation of Nutrient Recovery practices include:

1. Regulation framework analysis.
2. Business/process feasibility assessment (technical / economical).
3. Identification / Characterisation of bio-based input stream / effluent / recovered nutrients / economically prime important nutrient resource product composition.
4. Allocation / Contact with technology provider.
5. Installation of a Nutrient Recovery facility.
6. Contact with fertiliser manufacturer / waste (before End-of waste criteria application) management company.
7. Allocation of Bio-based fertiliser market (End-users: Farmers, Agricultural associations).

### 2.3 European / National / Regional policy frameworks

Throughout D1.4, the reader will notice the ongoing attempts to bridge European / National / Regional policy frameworks. This section provides the necessary input to comprehend the different deviations in the descriptions provided by the interviewees.

To continue from [Section 2.1](#), the varying composition and concentration of contaminants present in the municipal WW streams is an obstacle regarding the utilisation of WWT-derived products as BBFs. End-users do not accept fertilising products from WW. Farmers do not want to use fertilisers from sewage sludge or from industrial sludge only from clean solid bio-waste sources. The contamination risks due to effluent composition are a real high risk farmers are not willing to take. As of new EU fertilising products regulation sewage sludge, industrial sludge or dredging sludge are excluded as input material for production of fertilisers. However, the lack of knowledge related to the safety and risk of using fertilisers from WW, sewage sludge or industrial sludge still remains. Municipal WW contains potentially toxic elements (PTEs) (Zn, Cu, Ni, Pb, Cd, Cr, As, Tl or Hg), polycyclic aromatic hydrocarbons (PAHs), Organic micropollutants (OMPs) (Pharmaceutical residuals - addictive substances-pesticides) and microbiological pathogens in varying compositions and concentrations. In the scenario that municipal WW products are used as BBFs, the cost of the required measurement and analysis on a regular basis, becomes prohibitively high for an enterprise to bear. Even though there are legal opportunities to use treated, purified and certified WW products in soils for agricultural purposes, end-users do not fond of fertilising products from municipal WW as the value of the land and products is decreased and the risks of contamination are so high that the risk it is not worth taking.



According to Reg (EU) 2019/1009 EU, fertilising products may consist solely of materials complying with the requirements for one or more of the component material categories listed in its Annex II – Component Material Category (CMC) of FRP.

There are 11 component material categories:

1. Virgin material substances and mixtures.
2. Plants, plant parts or plant extracts.
3. Compost.
4. Fresh crop digestate.
5. Digestate, other than fresh crop digestate.
6. Food industry by-products.
7. Micro-organisms.
8. Nutrient polymers.
9. Polymers other than nutrient polymers.
10. Derived products within the meaning of the Animal By-products Regulations (ABPR).
11. By-products within the meaning of the Water Framework Directive (WFD).
12. Precipitated salts and derivatives (EU) 2021/2086
13. Thermal oxidation materials and derivatives
14. Pyrolysis and gasification materials.

As mentioned in Reg. EU 2019/1009 regarding:

CMC3: Compost: ‘The aerobic composting shall consist of controlled decomposition of biodegradable materials, which is predominantly aerobic and which allows the development of temperatures suitable for thermophilic bacteria as a result of biologically produced heat.’ ‘An EU fertilising product may contain compost obtained through aerobic composting of exclusively one or more of the following input materials: sewage sludge, industrial sludge or dredging sludge are excluded’

CMC 5: ‘Digestate other than fresh crop digestate (1) An EU fertilising product may contain digestate obtained through anaerobic digestion of exclusively one or more of the following input materials (c) except sewage sludge, industrial sludge or dredging sludge’

CMC 14: Biochar manufacturing is included according to the text below:

#### COMMISSION DELEGATED REGULATION (EU) 2021/2088

1. (a) An EU fertilising product may contain pyrolysis or gasification materials obtained through the thermochemical conversion under oxygen-limiting conditions of exclusively one or more of the following input materials: (a) living or dead organisms or parts thereof, which are unprocessed or processed only by manual, mechanical or gravitational means, by dissolution in water, by flotation, extraction with water, by steam distillation or by heating solely to remove water, or which are extracted from air by any means, except sewage sludge, industrial sludge or dredging sludge.

The manufacturer has to draw up the technical documentation in support of the conformity assessment of their fertilising product. The technical documentation, among others, has to contain a list of every component material used in the final product, with reference to its corresponding CMC and information on its origin or its manufacturing process. This list has to contain all the component materials and, consequently, any other ingredient deliberately incorporated into the fertilising product is expected to be found in the final composition of this fertilising product. This does not concern contaminants as they are not intentionally added.

There is no obligation for the manufacturer to declare the actual percentage of each component material as part of the final product. In case a component material could comply with the requirements for more than one Component Material Categories (CMCs), the manufacturer is free to choose the CMC that suits best their material and production. The manufacturer has to make sure that their material complies with all the requirements as set for the respective CMC. There are situations where two CMCs are mutually exclusive. A



material that falls under the scope of CMC 11 (by-product within the meaning of WFD) is by definition excluded from the scope of CMC 1 (virgin substance) (see Annex II, part II, CMC 1, point 1(d)). If a by-product is chemically reacted with another substance, then the resulting material can be eligible for CMC 1, as this CMC does not exclude materials derived from by-products. However, a food industry by-product that complies with requirements of the CMC 6 (food industry by-products) could also comply with the requirements set in the CMC 11.

All actors were also asked to comment on existing national and regional regulations regarding the applicability of Bio-based fertilisers. Such examples are listed below:

- a. Sludge cannot be spread on: pastures, vegetable crops, berries, waterlogged or frozen soil, or on inclined land (Austria).
- b. Use of urban sewage sludge on agricultural land is prohibited (1999) unless treated to reduce N and P contents by 85% (Belgium - Flanders).
- c. Use of sludge is allowed on soils where grain, sugar beet, oil-bearing crops or crops not used for human food and animal feed are cultivated. Samples of cultivated soil are to be taken at short intervals. (Finland - most strict heavy metal content values in Europe).
- d. Organic compounds disposal is limited, up to Max. 10 t/ha/yr; This disposal is not allowed on edible crops or gardening but allowed in areas growing cereal, seed crops, grass or fodder. (Denmark).
- e. Use of sludge is prohibited on grassland and forage crops, in soils in which fruit or vegetable crops are growing (except fruit trees after harvesting and before flowering), in ground indented for the cultivation of fruit or vegetables (at least 10 months before harvest), and in frozen soils (Belgium – Wallonia).

## 2.4 Differentiations between regional/national/EU regulations regarding WW disposal

Varying national standards and regulations make it difficult for manufacturers to sell across countries, and hence more than half of the produced bio-based fertilisers stay in the country of origin, disrupting the supply-demand balance. In the premises of WalNUT Task 1.2 a survey on the harmonisation of regional/national and European policy development directions for target pollutants that may affect CE marketable fertilising products was also conducted. Within future perspectives, any complicated and/or differentiated regulation would cause an unbalanced market/economy. Especially in the extreme case of Belgium, where there are differences in regulations between Flanders and Wallonia.

As reported in WalNUT Deliverable 6.1-‘Inventory and integrated assessment of the EU regulations related to production and application of bio-based fertilisers’, in Spain, sewage discharges are regulated locally or regionally, but the regulation of the public hydraulic domain is national and transposed from European regulations.

As an example, the public administration legal effluent standards in Spain are presented in Table 2-3. In Spain, limits for nutrients and contaminants concentration in WW’ discharging from IWWTPs are higher if their discharge is in a sewer. There are not general standards neither for heavy metals, PAHs nor any other of the aforementioned contaminants. The limits for effluents are established for each industry and accorded in an Integrated Environmental Authorisation (IEA). IEAs are mandatory since the publication of Directive 2010/75/UE of Industrial Emissions, transposed to Spanish national legislation in Law 5/2013 and Royal Decree 815/2013. When the next use of the produced sludge is in agricultural practices, (whether composted beforehand or not), it is mandatory to analyse its composition, at least, once every six months (according to Royal Decree 1310/1990), in order not to discharge high amounts of heavy metals on the soil.



Other examples of the public administration legal effluent standards for nutrients and contaminants for WW disposal in Italy in compliance with WalNUT Deliverable 6.1- 'Inventory and integrated assessment of the EU regulations related to production and application of bio-based fertilisers' are:

- for treated water: the resolution of the regional council n 107/2009 (DCR Veneto 107/2009) (column C, table 1, annex A)
- for sludge: legislative decree n 99/1992 (integrated with law decree 109/2018) for the application in agriculture, or legislative decree n 75/2010 (point 13, paragraph 2, annex 2).

The corresponding legal effluent standards in Spain are presented in Table 2-3.

Table 2-3: Public administration legal effluent standards in Spain

Parameter	Unit	Lower limit of vulnerability
COD	ppm	125
BOD <sub>5</sub>	ppm	25
SS	ppm	35
NT	ppm	30
N-NH <sub>4</sub>	ppm	12
Pt	ppm	8

The interviewee's (UWWTP10) responses to statements (a – e) i.e. national policies - examples of restrictions to sewage sludge application on agricultural land and how they elaborated on their opinion are presented in Table 2-4.

Table 2-4: Representative responses of an UWWTP on WalNUT survey statements.

Existing national regulations	AGREE (Why) / DISAGREE (Why)
a. Sludge cannot be spread on: pastures, vegetable crops, berries, waterlogged or frozen soil, or on inclined land. (Austria)	Disagree. 'Regulations are based on the assumed fact that (almost all) sludge is contaminated. Sludge application (or the use of any other fertiliser) should be allowed when it meets the foreseen legislation.'
b. Use of urban sewage sludge on agricultural land is prohibited (1999) unless treated to reduce N and P contents by 85%. (Belgium -Flanders)	Agree. 'The application of sludge (or any other type of fertiliser) must not contribute to a deterioration of our environment. Legislation is therefore necessary.'
c. Use if sludge is allowed on soils where grain, sugar-beet, oil-bearing crops or crops not used for human food and animal feed are cultivated. Samples of cultivated soil to be taken at short intervals. (Finland - Most strict heavy metal content values in Europe.)	Disagree. 'Regulations is based on the assumed fact that (almost all) sludge is contaminated. Sludge application (or the use of any other fertiliser) should be allowed when it meets the foreseen legislation.'
d. Max. 10 Tn/ha/yr; limit values for organic compounds. Not allowed on edible crops or gardening. Only allowed in areas growing cereal, seed crops, grass or fodder. Must be worked into soil 12h following application. (Denmark)	Agree. 'The application of sludge (or any other type of fertiliser) must not contribute to a deterioration of our environment. Legislation is therefore necessary.'
e. Use of sludge is prohibited on grassland and forage crops; in soils in which fruit or vegetable crops are growing (except fruit trees after harvesting and before flowering); ground indented for the cultivation of fruit or vegetables (at least 10 months before harvest), frozen soils. (Belgium – Wallonia)	Agree. 'The application of sludge (or any other type of fertiliser) must not contribute to a deterioration of our environment. However, these regulations do not make it easy to the supplier/producer as there is during couple of months no market available. Transport across the different member states can be a remedy for this.'

The interviewees were asked to address any obstacles, gaps or shortcomings in policies they comply with concerning:



- WW treatment

The regulation being the Water framework Directive (2000/60/EC) – establishes a framework for the protection of surface and groundwater in the EU 2000 Urban WW Directive (91/271/EEC) – requires the collection of WW and the implementation of secondary treatment for agglomerations with more than 2000 person equivalents. More advanced treatments for populations > 10000 person equivalents (1991)

Addressed Gap: Decentralised cases could be useful to perform resource recovery on a small scale rather than trying to implement it on large scale installations.

- Effluent disposal regulatory standards

- Nutrient discharge limits require effluents to contain less than 0.1 mg P/L and 1-3 mg N/L

- Nitrates Directive (91/676/EEC) – limits nitrates in water to 50 mg/l (1991)

- Groundwater Directive (2006/118/EC) – sets a quality standard of 50 mg/l of nitrates (2006)

Addressed Advance: More strict discharge limits could be a ‘trigger’ to further establish resource recovery.

- End-of-waste criteria

- Waste Framework Directive

Addressed Obstacle: The high level of environmental protection which is included and the high costs which are related to the analyses of (for example) micropollutants which could be present in a specific stream

- Nutrient recovery

- Critical raw materials list (CRM). List of 20 raw materials for which “supply security is at risk and economic importance is high”. Phosphate rock was added to the list in 2014

Addressed Shortcoming: focusing too much on this list could create a gap towards other interesting and useful streams containing different elements

- Distribution of recovered nutrients

- Fertiliser regulation EC (2003/2003) (July 2022) – The current version defines and lists inorganic fertilisers and micro-nutrients and regulates their market placement (2003).

- Nitrates Directive (91/676/EEC) – limit of 170 kg N/ha/yr from livestock manure in NVZ (1991)

- Sludge Directive (86/278/ EEC) – regulates the use of sewage sludge in agriculture (1886)

Addressed Obstacle: The high level of environmental protection which is included and the high costs which are related to the analyses of (for example) micropollutants which could be present in a specific stream.

In Italy, sludge can be used for the production of domestic fertilisers but not for fertilisers freely marketed in the EU.

To conclude with, at this moment, resource recovery is mostly a reaction on more strict discharge limits, rather than the value of the end-product. Via a more strategic and open market, this mindset could probably shift in time, leading to a more promising role in our business cases. Any UWWTP would be highly interested in complying with the common EU-Regulation concerning WW treatment/Nutrients recovery/BBF manufacturing & distribution so as to be able to distribute your goods freely on all EU-27 MS as long as it fit their business model and the sales price were competitive towards others.



## 3 Interviews of WWP and WWTP

### 3.1 WW Production from type C- MANUFACTURING Industries

Currently, the majority of companies removing excess of nutrients, reintroduce them in the production process and there is no need to recover them as secondary raw materials for BBFs. Nevertheless, in these and other companies there are certain WW treatment - derived products that can be post-treated (e.g. lime stabilization) into certified (by waste management companies) economically prime important nutrient resource-based products (BBFs) after their compliance with end-of-waste criteria.

The profile of the interviewed WW Producers (WWP) (a total of 8 interviewees), whether practicing Nutrient Recovery or not, are presented in Table 3-5. In this table are gathered also all the accompanying information defining the WW stream such as EWC (, e physical/chemical parameters of the streams, ToxicityISO 6341:2013, Electrical conductivity, Soluble sodium percentage, COD, BOD, TOC, etc.) and the content in nutrients/pollutants (composition (N, P, K, Ca, Mg, etc., concentration (mg/l)).



Table 3-5: Interviewed WWP's profiles

ID	Country	NACE code	EWC	NRT	Physical / chemical parameters	Content in not valorised nutrients)
WWP1	Spain	E37 - Sewerage	Urban	YES	(500 mg/l COD; 230 mg/l BOD)	N: 50 mg/l P: 8 mg/l Ca: 130 mg/l Mg: 35 mg/l
WWP2	Greece	C24.4.4 - Copper production	16 10 02 (Mirror Non-hazardous aqueous liquid wastes destined for off-site treatment)	NO	EC <1500 [mS/cm], TSS <25 [mg/l], BOD <sub>5</sub> < 10 mg/l, COD < 30 mg/l,	Cu: 0.42 mg/l, Fe: 0.12 mg/l, Mn < 0.01 mg/l, Mo < 0.01 mg/l, Se < 0.01, Zn: 0.21 mg/l, Cr < 0.005 mg/l etc.
WWP3	Hungary	C10.5-Manufacture of dairy products	02.05.01 Acidic whey	NO	COD: 73300 mg O <sub>2</sub> /l TOC: 29500 mg/l dry matter: 6.53% TSS 1060 mg/l pH: 4.1	Ca: 953 mg/l K: 1415 mg/l Total N: 1204 mg/l Total P: 870 mg/l
WWP4	Spain	C10.20- Mining and agglomeration of lignite	09.11 Animal waste of food preparation and products	NO	Similar to urban WW	Nitrogen, phosphorous, Cl, proteins and carbohydrates content
WWP5	Italy	E36.0.0 - Water collection, treatment and supply.	A concentrated effluent produced in an anaerobic digester that treats organic fraction of urban waste and sludge from urban WW treatment. WW from this digestate is not a waste but it could look like a 19.06.06	NO	total solids 6400 mg/l total volatile solids 2500 mg/l, COD 4100 mg/l, TOC 700 mg/l, BOD 2500 mg/l, conductivity 12000 microS/cm	total N: 1500 mg/l, total P: 32 mg/l, Ca: 520 mg/l, SO <sub>4</sub> : 260 mg/l

*EWC: European Waste Catalogue*

*NRT: Nutrient recovery Technology*



### 3.1.1 Mapping of NR technologies in WWP industries

Despite the barriers for the practice of nutrient recovery by WW producers, that will be discussed in the following sections, some companies have managed to recover nutrients. The information they were asked to specify in the survey, which lays the basis for the Literature study and analysis of business cases related to NR from WW cycles in WalNUT Task 7.1 ‘Identification of business opportunities within full value chain’, are the following:

- Name of Technology
- Nutrient-recovery source
- Nutrient-recovery design capacity (t/y - kg/d - kg/m<sup>3</sup> WW)
- How and by whom is recovered P managed? (e.g. used in the production, stored, certified, sold, etc.)
- Do you have a market for the recovered P?(YES (what) / NO (why))

The addressed reply is presented in Table 3-6.

Table 3-6: List of WW producers that practice NR

ID	P-recovery
WWP1	PHORWater. Urban WWTP. 10kg struvite/d. Not marketed yet.

The mapping of nutrient recovery technologies (based on EU authorised publicly accessible databases) has been performed in WalNUT D1.3 – EU27 matrix for bio-based input streams and NR technologies. All the representatives of the addressed companies were contacted to take the WalNUT survey but this attempt did not fructify. In this deliverable, the attempt to map NR technologies in the EU27 matrix has been completed by entries in Table 3-11.

### 3.2 WW treatment (Industrial and Urban)

This section regards the [survey](#) on Urban WW treatment plants and other type E – water supply; Sewerage; waste management and remediation activities industries for the identification of preconditions and factors that drive or hamper the deployment of Nutrient Recovery options.

UWWTPs, follow the conventional Centralised model for urban WW treatment.

With resemblance to the information presented in Table 3-5, for the mapping of the status of Nutrient Recovery (NR) options in centralised urban WWTP or in on-site WW treatment units of WW produced from type C-MANUFACTURING industries, in EU-27’ the EWC that best describes the highly rich in not valorised nutrients and non-hazardous industrial effluents after WW treatment was asked initially (Table 3-7) and the typical physical/chemical parameters of the WW streams WWTP treat (a qualitative approach to available information i.e. Toxicity ISO 6341:2013, EC, Soluble sodium percentage, COD, BOD, TOC, etc.) (The typical physical/chemical parameters of the WW streams that WWTP treat are described in Table 3-9.

Table 3-9). Moreover, as much information as possible was collected regarding the content in pollutants (i.e. not valorised nutrients), the composition (N, P, K, Ca, Mg, etc.) and their concentration (mg/l).



Table 3-7: Interviewed WWTPs' profiles

ID	Country	Type of WW	NRT	Effluent EWC
IWWTP1	Spain	Industrial	NO	IWWTP1a: EWC N/A - Treated wastewater IWWTP1b: EWC 02 06 03 - Sludge from WWT in a bakery industry containing, at least, N and P.
IWWTP2	Spain	Industrial	NO	IWWTP2a: EWC N/A - Treated wastewater IWWTP2b: EWC 19 08 12 - Sludge from WWT from a sauces and dips industry. IWWTP2c: EWC 02 03 05 sludge is produced during the treatment process, containing, at least, Nitrogen.
IWWTP3	Spain	Industrial	NO	IWWTP3a: EWC N/A - Treated wastewater IWWTP3b: EWC 03 03 11 - Sludge from WWT from a paper industry.
IWWTP4	Spain	Industrial	NO	IWWTP4a: EWC N/A - Treated wastewater IWWTP4b: EWC 02 05 02 - Sludge from WWT from a dairy industry (Mixed sludge from DAF and SBR containing, at least, N and P.
IWWTP5	Spain	Industrial	NO	IWWTP5a: EWC N/A - Treated wastewater IWWTP5b: EWC 02 07 05 - Sludge from WWT from a beer industry. Low amounts of N and P.
IWWTP6	Spain	Industrial	NO	IWWTP6a: EWC N/A - Treated wastewater IWWTP6b: EWC 19 08 12 - Sludge from WWT from plastic recycling industry at least containing small amounts of N and P IWWTP6c: High conductivity water stream.
IWWTP7	Greece	Urban	NO	
IWWTP8	Spain	Industrial	NO	IWWTP8a: EWC N/A - Treated wastewater IWWTP8b: EWC 07 06 12 - Non hazardous sludge from WWT in a chemical industry.
UWWTP9	Anonymous	Urban	NO	WWTP designed to treat a flow of 100,000 m <sup>3</sup> /d with peak season contaminant loads of 588 mg/l of Biochemical Oxygen Demand (BOD <sub>5</sub> ) and 548 mg/l of Suspended Solids (SS). UWWTP9:19 08 05 sludges from treatment of urban WW
UWWTP10	Anonymous	Urban	YES	EWC of influent: N/A Urban WW Average influent capacity: 19.109 (m <sup>3</sup> /day) EWC of effluent: N/A Urban WW Average influent capacity: 19.109 (m <sup>3</sup> /day), Cu: 0.003-0.011, Zn: 0.033-0.063



The responses of WWPs (a total of 5 interviewees) were completed by those of Industrial WW Treatment Plants (IWWTP) (a total of 8 interviewees) and Urban WW Treatment Plants (UWWTP) (a total of 2 interviewees). Their profile is presented in Table 3-7.

### 3.2.1 Management of non-hazardous effluents from WW treatment

Currently (March 2022-March 2023), the management (Table 3-8) (i.e. valorisation) of economically prime important nutrient resource-based products that derive from Bio-based input streams involves composting (7 out of 13 interviewees), discharge into the sewage network for purification and driven to a centralised WWTP (5 out of 13 interviewees), external authorised management (drying, storage) (4 out of 13 interviewees), discharge to a river (4 out of 13 interviewees), application in agriculture (4 out of 13 interviewees) and application as an alternative fuel (e.g. in cement plants) (1 out of 13 interviewees). Last but not least, 1 out of the 13 interviewees mentioned anaerobic digestion, landfilling, incineration, mono-incineration and co-incineration with urban waste (and/or mechanical/natural drying), along with the aforementioned methods of management. The data have been assessed and are presented in Figure 3-1. The data have not been quantified to percentages, for each interviewee can manage their effluents in numerous manners.

Table 3-8: Management of non-hazardous effluents from WW treatment

ID	Effluent management
IWWTP1	<b>Composting</b> , <i>Discharge into the sewage network for purification and driven to a centralised WWTP</i>
IWWTP2	<b>Composting</b> , <i>Discharge into the sewage network for purification and driven to a centralised WWTP</i>
IWWTP3	<b>Composting</b> and Discharge to a river
IWWTP4	<i>Application in agriculture</i> , Discharge to a river, <b>Composting</b>
IWWTP5	External authorised management, <i>Discharge into the sewage network for purification and driven to a centralised WWTP</i>
IWWTP6	Discharge to a river, <b>Composting</b> , External authorised management
IWWTP7	<b><i>Application as an alternative fuel (e.g. in cement plants)</i></b>
IWWTP8	<i>Discharge into the sewage network for purification and driven to a centralised WWTP</i> , External authorised management
UWWTP9	<i>Application in agriculture</i> and <b>composting</b>
UWWTP10	Anaerobic digestion <b><i>Application as an alternative fuel (e.g. in cement plants)</i></b> Landfilling Incineration External authorised management Mono-incineration and co-incineration with urban waste (Mechanical/natural drying)
WWP3	<i>Application in agriculture</i>
WWP4	Discharge into the sewage network for purification
WWP5	<b>Composting</b> , <i>Application in agriculture</i> , Discharge to a river



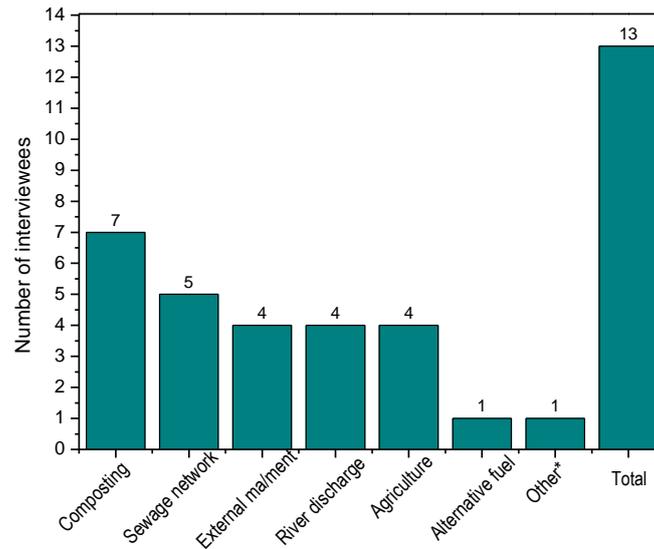


Figure 3-1: Effluent management manners (\*Other refers to anaerobic digestion, landfilling, incineration, mono-incineration and co-incineration)

Regarding water reuse, after compliance of UWWTP9 with *Council Directive 91/271/EEC* concerning UWWT and *Regulation (EU) 2020/741* on minimum requirements for water reuse (into force in 2023), most of the recovered water after WWT can be reused in agriculture or is discharged in rivers or to the sea. Moreover, as reported in WalNUT Deliverable 6.1-‘Inventory and integrated assessment of the EU regulations related to production and application of bio-based fertilisers’, in Spain, sewage discharges are regulated locally or regionally, but the regulation of the public hydraulic domain is national and transposed from European regulations. There are no general limits for an industrial sector in Spain. The limits are established for each industry and accorded in an Integrated Environmental Authorisation (IEA) emitted by public administration. IEAs are mandatory since the publication of Directive 2010/75/UE of Industrial Emissions, transposed to Spanish national legislation in Law 5/2013 and Royal Decree 815/2013. These limits are higher if the discharge of the wastewater is into a sewer instead of discharging it into natural water channels.



### 3.2.2 Mapping of WW streams

The typical physical/chemical parameters of the WW streams that WWTP treat are described in Table 3-9.

Table 3-9: Typical physical/chemical parameters of the WW streams WWTP treat

ID	WW streams (Influent to be treated) Physical/chemical parameters of the WW streams	On-site WW treatment
IWWTP1	COD $\approx$ 7300 ppm. TSS $\approx$ 2570 ppm. EC $\approx$ 4,6 mS/cm. pH $\approx$ 8,5. N $\approx$ 18 ppm. P $\approx$ 11,5 ppm. COD: 9546.86 mg/l; MES: 1331.82 mg/l, pH: 7.84; EC: 6139,09 $\mu$ s/cm, Nt: 8,46 mg/l; Pt: 8.96 mg/l	Yes
IWWTP2	Industrial WW effluent with no EWC, coming from a food and beverage industry: COD $\approx$ 6000 ppm. TSS $\approx$ 800 ppm. EC $\approx$ 2,4 mS/cm. pH $\approx$ 6,5. N $\approx$ 80 ppm. COD: 5456,7 mg/l; MES: 1500 mg/l, pH: 6.45; EC: 1.34 mS/cm, Nt: 58,46 mg/l	Yes
IWWTP3	Effluent of a paper industry's plant (no EWC): COD $\approx$ 5300 ppm. TSS $\approx$ 650 ppm. Hardness $\approx$ 950 ppm. COD: 6181,32 mg/l; MES: 702,32 mg/l, Hardness: 1982,4 mg/l	Yes
IWWTP4	Industrial wastewater from an industrial dairy plant (no EWC): COD $\approx$ 3000 ppm. TSS $\approx$ 600 ppm. EC $\approx$ 3 mS/cm. pH $\approx$ 11. N $\approx$ 125 ppm. P $\approx$ 17 ppm. IWWTP4a: COD: 2440,1 mg/l; MES: 275 mg/l, pH: 11,36; EC: 3126,3 $\mu$ S/cm, Nt: 118 mg/l; Pt: 18,02 mg/l IWWTP4b: High conductivity stream	Yes
IWWTP5	COD $\approx$ 4000 ppm. TSS $\approx$ 1000 ppm. EC $\approx$ 2 mS/cm. pH $\approx$ 7.75. N $\approx$ 36 ppm. P $\approx$ 15 ppm IWWTP5a: Wastewater coming from a brewery industry: COD: 4222.45 mg/l; MES: 1209.15 mg/l, pH: 7.05; EC: 2452.07 $\mu$ S/cm, Nt: 39.5 mg/l; Pt: 44.48 mg/l IWWTP5b: Stream from boiler room: High conductivity	Yes
IWWTP6	Wastewater coming from washing stages in a plastics recycling industry: COD $\approx$ 2500 ppm. TSS $\approx$ 1700 ppm. EC $\approx$ 2.3 mS/cm. pH $\approx$ 7.5. N $\approx$ 45 ppm. P $\approx$ 9 ppm. COD: 6155.63 mg/l; MES: 4281.95 mg/l, pH: 6.89; EC: 2.61 mS/cm, Nt: 147.19 mg/l; Pt: 25.92 mg/l.	Yes
IWWTP7		Centralised urban WWTP
IWWTP8	COD: 19.161 mg O <sub>2</sub> /l; TSS: 3.228 mg/l; pH: 6.68; EC: 2.2 mS/m; T: 28.6 °C, Nt > 90 mg/l. This WW stream is rich in PTEs: Zn, Cu, Ni, Pb, Cd, Cr, As, Tl or Hg. Most of them are removed in the sludge. Thus, this sludge has to be managed and treated by a specific company.	
UWWTP10	B<0.21, Cu:0.021–0.246, Mo<0.105, Fe: 1.29-2.43, Zn: 0.128-0.678	

In Table 3-10 an example of the composition of WW produced from type C- manufacturing (according to NACE code) industries an urban WW stream units of before and after treatment is presented, as a guideline for the mapping of UWWTPs.



Table 3-10: Example of influent and effluent composition

UWWTP9		Units	2021
COD	In	ppm	472.67
	Out	ppm	28.29
BOD <sub>5</sub>	In	ppm	256.92
	Out	ppm	5.48
SS	In	ppm	257.79
	Out	ppm	8.94
Nt	In	ppm	48.11
	Out	ppm	10.28
N-NH <sub>4</sub>	In	ppm	39.43
	Out	ppm	2.01
Pt	In	ppm	5.01
	Out	ppm	2.64

### 3.2.3 WW treatment procedures followed for non-valorised nutrients' removal

WWP and WWTP comply with disposal limits of their effluents. In the premises of WalNUT Task 1.2 regarding the detailed mapping of the developed technological alternatives and their current status, the interviewees (WWP and WWTP) were asked to describe the WWT Technology (WWT) applied for the treatment of their WW streams (The typical physical/chemical parameters of the WW streams that WWTP treat are described in Table 3-9).

Table 3-9). The mapping of WW Treatment Technologies applied on each influent for nutrient/pollutant removal to meet with the legal effluent standards before disposal will be presented in this section.

- WWP1: On-site treatment. The most usual technology is biological treatment combined with tertiary treatment (chemical precipitation, filtration and disinfection).
- WWP2: WW is gathered and collected by a WW aggregator to treat outside the premises of the company (reverse osmosis)
  - N and P are removed and the sludge is composted.
- WWP3: Turned into biogas
  - N and P are not measured in the paper industry.
- WWP4: WW is gathered and treated on -site (WW Treatment Unit developed by WWTP or technology provider) Physico-chemical and aerobic biological treatment
- WWP5: WW is gathered and treated on -site (WWT Unit developed by WWT Plant or technology provider). Activated sludge is treated with nitrification/denitrification; biological removal is applied for P removal and powdered activated carbon (PAC) or FeCl<sub>3</sub>. Treated water is discharged in a river and has no EWC; The EWC of dried sludge is 19.06.06.
- IWWTP1: Occupation of a Membrane Batch Reactor (MBR) for the removal of pollutants (i.e. not valorised nutrients) of their WW streams (with addition of N and P in some cases).
- IWWTP2: Cavitation air flotation (CAF)
- IWWTP3: Anaerobic digestion + aerobic reactor + sludge centrifuge to dehydrate the sludge
- IWWTP4: Primary settling (coagulation-flocculation settler) + Dissolved air flotation (DAF) + Sequential Batch Reactor (SBR) + Sludge centrifugation
- IWWTP5: Primary settling (coagulation-flocculation settler) + Anaerobic digestion + secondary settling; sludge dehydration (centrifuge)
- IWWTP6: Screening + Homogenisation + Dissolved air flotation + Activated sludge treatment; Sludge dewatering (centrifuge decanter)
  - N and P are removed and the sludge is composted.
- IWWTP8: Flotation + Conventional activated sludge system; Sludge dehydration (centrifuge)



- N and P are removed from the WW in the sludge, then, it is dried and treated in a specific plant.
- UWWTP9: WWTT for urban WW in Spain is biological treatment combined with tertiary treatment (chemical precipitation, filtration and disinfection). The WWT is carried out by means of the A2O process for biological nutrient removal, which includes anaerobic, anoxic and aerobic stages, allowing significant nutrients (nitrogen (N) and phosphorous (P)) removal.
- UWWTP10: Preliminary Treatment (Screening, Grit Removal) – Primary Treatment (Sedimentation) – Secondary Treatment (Aerobic Activated Sludge Process)

### 3.2.4 P-recovery and N-recovery options from bio-based input streams in European WWTP

The contribution of the interviewees on whether they practice P recovery (combined with P removal) before the disposal of economically prime important nutrient resource based effluents was limited, representing the current status in the whole Europe as reported by the WalNUT D1.3 – ‘EU27 matrix for bio-based input streams and NR technologies’. This mapping was accompanied by details including the quantity/manner of handling/market of recovered P and/or N (Table 3-11) to complement the results of the WalNUT survey in barriers for BBF marketing.



Table 3-11: P-recovery and N-recovery technologies practiced by UWWTP10

I practice:	From:	P recovered quantity	P recovered management	Do you have a market for the recovered P? (YES (what) / NO (why))
P recovery by struvite precipitation – magnesium ammonium phosphate (MAP) precipitation from the sludge dewatering liquors (pilot test)	Digested sludge (reject water)	5-15% of influent P	Handled by third party	No, niche product
P recovery from sewage sludge ashes (SSA) (full-scale application in 2026)	Sewage sludge	1800 tn/y	Handled by third party	Yes, NPK-fertiliser
P recovery by calcium phosphate (Ca-P) precipitation (full-scale application in 2026)	Sewage sludge	1800 tn/y	Handled by third party	Yes, Additive in animal feed
P recovery phosphoric acid (H <sub>3</sub> PO <sub>4</sub> ) production (full-scale application in 2026)	Sewage sludge	1800 tn/y	Handled by third party	Yes, chemical
I practice:	From:	N recovered quantity	N recovered management	Do you have a market for the recovered N? (YES (what) / NO (why))
(Steam – air – digester – microwave) Stripping on the digester reject water	Digested sludge (reject water)	In progress	Recovered N is used by the technology supplier	No, because technology supplier deals with the distribution of the product (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>



Consecutively, in the previous [Sections](#) it was presented that effluents are not to be disposed uncritically for they are considered to be economically prime important nutrient resource based streams. The aforementioned mapping of the WW treatment trains followed for pollutant (i.e not valorised nutrient removal) for the aforementioned WW streams is a step forward, towards the facilitation of the deployment of NR practices in increasingly more WW treatment facilities.

### 3.2.5 Agreement with existing statements

When asked whether they have been preoccupied with any of the following statements, WWP3 agreed strongly with the following statements and the examples that accompanied them:

- Implementation of stricter NR policies in WW will require access of WWTP to extend their territory in urban, industrial and agricultural areas laying longer pipelines. (ex. Negotiations over rights of way – multiple litigation processes – rerouting due to difficult terrain or sensitive archaeological or cultural sites - waste time and resources)
- Development of decentralised WW treatment for nutrient recovery can greatly reduce CAPEX and OPEX. (ex. Placing small treatment plants at the point of need (WW producer), CAPEX can be cut by as much as two-thirds, and OPEX can be reduced, too – all with no sacrifice in quality of treatment.)
- P recovery costs exceed conventional P ore costs. (ex. Assuming a load of 660 g P per capita per year, recovery costs would be 3.600–8.800 € per ton recovered P under German market conditions).

### 3.3 Barriers that WWP, IWWTP and UWWTP should overcome to apply Nutrient Recovery practices

The identification of the preconditions and factors that drive or hamper the deployment of Nutrient Recovery options already in industrial WW streams in Europe involved surveying on numerous factors covering a great extent of factors, is presented in Table 3-12.

The barriers are presented in Table 3-12 in order of significance.



Table 3-12: Barriers that WWP, IWWTP and UWWTP should overcome to apply Nutrient Recovery practices (raw and quantitative data)

Barriers to overcome for Nutrient Recovery practices	Interviewees that agree	Total	
1. Limited accessible commercialization pathway/market of recovered nutrients for fertiliser manufacturing industries.	IWWTP1 & all WWP	6	42.9 %
2. Total operational expenditure (OPEX) (maintenance costs (2.5 % of CAPEX) – power/energy consumption costs – chemical/consumables costs – labour costs – treatment and disposal costs).	IWWTP7, WWP3 & UWWTP10 WWP4, WWP5	5	35.7 %
3. Lack of engineering expertise and knowledge of the available NR practices.	IWWTP1, IWWTP7, IWWTP1, IWWTP5	4	28.6 %
4. Low concentration of nutrients in economically prime important nutrient resource based products (fermenter effluents, sludges etc.), that make NR uneconomical. (E.g. Low N concentrations of only 30 mg per litre NH <sub>4</sub> -N in average Dutch wastewater may make NH <sub>4</sub> recovery uneconomical).	WWP3, IWWTP1, IWWTP1, IWWTP5	4	28.6 %
5. Unawareness of regulatory updates framework of nutrient recovery	All WWP	4	28.6 %
6. Unaware of future restrictions on mineral fertilisers utilization	All WWP	4	28.6 %
7. Questionable quality and safety of Recovered Nutrients (Contamination risks due to effluent composition).(PTEs, PAHs, pharmaceutical residuals, microbiological pathogens) - transfer to food chain).	WWP3 & UWWTP10, IWWTP7)	3	21.4 %
8. Different nutrient reuse standards, which is the primary cost driver, in every Member States.	IWWTP7) UWWTP9 WWP4	3	21.4 %
9. Initial capital expenditure (CAPEX) of construction and equipment for advanced WW Treatment Technologies (Nutrient recovery).	IWWTP7, WWP3 & UWWTP9	3	21.4 %
10. Access to reliable financial feasibility assessments of the NR option in WWT.	WWP3, WWP4 & IWWTP7	3	21.4 %
11. If recovered nutrients are not used on site, distribution and transport have to be organized (geographical and temporal discrepancies between supply and demand, lack of infrastructure, or cost).	IWWTP7, WWP3 & WWP4	3	21.4 %
12. While the current selling price of the recovered product does not make the NR process economically viable, the price of recovered nutrients will be considerably higher than the price of mineral fertiliser.	IWWTP7, UWWTP9	2	14.3 %
13. Low end-user awareness/acceptance for the application of recovered nutrients.	WWP3 & UWWTP10	2	14.3 %
14. Handling of this new line of products in the portfolio (certification, marketing, etc.)	WWP3 & UWWTP10	2	14.3 %
15. Prohibitive Whole Life Cost (WLC, INITIAL CAPEX + (Annual OPEX x 14) of Nutrient recovery Technologies for a life span of 40 years).	IWWTP7, WWP5	2	14.3 %
16. Governmental support (Direct help - financial support in scaling-up innovative Nutrient Recovery Technologies (CAPEX / OPEX))	IWWTP7, WWP3	2	14.3 %



17. Low existing product's sale price postpones the time when this NR technology will render profit.	IWWTP7, WWP5	2	14.3 %
18. Lack of land use availability e.g. Limitation of land generally increases the capital cost of the technology.	IWWTP7 & WWP3	2	14.3 %
19. Extra space requirements to install a WWT unit in the facility.	IWWTP7 & WWP4	2	14.3 %
20. Variance & Constant evolution in NR Technologies (NRTs) – not being able to decide which NRT to apply.	IWWTP7, WWP3	2	14.3 %
21. External interactions (Distribution & transport of recovered compounds - Exports to other countries, Approach of other WW treatment companies, WW treatment technology providers, recovered nutrients collectors).	WWP3, WWP5	2	14.3 %
22. Policy framework implications (Complexity of policies, frequent updates) (e.g. recycling of nutrients is mostly governed by fragmented decision-making in regional administrations)	UWWTP10	1	7.1 %
23. Ownership of nutrients in WW streams after they have been recovered in the WWTP (or unit).	UWWTP10	1	7.1 %
24. NRTs need technological assistance (training-high level of operator attention-expertise & -operational support).	IWWTP7	1	7.1 %
25. No ability to guarantee the marketability of the recovered nutrients because the products' content in pathogens, heavy metals and/or other contaminants.	IWWTP7	1	7.1 %
26. Shock and peak WW loads that can upset NR process.	WWP3	1	7.1 %
27. Establishment of certification procedures for recovered nutrients and WW-based products.	WWP3	1	7.1 %
28. Fluctuations of influent composition (Shock and peak WW loads can upset NR process).	WWP3	1	7.1 %
29. Establishment of traceability protocols for recovered nutrient products which could contain (organic) contaminants (the level of impurities which could be a threat to health, safety and environment, and product quality and application techniques).	WWP3	1	7.1 %
	Total of interviewees	14	



Table 3-13: Barriers that WWP, IWWTP and UWWTP should overcome to apply Nutrient Recovery practices (qualitative data)

Barriers to overcome for Nutrient Recovery practices	Interviewees that agree	
<b>Major significance</b>		
1. Limited accessible commercialization pathway/market of recovered nutrients for fertiliser manufacturing industries.	IWWTP1 & all WWP	42.9 %
2. Total operational expenditure (OPEX) (maintenance costs (2.5 % of CAPEX) – power/energy consumption costs – chemical/consumables costs – labour costs – treatment and disposal costs).	IWWTP7, WWP3 & UWWTP10 WWP4, WWP5	35.7 %
3. Lack of engineering expertise and knowledge of the available NR practices.	IWWTP1, IWWTP7, IWWTP1, IWWTP5	28.6 %
4. Low concentration of nutrients in economically prime important nutrient resource based products (fermenter effluents, sludges etc.), that make NR uneconomical. (E.g. Low N concentrations of only 30 mg per litre NH <sub>4</sub> -N in average Dutch wastewater may make NH <sub>4</sub> recovery uneconomical).	WWP3, IWWTP1, IWWTP1, IWWTP5	28.6 %
<b>High significance</b>		
5. Unawareness of regulatory updates framework of nutrient recovery	All WWP	28.6 %
6. Unaware of future restrictions on mineral fertilisers utilization	All WWP	28.6 %
7. Questionable quality and safety of Recovered Nutrients (Contamination risks due to effluent composition).(PTEs, PAHs, pharmaceutical residuals, microbiological pathogens) - transfer to food chain).	WWP3 & UWWTP10, IWWTP7)	21.4 %
8. Different nutrient reuse standards, which is the primary cost driver, in every Member States.	IWWTP7 UWWTP9 WWP4	21.4 %
9. Initial capital expenditure (CAPEX) of construction and equipment for advanced WW Treatment Technologies (Nutrient recovery).	IWWTP7, WWP3 & UWWTP9	21.4 %
10. While the current selling price of the recovered product does not make the NR process economically viable, the price of recovered nutrients will be considerably higher than the price of mineral fertiliser.	IWWTP7, UWWTP9	14.3 %
11. Low end-user awareness/acceptance for the application of recovered nutrients.	WWP3 & UWWTP10	14.3 %
12. Handling of this new line of products in the portfolio (certification, marketing, etc.)	WWP3 & UWWTP10	14.3 %
13. Policy framework implications (Complexity of policies, frequent updates)		
14. (e.g. recycling of nutrients is mostly governed by fragmented decision-making in regional administrations)	UWWTP10	7.1 %
15. Ownership of nutrients in WW streams after they have been recovered in the WWTP (or unit).	UWWTP10	7.1 %
<b>Minor significance</b>		
16. Access to reliable financial feasibility assessments of the NR option in WWT.	WWP3, WWP4 & IWWTP7	21.4 %
17. If recovered nutrients are not used on site, distribution and transport have to be organized (geographical and temporal discrepancies between supply and demand, lack of infrastructure, or cost).	IWWTP7, WWP3 & WWP4	21.4 %



18. Prohibitive Whole Life Cost (WLC, INITIAL CAPEX + (Annual OPEX x 14) of Nutrient recovery Technologies for a life span of 40 years).	IWWTP7, WWP5	14.3 %
19. Governmental support (Direct help - financial support in scaling-up innovative Nutrient Recovery Technologies (CAPEX / OPEX))	IWWTP7, WWP3	14.3 %
20. Low existing product's sale price postpones the time when this NR technology will render profit.	IWWTP7, WWP5	14.3 %
21. Lack of land use availability e.g. Limitation of land generally increases the capital cost of the technology.	IWWTP7 & WWP3	14.3 %
22. Extra space requirements to install a WWT unit in the facility.	IWWTP7 & WWP4	14.3 %
23. Variance & Constant evolution in NR Technologies (NRTs) – not being able to decide which NRT to apply.	IWWTP7, WWP3	14.3 %
24. External interactions (Distribution & transport of recovered compounds - Exports to other countries, Approach of other WW treatment companies, WW treatment technology providers, recovered nutrients collectors).	WWP3, WWP5	14.3 %
25. NRTs need technological assistance (training-high level of operator attention-expertise & -operational support).	IWWTP7	7.1 %
26. No ability to guarantee the marketability of the recovered nutrients because the products' content in pathogens, heavy metals and/or other contaminants.	IWWTP7	7.1 %
27. Shock and peak WW loads that can upset NR process.	WWP3	7.1 %
28. Establishment of certification procedures for recovered nutrients and WW-based products.	WWP3	7.1 %
29. Fluctuations of influent composition (Shock and peak WW loads can upset NR process).	WWP3	7.1 %
30. Establishment of traceability protocols for recovered nutrient products which could contain (organic) contaminants (the level of impurities which could be a threat to health, safety and environment, and product quality and application techniques).	WWP3	7.1 %



### 3.3.1 Data assessment - conclusions

To further understand the profile of the interviewees, WWP3 presented high awareness for NR practices since they have attempted to apply NR practices after identifying / characterising the composition of their WW streams/effluents but could not partner with a technology provider for reasons of ‘limited available technology’, as they commented. Moreover, WWP5 mentioned that they have attempted to adapt and adopt a NR technology by implementing the following steps:

- Regulation framework analysis
- Business/process feasibility assessment
- Identification / Characterisation of the composition of WW
- Installation of NR unit
- Find market for recovered nutrients.

UWWTP9 has also performed a regulation framework analysis (effluent, NR quality) and a business/process feasibility assessment (Technical / economical), concluding that there is ‘no legal security and the CAPEX is a prohibiting parameter. They have installed a pilot plant on nutrient recovery, but upscaling has not been successful.

The majority of IWWTP commented that they have yet to consider NR practices due to the technical limit.

According to the quantitative and qualitative analysis of the presented data in

Table 3-13, the barrier that most WWP and WWTP face (35.7 %) is the ‘*Limited accessible commercialization pathway/market of recovered nutrients*’. The second most important barrier (28.6 %) with at least one representative from WWP, IWWTP and UWWTP agreed on is the ‘*Total operational expenditure (OPEX) (i.e. maintenance costs (2.5 % of CAPEX) – power/energy consumption costs – chemical/consumables costs – labour costs – treatment and disposal costs)*’. At least one UWWTP also agreed with WWP on the following three barriers:

1. *Questionable quality and safety of Recovered Nutrients (Contamination risks due to effluent composition).(PTEs, PAHs, pharmaceutical residuals, microbiological pathogens) - transfer to food chain).*
2. *Initial capital expenditure (CAPEX) of construction and equipment for advanced WW Treatment Technologies (Nutrient recovery).*
3. *Different nutrient reuse standards, which is the primary cost driver, in every Member States.*

All WWP (28.6 % of the total interviewees) agreed on

1. *‘Unawareness of regulatory updates framework of nutrient recovery’* and
2. *‘Unaware of future restrictions on mineral fertilisers utilisation’*

Since indeed currently (March 2023) there is no forthcoming future restriction on mineral fertilisers utilization it seems that this would be a ‘convincing’ measure to apply at the altar of nutrient recovery practice.

In Italy, the barriers that have drawn the most attention are:

- the impossibility to classify the products from nutrient recovery within the Italian law
- the considerations regarding the production costs,
- the included quality risks, and



-the expectedly small productions to play a significant role in the market.

In Table 3-12, 3 out of 5 WWPs highlighted the total operational expenditure (OPEX) (maintenance costs (2.5 % of CAPEX) – power/energy consumption costs – chemical/consumables costs – labour costs – treatment and disposal costs) as the main barrier in the deployment of NR practices which could result in an ‘*increase of product sales price*’, as UWWTP10 commented.

None of the interviewees considered the following statements as barriers in NR practices:

- Unawareness of NR perception as a possibility to my influents - Unawareness of NR benefits - Unawareness of social impact of NR
- Lack of interest from WW producers.
- Due to the low quality of the effluents, non-selective incineration or land burying are more cost-effective solutions.
- The need to use or storage Recovered Nutrients on site.
- The need for follow on operational support from technology providers.
- Not finding financial support for up-scaling of bench/lab scale innovative NR processes
- Not consistent influent composition
- Environmental safety of Nutrient Recovery Technologies.

All WWPs agreed for the absence of NR practices so far on:

- Unawareness of regulatory updates framework of nutrient recovery
- Unawareness of future restrictions on mineral fertilisers utilization.

To conclude with, as UWWTP10 commented, one of the main challenges is about to become the homogenous implementation on regional level of the European policies. Although farmers from France commented that the ownership of nutrients in WW streams after they have been recovered in the WWTP (or unit) should not be considered as a limitation in practicing NR, UWWTP10 asked for clarifications regarding which part is responsible for the quality of the final NR-based product which would also solve the case of questionable quality and safety of recovered nutrients (contamination risks due to effluent composition). Another preoccupation that was highlighted by both a WWP (WWP3) and an UWWTP (UWWTP10) is to eliminate the perception that a WWTP is nothing but a waste processing/producing company and that ‘WW should be defined as a (possible) resource, not as waste’, as UWWTP10 commented. This involves overcoming the low end-user awareness/acceptance for the application of nutrients from NR practices as well as handling the new line of products in the portfolio (certification, marketing, etc.) which is linked to the clarification of who the responsible for the quality of these products is.

The aforementioned parameters have also been highlighted in WalNUT D1.3 ‘EU27 matrix for bio-based input streams and NR technologies and WalNUT D6.1 ‘Inventory and integrated assessment of the EU regulations related to production and application of bio-based fertilisers’ as it is in the scope of WalNUT project. Declassification of waste has been added in the agenda of EU Commission and many adjustments have been made towards this end.



### 3.4 Measures to be implemented that would benefit WWP, IWWTP and UWWTP to apply NR practices

The proposed measures to be implemented by WWP, IWWTP and UWWTP that would unlock the Nutrient Recovery barriers are presented in Table 3-14.

Throughout the evaluation of the responses, much attention has been paid to the expressed opinions by the representatives of UWWTPs. As an example, an UWWTP (UWWTP10) disagreed with the statement that *‘Implementation of stricter NR policies in WW will require access of WWTP to extend their territory in urban, industrial and agricultural areas laying longer pipelines. (Negotiations over rights of way – multiple litigation processes – rerouting due to difficult terrain or sensitive archaeological or cultural sites - waste time and resources)’*. Therefore, they strongly agreed with the statement that *‘Development of decentralised WW treatment for nutrient recovery can greatly reduce CAPEX and OPEX. (Placing small treatment plants at the point of need (WW producer), CAPEX can be cut by as much as two-thirds, and OPEX can be reduced, too – all with no sacrifice in quality of treatment)’*. The UWWTP also agreed that *‘P recovery costs exceed conventional P ore costs. Assuming a load of 660 g P per capita per year, recovery costs would be 3.600–8.800 € per tonne recovered P under German market conditions.’*

Regarding the potential measures to unlock NR barriers in Italy, it was clarified that regarding the obligation to NR, this could be valid, but only in particular contexts (eg availability of high flow rates of concentrated effluents). Moreover, the viability of an NR practice could/should be supported by the fossil-based fertiliser taxes.

WWPs and IWWTPs remained neutral for the most part of proposed measures for NR employment presented in Table 3-14. The majority of the interviewees (5 out of the 6 interviewees that completed this survey agreed on the enactment of a minimum amount of nutrients from NR practices in BBFs and their price guarantee. The 6<sup>th</sup> interviewee remained neutral.

All IWWTP agreed that a direct help - financial support in scaling-up innovative Nutrient Recovery Technologies (CAPEX / OPEX) will promote the development of NR solutions and their market penetration.



Table 3-14: Measures to be implemented that would unlock the Nutrient Recovery barriers

To overcome economic barriers		Strongly agree	Agree	Neutral	Disagree
Government measures that would make the process economically feasible:					
i	Obligation of NR practices by WW producers will be a motivating factor to perform NR, reducing access price to technology and reducing the price of recovered nutrients. Circular economy Regulation: Obligation to recover nutrients from WW streams.	IWWTP1&5, UWWTP9, UWWTP10	WWP1, WWP3& IWWTP7	IWWTP7, WWP5	
ii	Direct help - financial support in scaling-up innovative Nutrient Recovery Technologies (CAPEX / OPEX).		WWP1 & IWWTP7 UWWTP9	7 IWWTP & WWP3, WWP5	UWWTP10
iii	Obligation in the use of RN first instead of mineral.		7 IWWTP, 3 WWP, UWWTP10	WWP1, IWWTP7, UWWTP9, WWP5	
iv	Minimum amount of NR in BBFs and price guarantee	IWWTP1-3&5 UWWTP9 UWWTP10	WWP1 & IWWTP7	4 WWP	
v	Taxes on the use of mineral sources for fertilisers.	UWWTP10, WWP5	IWWTP1&5, 3 WWP	WWP1 & IWWTP7	UWWTP9
	A network allowing identifying other businesses from the rest of the WW chain (end-users and fertiliser manufacturers) next to my business will minimize the cost of logistics.	UWWTP9, UWWTP10		IWWTP1-5-7	
	Competition will be a motivating factor to perform NR. Reducing access price to technology and reducing the price of NR.	UWWTP9	IWWTP1-9		
<b>Regulations</b>					
	Stricter disposal of WW criteria will increase the number of WWT/NR facilities.	7 IWWTP, UWWTP9	WWP5	WWP3, UWWTP10	WWP1 & IWWTP7
	Common fertiliser regulation in Europe.	UWWTP9 UWWTP10	IWWTP7	IWWTP1&5, WWP3	
	If several WW producers recover the same nutrient, value-chain development could be facilitated by acting as one supplier of the recovered nutrient, thus increasing their collective market power.	UWWTP9 UWWTP10		IWWTP1-5&7 & WWP3	



### 3.4.1 Data assessment - conclusions

In Figure 3-2 the proposed measure with the most votes (11/15 agree, 4 neutral) is the '*Obligation in the use of recovered nutrients first instead of mineral*'. It is remarkable that while many interviewees did not respond to every field of the survey, all 15 of them responded to this proposal.

The measure '*Stricter disposal of WW criteria will increase the number of WWT/NR facilities*' is the one with the most 'Strongly agree' votes (8/15), 1/15 'Agree' vote, 2/15 neutral votes and 2/15 'Disagree' votes.

The measure '*Minimum amount of Recovered nutrients (RN) in BBFs and price guarantee*' got 5/12 'Strongly agree' votes, 2/12 'Agree' votes and 5/12 'Neutral' votes. The third in line measure with most 'Strongly agree' votes (4/9), 3/9 'Agree' votes and 2/9 'Disagree' votes is '*Obligation of NR practices by WW producers will be a motivating factor to perform NR, reducing access price to technology and reducing the price of recovered nutrients. Circular economy Regulation: Obligation to recover nutrients from WW streams*'.

The measure '*Taxes on the use of mineral sources for fertilisers*' got 2/12 'Strongly agree' votes, 7/12 'Agree' votes and only 1/12 'Disagree' votes. However, the comment of Farmer<sub>2</sub> '*Not a good solution at all!*' when asked the same question should be kept in mind for in France, there is already a "fake tax" on the utilization of mineral fertilisers. N price increased by 3 times and P by 2 times with the increase of gas prices.

The measure '*Direct help - financial support in scaling-up innovative Nutrient Recovery Technologies (CAPEX/ OPEX)*' is the one with the most neutral votes (10/14), but the interviewees that agreed were 3/14 while only one interviewee disagreed with the proposed measure. The number of interviewees that evaluated the rest of the proposed measures does not suffice for a representation of WWP and IWWTP opinion.

It seems that '*Competition will be a motivating factor to perform NR, as well as reducing access price to technology and reducing the price of NR*', since 1/9 interviewees strongly agreed and the rest 8 also agreed.

Even though only 5 of the 15 in total interviewees responded to the evaluation of the proposed measure '*A network allowing identifying other businesses from the rest of the WW chain (end-users and fertiliser manufacturers) next to my business will minimize the cost of logistics*' and the 3 of them were Neutral, it seems that it needs to be considered as both UWWTPs Strongly agreed on it.

The same tendency was followed with both UWWTPs out of the 6 interviewees Strongly agreeing on either '*Common fertiliser regulation in Europe*' and '*If several WW producers recover the same nutrient, value-chain development could be facilitated by acting as one supplier of the recovered nutrient, thus increasing their collective market power*'.



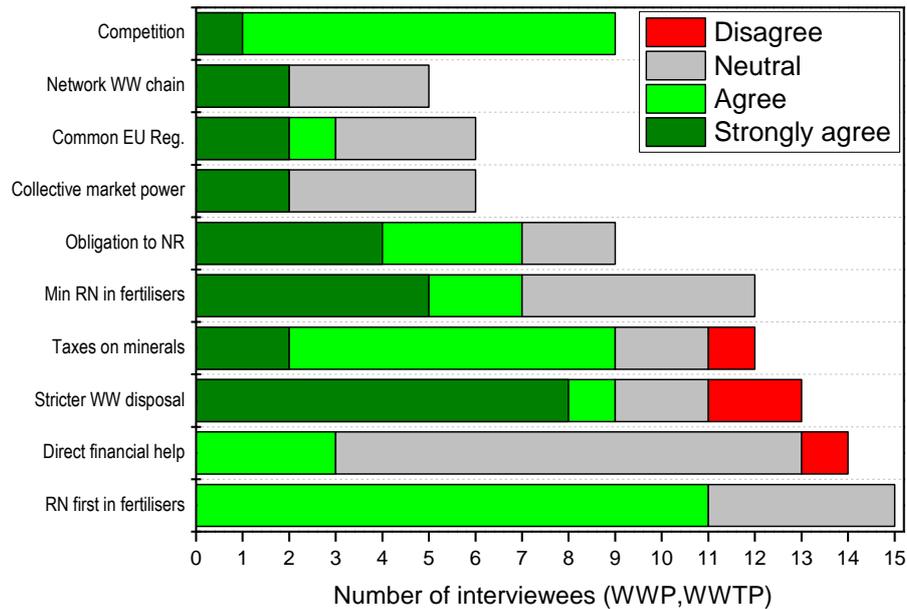


Figure 3-2: Measures to be implemented by WWP and WWTP that would unlock the Nutrient Recovery barriers (Total of interviewees: 15)

To conclude with, it would be highly beneficial to ensure that during the development of new districts, NR is evaluated beforehand. Adapting the current/existing WWT systems should be more difficult and definitely not cost-effective. It could be a trade-off with the increased cost of logistics related to a centralised supplier. Moreover, in the future, NR could/should be an opportunity/a need to meet stricter discharge limits. However, there is a contradiction between IWWTP1&5 and IWWTP1&7 on whether the stricter disposal of WW criteria will increase the number of WWT/NR facilities.



### 3.5 Motives to be considered in the implementation of a NR technology

In Table 3-15 the proposed motives to be considered in the implementation of Nutrient Recovery practices are being evaluated by WWP and WWTP.

Table 3-15: Motives to be considered in the implementation of Nutrient Recovery practices

Rate with 1 (Yes, I would implement NR for this) -2 (Maybe I would consider NR options) -3 (No, I would not implement NR for this)	IWWTP1 -3-5-8	WWP3	WWP4	WWP5	UWWTP9
Market place and guaranteed value of recovered nutrients	2	1	2	1	1
High quality of Recovered Nutrients due to influent's composition (No risk of contamination of food chain )	2	1	1	1	3
Techno economically feasible (CAPEX, OPEX)	1	1	3	1	2
Motivation to be environmentally friendly	1	2	2	3	1
The competitor's companies have already implemented NR in their WW treatment process	2	2	1	3	2
Financial support from political institutions to share the risks of innovation implementation	2	2	2	3	2
User acceptance for the application of recovered nutrients	2	2	2	3	2
New line of products in the portfolio	2	2	2	3	3
Available space e.g. Limitation of land generally increases the capital cost of the technology	3	2	3	3	1
External interactions (Exports to other countries, Approach of new partners (other companies producing the same WW influent, WW treatment companies, WW treatment technology providers, recovered nutrients collectors))	3	1	3	3	3



### 3.5.1 Data assessment - conclusions

To begin with, 3/8 interviewees would implement NR practices if they had the *'Market place and guaranteed value of recovered nutrients'*. The 4 IWWTPs represented did not agree with this statement.

As it was expected, while all WWTPs were positive towards the *'High quality of Recovered Nutrients due to influent's composition (No risk of contamination of food chain)'*, the UWWTP was opposed. Sewage sludge has not been included yet (March 2023) in Reg. EU 1009/2019.

Unlike IWWTPs and WWTPs, *'Techno economic feasibility (CAPEX, OPEX)'* was not such a convincing factor for the UWWTP to implement NR practices.

The 8 interviewees in In Table 4-16, the profile of Fertiliser manufacturers (FMs) is presented. The commercial fertilising end-products (BBFs) FM<sub>Hungary</sub> handles is of biochar and high qty compost from clean solid biowaste sources only that have been Certified according to 36/2006 FVM degree (HU) and EU 2019/1009 CMC3 and CMC14. The aforementioned certifications provide the sources with the "End-of-waste Status". 'End of Waste Status' refers to the status of a waste material that meets requirements to no longer be classified as waste but as resource for new production processes.

Table 4-16 are neutral towards the motives *'Financial support from political institutions to share the risks of innovation implementation'* and *'User acceptance for the application of recovered nutrients'* for the implementation of NR practices.

The interviewees in total would not be motivated to implement NR practices by a *'New line of products in the portfolio'*. The same applies for the motive under consideration *'Available space'*. The UWWTP was the only one to put emphasis on the fact that *'Limitation of land generally increases the capital cost of the technology'*.

Last but not least, 7 out of 8 interviewees would not be motivated to implement NR practices by *'External interactions (Exports to other countries, Approach of new partners (other companies producing the same WW influent, WW treatment companies, WW treatment technology providers, recovered nutrients collectors))'*.

To conclude with, even though *'Environmental friendliness'* was not one of the favorite factors for the implementation of NR practices, *'Stricter disposal of WW criteria'* and *'Minimum amount of NR in BBFs and price guarantee'* seem more motivating towards an increase in the number of WWT/NR facilities. Therefore, the *'Obligation to comply with relevant policy and legislative frameworks'* is not the only way towards this end.



## 4 Interviews of BBF end users

### 4.1 Fertiliser Manufacturers

This survey concerns:

- i) the incorporation of nutrients recovered from urban WW and sewage sludge, food, industrial WW and brine as primary and secondary macro-nutrients or micro-nutrients in bio-based fertilisers (BBFs) and
- ii) the valorisation of products deriving from the treatment of urban WW and sewage sludge, food, industrial WW and brine, as bio-based fertilisers (BBFs).

The target of this survey is the allocation of the lock-ins and barriers that hamper the production and use of Bio-Based fertilisers. BBFs are not to be confused with animal metabolism -derived Fertilisers.

#### 4.1.1 The profile of fertiliser manufacturers

In Table 4-16, the profile of Fertiliser manufacturers (FMs) is presented. The commercial fertilising end-products (BBFs) FM<sub>Hungary</sub> handles is of biochar and high qty compost from clean solid biowaste sources only that have been Certified according to 36/2006 FVM degree (HU) and EU 2019/1009 CMC3 and CMC14. The aforementioned certifications provide the sources with the “End-of-waste Status”. ‘End of Waste Status’ refers to the status of a waste material that meets requirements to no longer be classified as waste but as resource for new production processes.

Table 4-16: List of BBF end-users (FMs) that participated in the WalNUT survey

ID	Country	Origin*	BBF	Quantity
FM <sub>Hungary</sub>	Hungary	Clean solid biowaste sources	Biochar and high quality compost	300 t/y
FM <sub>Belgium</sub>	Belgium	Urban WW Industrial WW (potato processing, manure processing, dairy)	Struvite (5% N, 28% P <sub>2</sub> O <sub>5</sub> , 15% MgO with Zn as a PTE complying with the legal fertilising standards for fertiliser manufacturing)	NA
FM <sub>France</sub>	France	NA	NA	NA

\*Origin of recovered nutrients or nutrient-rich WWT (NR)-based products (i.e. economically prime important nutrient resource based products such as STRUvite, biochar, etc.)

NA: Not available

#### 4.1.2 Differentiation of EU and national regulations on fertilising products.

When asked if they are aware of any differentiation of EU regulations with corresponding national regulations regarding the fertilising products, FM<sub>Hungary</sub> mentioned that the Hungarian national regulations are stricter than EU regulations their entrepreneurial impetus has not been affected.

FM<sub>Belgium</sub> preferred complying with EU declaration of the quality requirements for a fertiliser since the differentiations of national regulations with EU ones creates export limitations.



### 4.1.3 Experience with end-user acceptance of BBFs

This part of the survey is the most representative of end-user acceptance of BBFs after their interaction with fertiliser manufacturers. The experience of FM<sub>Hungary</sub> with end-users regarding their acceptance of BBFs is overall positive with the condition that they are produced from clean solid biowaste sources only and not from municipal WW or WW sludge that are excluded from EU 2019/1009. The same applies in the interactions of FM<sub>Belgium</sub> who commented that as long as the quality of BBFs is satisfactory, the user does not mind. Other reported statements are listed below.

### 4.1.4 Barriers that FM should overcome to use products from Nutrient Recovery practices

In Table 4-17 are shown the factors that have kept fertiliser manufacturers from using recovered nutrients in BBFs manufacturing or promoting economically prime important nutrient resource-based products.



Table 4-17: Barriers that FM should overcome to use products from Nutrient Recovery practices

<b>Nutrient Recovery: why &amp; how?</b>		
Unawareness of recovered nutrients' perception as a raw material for fertilisers - Unawareness of nutrient-rich effluents' benefits - Unawareness of social impact of recovered nutrients. <b>FM<sub>France</sub></b>	Not having access to economic feasibility data for recovered nutrients utilization for BBF manufacturing. <b>FM<sub>France</sub></b>	Lack of engineering expertise and knowledge of purification processes after WWT. <b>FM<sub>France</sub></b>
Lack of engineering expertise and open knowledge of manufacturing processes for bio-based fertilisers' synthesis. <b>FM<sub>France</sub></b>	of alteration/adaption of	Need for technological assistance (training-high level of operator attention-expertise & follow -on operational support). <b>FM<sub>France</sub></b>
<b>Financial barriers</b>		
Lack of economic incentives for waste valorisation - governmental support (Direct helps - subsidies or tax breaks - financial support with CAPEX / OPEX)) <b>FM<sub>Hungary</sub> &amp; FM<sub>Belgium</sub></b>	Not sustainable extra total operational expenditure (OPEX) (maintenance costs (2.5 % of CAPEX) - power/energy consumption costs -consumables costs - labour costs - treatment and disposal costs).	Prohibitive Whole Life Cost (WLC, INITIAL capex + (Annual OPEX x 14) of bio-based fertilisers manufacturing processes for a life span of 40 years).
Not finding financial support for up-scaling processes for RN utilization (at bench or lab scale).		Limited accessible commercialization pathway/market for bio-based fertilisers.
<b>Regulation</b>		
Conflict between legislation for P as a resource in fertiliser production or as a pollutant in WWT <b>FM<sub>Belgium</sub></b>		
Ownership of nutrients in effluents after they have been recovered in a WWTP	Other complexity of policies (fragmented decision-making, regional dependence <b>FM<sub>Hungary</sub> &amp; FM<sub>Belgium</sub></b> )	Different regulation across the different MS <b>FM<sub>Belgium</sub></b>
Unaware of future restrictions on mineral fertilisers utilization	Unaware of regulatory updates framework on inclusivity of economically prime important nutrient resource-based products	Every Member State has different nutrient reuse standards, which is the primary cost driver

<b>Effluent composition</b>		
Low nutrient/economically prime compounds concentrations in WW/fermenter effluent/sludges make BBF synthesis uneconomical.	Not ability to guarantee the quality of the product because of the low effluent purity (pathogens, and/or other contaminants) to enter the market.	Not consistent effluent composition.
<b>Nutrient composition Recovered nutrients</b>		
Low or uncertain concentration of nutrients in WWT-derived products <b>3/3</b>	Unstable (quality, quantity) supply from WW producers <b>FM<sub>Hungary</sub> &amp; FM<sub>Belgium</sub></b>	Quality and safety of Recovered Nutrients (Contamination risks due to effluent composition) <b>FM<sub>Belgium</sub></b>
Collection/transport/distribution of effluents/recovered nutrients from WW producers/WWTP )) <b>FM<sub>Belgium</sub></b>	Unreliable certification/authorization of BBFs (regional/national/EU regulations) <b>FM<sub>Hungary</sub> &amp; FM<sub>Belgium</sub></b>	Farmers are not willing to change their fertilising practices (dose/equipment/product).



		No demand = no offer <b>FM<sub>Hungary</sub> &amp; FM<sub>Belgium</sub></b>
farmers prefer the use of chemical rather than bio-based fertilisers because the application of the latter involves more labor <b>FM<sub>Hungary</sub> &amp; FM<sub>Belgium</sub></b>		
If recovered nutrients/nutrient rich effluents are not used on site, distribution and transport have to be organized (geographical and temporal discrepancies between supply and demand, lack of infrastructure, or cost).	Price of recovered nutrients is considerably higher than price of mineral raw materials.	Existing BBF product sale price does not make the BBF synthesis economically feasible.



#### 4.1.4.1 Data assessment - conclusions

Regarding the nutrient composition, a low or uncertain concentration of nutrients in WWT-derived products is a preoccupying factor and FM<sub>Hungary</sub> commented that *'BBFs should be characterised by high nutrient density so as to be economical and less risky when applied at low dose'*. In the case of P recovery, BBFs should have an above of the 30% minimum of P<sub>2</sub>O<sub>5</sub> content. FM<sub>Belgium</sub> suggested mixing BBFs with other products to balance concentrations. Both FM<sub>Hungary</sub> and FM<sub>Belgium</sub> agreed that farmers are not willing to change their fertilising practices (dose/equipment/product). FM<sub>Hungary</sub> also suggested *'Appropriate sizing of product to fit the existing equipment'*. In France as well, end-users do not have any negative opinion of NR but doubt whether NR products are compatible with their manufacturing processes. As an example, a BBF in liquid form could not be applied on field since farmers only have the equipment to process pellets.

Regarding the collection/transport/distribution of effluents/recovered nutrients from WW producers/WWTP apart from the high transportation and handling cost, the interviewees expressed their concern regarding the high C footprint (FM<sub>Hungary</sub>). Given the aforementioned parameters and the fact that the purification from contaminants is highly expensive nutrient recovery becomes uninteresting and effluents are often exported to developing countries in Africa to dump the waste (FM<sub>Hungary</sub>).

The FM from Hungary mentioned that a BBF sale price has yet to be defined for there is no end-user demand and agreed that there is a conflict between legislation for P as a resource in fertiliser production or as a pollutant in WWT. When asked whether they considered the ownership of nutrients in effluents after they have been recovered in a WWTP an obstacle in NR practices and to mention any other complexity of policies (i.e. fragmented decision-making, regional dependence) they mentioned that any WWTP is currently not bothered by such technicalities given that they are consumed by running the core WWTP operations *'as cheap as possible'*.

It is understood that there is already high science-based knowledge, field experience and investigations regarding the utilization of BBFs for example as N fertilisers and their potential effect on nitrate leaching. The measured nitrate residue gives an estimation of the nitrate amount that can potentially leach to ground and surface water. Also, the soil/water sampling/analysis by Authorities is restless. However, there is a lack of knowledge related to the safety and risk of using fertilisers from WW, sewage sludge or industrial sludge and farmers stick to the use of BBFs only from clean solid biowaste source rather than sewage water and sewage or industrial sludge, as repeated in the previous section. It is highly important that heavy metals are removed. So as to guarantee the quality of the recovered nutrients because of the low effluent purity (pathogens, and/or other contaminants) to enter the market. In other words, the traceability needs to be guaranteed. Fortunately, the effluents' composition is mostly standardized.

FM<sub>France</sub> mentioned that, in conventional agriculture, there is a competition with products that are highly concentrated in nutrients. So, spreading quantities are higher; if the products are not very concentrated it will be a big barrier. The problem is deeper. If no obligation, the farmers will not go towards BBF. If no valorisation price can be achieved no market for BBFs will be formed. Certainly, the market will grow depending on the price and communication strategy/ added value. Uncertainties of economic benefits along the value chain are a barrier; it is very difficult to get added value from compost for instance.

In France, it is considered that there are no fundamental financial support barriers but they need to be complemented by efforts from Europe.



### 4.1.5 Motives to be considered in the utilization of products from NR practices

Potential motives to be considered for the utilization of recovered nutrients in BBFs manufacturing or promoting economically prime important nutrient resource-based products are presented in Table 4-18.

Table 4-18: Motives to be considered for the utilization of recovered nutrients in BBFs manufacturing or promoting economically prime important nutrient resource-based products

	Strongly agree	Agree	Partially agree	Disagree
1. Enactment of minimum amount of recovered nutrients in fertilisers and price guarantee.	FM <sub>Hungary</sub>	FM <sub>Belgium</sub>		
2. Obligation in the use of recovered nutrients first instead of minerals.		FM <sub>Belgium</sub>		FM <sub>Hungary</sub>
3. Prohibition of/increase in charges for storage and non-selective effluent incineration.	FM <sub>Hungary</sub> FM <sub>Belgium</sub>			
4. Price guarantee of recovered nutrients/nutrient rich WWT derived effluents			FM <sub>Hungary</sub> , FM <sub>Belgium</sub>	
5. Tax benefits for using renewable raw materials. / Tax in the use of mineral sources for fertilisers.	FM <sub>Hungary</sub>	FM <sub>Belgium</sub>		
6. Commercial agreements for exclusivity of next-generation BBF production technology to introduce to the marketplace.	FM <sub>Hungary</sub>	FM <sub>Belgium</sub>		
7. R&D grants for elaboration of new BBF manufacturing technologies.	FM <sub>Hungary</sub>	FM <sub>Belgium</sub>		
8. Process innovation: Direct helps - financial support in more demanding pre-treatment (purification - removal of contaminants) processes of the recovered nutrients from WW streams (CAPEX / OPEX).	FM <sub>Hungary</sub>		FM <sub>Belgium</sub>	
9. Process & product innovation: Direct helps - financial support in innovative Fertiliser Manufacturing Technologies for the utilization of economically prime important nutrient resource based products (CAPEX / OPEX).	FM <sub>Hungary</sub>		FM <sub>Belgium</sub>	
10. Due to the nature of nutrient rich effluents after WW treatment, building small scale fertiliser installations (by a technology provider) on the generation site, managed by fertiliser manufacturers would be a practical solution to the problem of collection, sanitation and downgrading during transport.	FM <sub>Hungary</sub>	FM <sub>Belgium</sub>		
11. Modern product portfolio will attract new customers (e.g. private households)	FM <sub>Hungary</sub>	FM <sub>Belgium</sub>		
12. Access to open science repositories with innovative available information ready to use.	FM <sub>Hungary</sub>	FM <sub>Belgium</sub>		
13. Involvement of technology providers in transformation of economically prime	FM <sub>Hungary</sub>	FM <sub>Belgium</sub>		



important nutrient resource based products into BBFs				
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#### 4.1.5.1 Data assessment - conclusions

All FMs agreed that if the product specification, availability and specificity of nutrients, soil enrichment by included elements, as well as direct usability of N or not, are not already known, they need to be proven beforehand.

FM<sub>Hungary</sub> disagreed with being obligated to use recovered nutrients first instead of minerals as a measure to spread NR awareness. They agreed partially that a price guarantee of recovered nutrients/nutrient rich WWT derived effluents would motivate NR practices. FM<sub>Hungary</sub> marked that their enterprise would need any time between 2 to 4 years for the smooth implementation of the Reg (EU) 2019/1009 from 16<sup>th</sup> July 2022.

FM<sub>Belgium</sub> commented that the most substantial barrier is the lack of legislation to enable diverse use of BBFs especially from municipal/manure origin.

FM<sub>France</sub> has performed both a regulation framework analysis (regarding recovered nutrients or effluent quality) and a technical/economical feasibility assessment of a BBF manufacturing process / business. However, the knowledge is not very vulgarised and there is not much available knowledge, respectively, regarding these matters. They have also taken the step of identification / characterization of recovered nutrients / effluents composition. This attempt could be in vain because a good knowledge background in terms of definition of the different existing classes of effluents according to the different present substances and standardization levels is required. Moreover, it is necessary to know the composition of primary matter in order to manufacture the products, and currently, there is no knowledge bank accessible to the public regarding this matter. They also commented that ‘biogas digesters are a very bad idea. Industries should be motivated to get interested in BBFs instead’. Moreover, there is ‘strong lobbying regarding the use of struvite in organic farming’.

FM<sub>Hungary</sub> also mentioned that they have taken some steps towards the use of recovered nutrients or economically prime important nutrient resource-based products in BBF manufacturing. However, they are overall not interested in changing focus of products at the moment, since right now, they produce meat and meal bone products for organic agriculture, mostly. The BioPhosphate is underway to be accredited Regulation (EU) 2019/1009 certified by ‘Notified Body’ NB2806 on EU fertilising products.



## 4.2 Farmers & Agricultural Associations

These surveys concern the valorisation of products deriving from the treatment of urban WW and sewage sludge, food, industrial WW and brine, as bio based fertilisers (BBFs).

The origin of the farmers, farmers' representatives and agricultural associations interviewed is presented in Table 4-19.

The farmers (F1, F2 and F3) that responded to the WalNUT survey were currently not involved in organic farming and did not have an on-land animal husbandry. Moreover, F1 and F3 are supplied with fertilisers by an agricultural association. F2 is also supplied with fertilising products from an only farming cooperative agricultural association, they use animal- metabolism products as well as from a WW-based products managing companies that are mainly based in local communities not as private companies. F3 commented that often, these consultants try to sell their products so *'I don't always take all their advice, they don't solve the actual problem'*. F3 depends by 90 % on fossil-based fertilisers and is willing to continue using BBFs and is interested in further reducing dependency on fossil-based fertilisers in the future, depending on the situation, the kind, the advantages and the price. F3 applies 3-4 t/year of certified sludges (non-hazardous industrial effluents) on a land of 15 ha.

Table 4-19: Interviewed BBF end-users profiles

ID	Country
F1	Canada
F2	France
F3	France
AA1	Belgium
AA2	Hungary
F4	Hungary
F5	France
F6	France
AA3	Spain
F7	Spain
F8	Italy

Table 4-20: List of BBFs

ID	BBFs	Spreading quantity	Comments
F2	Non-hazardous industrial effluents (sludges)	15 t (m <sup>3</sup> )/ha/yr	Sewage sludge from local communities (Fouras, Rochefort both in Charente-Maritime, France) from treatment plant
F2	Aerobically transformed products (compost)	10 t (m <sup>3</sup> )/ha/yr	Compost of sewage sludge
F3	Certified sludges (non-hazardous industrial effluents)	3-4 t/year on a land of 15 ha.	
AA1	Green compost		
AA1	Non-animal digestate		
F4	NA		NA
F5			Guano (not within WalNUT project)
F5	"NFU 44095" sludge composts + green waste composts		(French regulation) 95% of their activity. Either forced aeration or turning. Sometimes the sludges are rich in P, then they are treated separately. Or plant ashes, potassium. They have very specific demands



			in agriculture and wine production to have 3 to 5 in P.
F6	Sludge compost with green waste	8-10 t (m3)/ha/yr	Compost “NFU 44095” in the French regulation (in a storage platform on -site for 4 months)

The agricultural association in Belgium (AA1) is not involved in importing fossil-based fertilisers. They mentioned that they have not yet been presented by any fertiliser manufacturer the option of WW-based bio-fertilising products. However, their suppliers (i.e. fertiliser manufacturing companies) have informed them of utilising nutrients after valorisation of WW streams (instead of fossil-based ones) as a nutrients' source for their products. Although they have not yet included any fertilising products from the valorisation of WW in their portfolio. They also mentioned that it has been easy convincing farmers to take up the practice of WW-based bio-fertilisers and they are willing to continue their promotion since the demand for WW-based bio-fertilisers by farmers has increased over the years.

The agricultural association in Hungary (AA2) imports phosphate from Finland and Syria. Regarding WW-based products, they mentioned that they believed, the benefits of BBF utilisation would be the replacement of mineral fertilisers, that in their mind they are renewable and less costly. However, it has not been easy to convince farmers to take up the practice of WW-based BBFs given the common notion amongst farmers to not accept municipal WW-based products as bio-fertilising products. Of course, as AA2 said: ‘processed and purified municipal WW-based products have been used in the past, and are still legal to apply, but in practice they are not used anymore’. Actually, the demand for BBFs by farmers could only increase for BBFs from clean bio by-product streams, which do not even potentially contain pharmaceutical residuals, illicit drugs, pathogens and/or other contaminations.

The interviewed people in France are commercials/technicians not aware of the manufacturing processes of fertilisers they sell but they were working closely with farmers so they asked them questions about their point of view. A few additional information that came up during the interview: They are operating in the South-West region of France, around Toulouse and Bordeaux. They operate in a structure of product commercialisation. They sell either their own production of manufactured products or re-sell with trade from other companies. There are 3 technician-commercials and one regional coordinator, among other employees. They have contracts with the local authorities for the sludges. It is the same for green waste compost, function through public requests for proposals or via lease companies for WW treatment companies. The Charente-Maritime region is a big consumer of this kind of products. Some farmers are completely against, sometimes due to agri-bashing “urbans can keep their shit”, and a little percentage are open to it.

F6 is not involved in organic farming and does not have an animal husbandry on land. They are supplied fertilizers by fertiliser manufacturers and agricultural associations. They depend by 95% to 100% on fossil-based fertilisers for N.

AA3 has yet to be presented by fertiliser manufacturers the option of WW-based fertilising products. The farmers they work with are familiar with pig, cow or poultry manure and they do not have access to information about BBFs. They are open however to work with WW-based fertilising products, that they consider rich in N, as long as they comply with the regulatory framework and they are cheaper than inorganic fertilisers.

F7 who is not involved in organic farming and has an animal husbandry on land, uses primarily animal-metabolism products for fertilisation purposes and are based by 1/3 of their needs on fossil-based fertilisers F7 (1/4). They consider the analysis of soil composition to be quite expensive they have not had the soil quality tested by any certified organisation and have difficulty in addressing the problems regarding soil composition. F7 performs analysis on the manure they apply but not by a certified organisation. They also apply manure digestate on land.

F2 considers the fact that BBFs are products with different elements of quality: organic matter, several main nutrients (NP), micro-elements along with their local origin as the greatest benefits of their utilisation and they are open to continue the use of BBFs and also ask for more BBF options.



Price is the biggest challenge farmers face. F3 commented that transportation of WW-based fertilisers could be a trouble on the roads. F3 commented that they had no competition with local farmers regarding the utilisation of sludges. F3 was also concerned that the lack of science-based knowledge on the evaluation of the BBFs performance effect on soil quality and crop yield in greenhouses, could not be compensated for all the other countries by full field scale settings only in France. Moreover, crop yield variations associated with changes in fertilisation practices could be linked to back pay (wage violations to describe difference in sum between what the employee was paid and what he/she should have been paid).

The farmer in Hungary is involved in organic farming and also has an animal husbandry on land. They are supplied fertilisers by fertiliser manufacturers and they seem to take an interest in soil quantity (nutrients and organic content) for they have it tested by certified organisations and they have partnered with a consultant on soil enrichment. As they commented, they still highly depend on fossil-based fertilisers and Phosphorus in particular for the majority of soils are P deficient. They have not been presented by a fertiliser company or agricultural association the option of WW-based bio-fertiliser yet.

F6 in the benefits of BBFs' utilisation mentioned '*Less purchase of P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O allows better growth start for plants*'

F8 is not involved in organic farming and does not have an animal husbandry on land. They are supplied fertilizers by fertiliser manufacturers and agricultural associations. They depend by 95% to 100% on fossil-based fertilisers for N. They still depend on fossil-based fertilisers by 50 % and they plan to reduce further dependency on fossil-based fertilisers in the future. They use WW-based (urban WW and sewage sludge, agri - food and industrial WW and brine) Nutrient Recovery products as Bio-Based Fertilisers for arable land fertilisation. They import ammonium nitrate (from N extracted in Morocco and USA). According to F8, deviations from a preferred (commercially available fossil-based) fertilising product would need to be compensated by a 60 % decrease in the price to attract more BBF end-users.

#### 4.2.1 Barriers regarding the utilization of BBFs

Even though during the preparation of the survey that is presented in Table 4-21, the concern that in case a BBF application dosage is small (due to condensation), it would be perceived of low quality through the prism of its content in fertiliser components all farmers mentioned that they would check the content in nutrients and the directions for the BBF application. Furthermore, the deficiency in phosphorus seems to bridge the conflict between P as a resource in fertiliser production or as a pollutant.

F3 highlighted that other farmers are not even aware of BBFs.

In France, F2 highlighted the 'high presence of Chambres of Agriculture' and/or other cooperatives and the access to a lot of information from their network. Moreover, as F2 commented, the quality of life of the increasing number of urban people moving to the countryside could be affected by mal odour problems after spreading of WW-based fertilisers. The initial capital expenditure (CAPEX) of construction and equipment for BBFs' storage, handling and spreading is currently covered by local communities, in France.

AA2 and F4 were positive that farmers use what they reasonably access.

Regarding the survey statement: '*The quantity of BBFs is insufficient for fertilisation of larger portions of land*' it was concluded that for most BBFs that is correct. High nutrient density in BBFs is critically important as the KPI for economy and applicability. The high uncertainty and variations makes it highly risky and costly. The varying contamination is so complex, that regular analytics is costly, that producer cannot afford.

- The application of WW-based fertilisers is absolutely prohibited in crop cultivation/organic farming.
- WW-based fertilising products are a high risk storage material.

Regarding the survey statement: '*There is conflict between P as a resource in fertiliser production or as a pollutant*' it was concluded that this is a misconception. P in rapid solution fertilisers can be bounded to soil



Ca for long term. In laboratory soil sample all P can be easily extracted, but P in soil reality is not plant available for long term. So artificial lab results and soil field reality are 2 different issues.

F5 says that transport can be a problem as the products are loose, so space is needed to discharge the product instead of bags that are most commonly used. It has a big incidence on price, so usually the sales are local (regional). Moreover, they cannot be stored or spread near houses due to odour problems.

Furthermore, if the bio-based fertilising product is less concentrated this is not considered a problem, as long as it *'doesn't require to spread 10 tons instead of 2, for instance'*.

The dynamic is slowed down by fears of heavy metals, pharmaceutical and other kinds of residues in the organic matter. But as fertiliser manufacturer/commercial, they need to make up for their credibility so they guarantee certain homogeneity of products and quality. Some farmers analyse the products they offer.

Machinery can also be a hinder if the use of BBF requires new machinery, normally BBF products are highly dosed and in pellets.

The competition for BBF producers puts doubts on this type of products (concerns of quality for instance).

Table 4-21: Allocation of lock-ins and barriers regarding the utilization of BBFs.

	Agree	Partially agree	Neutral	Partially disagree	Disagree
<b>BBF application</b>					
Farmers prefer the use of traditional fossil-based rather than bio-based fertilisers because the application of latter involves more labor and is more expensive.	3,F6, F7, F8			AA1	AA2, F4
Collection/transport/distribution of BBFs is challenging.	F1,F3, F7, F8	F2, F6	AA1, AA2, F4		
The application of WW-based fertilisers is prohibited in crop cultivation/organic farming.	F3, AA2,F4, F6	F1, F8	F2, AA1		
Sales of the produced crops are destined only for export (i.e. less profit).		F8	AA1	2	F3, F6
Permission is needed by landowner to spread BBFs on hired farmland.		F8		AA1,F1, AA2,F4, F6	F2,F3
BBF utilization is a stigmatized practice involving negative feelings about it (Food industry concerned about reputation of brand).	F8	F6, F7		2, AA2,F4	F3, AA1
Fertilisation with BBFs is not popular in my area (excess manure from animal husbandry).		F2, F7	AA2, F4, F8	F1, AA1	F3, F6
Lack of follow-on support from consultants on innovative BBF application methods.	F3, F7		AA2, F4, F8	F1, AA1	F2, F6
Spreading of BBFs requires dry weather to allow driving through the arable land.	F1,F3, F6, F7		F2, AA2, F4, F8	AA1	
Lack of science-based knowledge on the evaluation of the BBFs performance effect on soil quality and crop yield in greenhouses and full field scale settings.	F3, F7	F8	F1, F8	AA1, AA2,F4	F2, F6
Crop yield variations associated with changes in fertilisation practices.	F3, AA2,F4	AA3	F1, AA1, F8		F2, F6, F7



Spreading of WW-based fertilisers leads to mal odor problems.	F3, AA2,F4, F7	2	F8	AA1, F6	
If a BBF application dosage is small (due to condensation), it is perceived of low quality through the prism of its content in fertiliser components.	AA2,F4		AA1, F8	F1, F6, F7	F2,F3
P in sludge is bound to soil; therefore, 5 years of waiting are needed for P release.	AA2,F4		F8	F1, AA1	F3, F6
Uncertain composition, quality and safety (contamination risks due to effluent composition) of BBFs.	F1, AA2,F4, F7	AA1	F3, F8	F2	F6
Cannot trust certification/authorization of BBFs - Risk of the presence of contaminants (i.e. microplastics, pharmaceutical residuals, etc.).	F1,F3, AA2,F4, F7	F8	AA1		F2, F6
Lack of storage space availability Complaints about odor from storage (and spreading)	F1,F3	AA1	F2		F6
<b>Policy framework implications</b>					
There has been no pressure so far for farmers to utilize BBFs.	F1,F3, AA2,F4, F6, F7	AA1, F8			F2
There is conflict between P as a resource in fertiliser production or as a pollutant.		F1, AA1, F6, F8			F2,F3, AA2, F4
<b>BBF market</b>					
The quantity of BBFs is insufficient for fertilisation of larger portions of land.	F2,F3, AA2,F4, F6, F8		F1, AA3	AA1	F7
Lack of promotion of BBF utilization (farmers' - agricultural associations' awareness) - No BBFs on the market.	F1,F3, AA2,F4, F7, F8	AA1	F6		F2
<b>Financial barriers</b>					
Initial capital expenditure (CAPEX) of construction and equipment for bio-based fertilisers storage, handling and spreading.	F1,F3, F8	F2		AA1, AA2,F4, F6	



### 4.2.1.1 Data assessment -conclusions

The responses of all BBF end-users interviewees (but F5) are presented in Table 4-21.

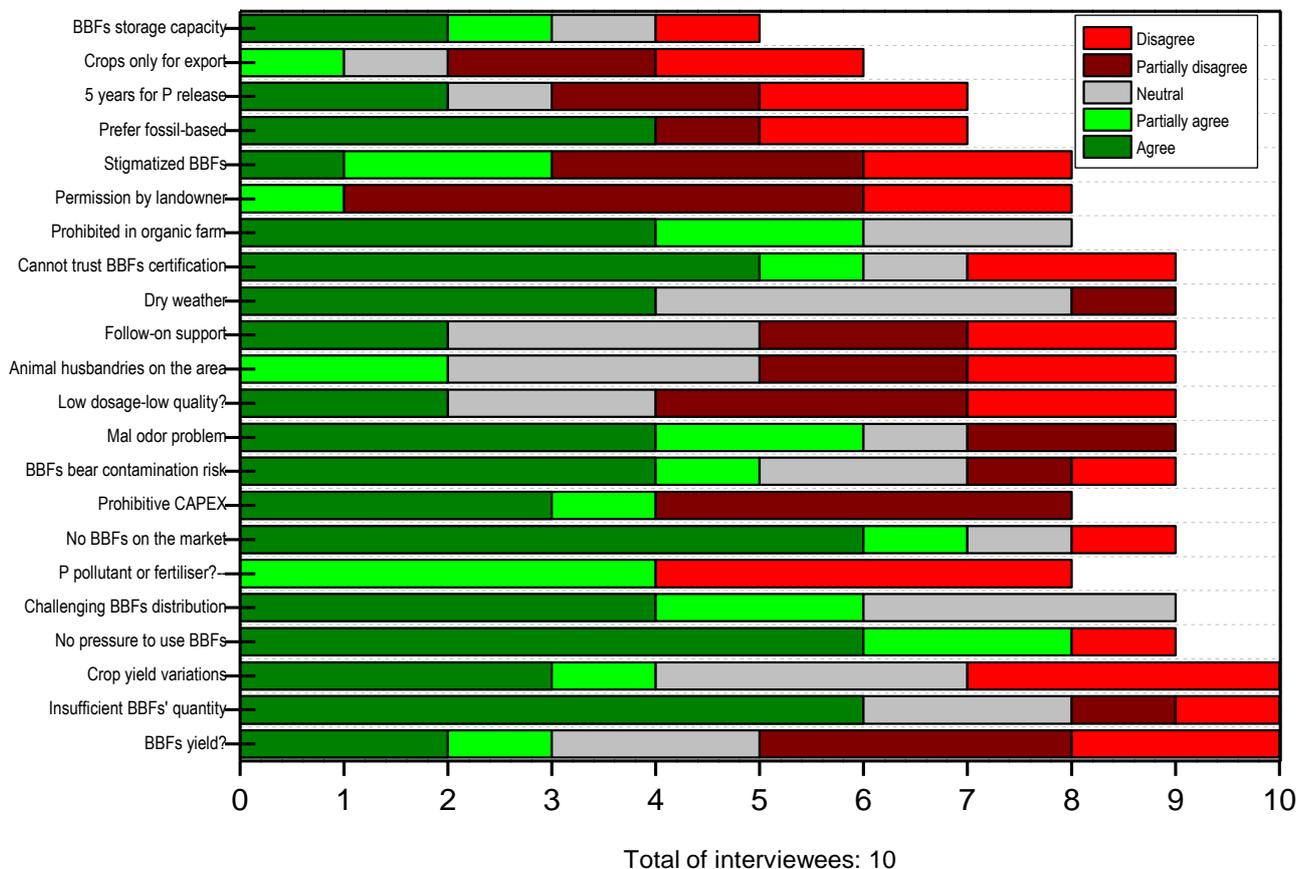


Figure 4-3: Allocation of lock-ins and barriers regarding the utilization of BBFs.

According to F3 experience, a farmer needs to check soil analyses first, ensure the origin of sludges, their quality, sees sometimes pesticides are not good, for synthetic N not always the % they say (eg 29% instead of 31).

All interviewees expressed their concern regarding the *'Lack of science-based knowledge on the evaluation of the BBFs performance effect on soil quality and crop yield in greenhouses and full field scale settings'* and *'Crop yield variations associated with changes in fertilisation practices'*. *'The quantity of BBFs is insufficient for fertilisation of larger portions of land'*. However, the expressed opinions do not lead to clear conclusions.

Lack of experience with BBFs handling is depicted by the agreement of 9/10 interviewees with the *'Collection/transport/distribution of BBFs is challenging'* statement and 4/9 with the *'Spreading of BBFs requires dry weather to allow driving through the arable land'* statement. 4/9 remained neutral and only one interviewee disagreed. Moreover, only 5 in 10 interviewees tried to evaluate the statement *'Lack of storage space availability. Complaints about odor from storage (and spreading)'*, with 3/5 agreeing, 1/5 remaining neutral and 1/5 disagreeing.

Only 2 out of 9 interviewees disagreed with the statements *'Uncertain composition, quality and safety (contamination risks due to effluent composition) of BBFs'* and *'Spreading of WW-based fertilisers leads to mal odor problems'*.

4 out of 9 interviewees disagreed with the statements that *'Fertilisation with BBFs is not popular in my area due to utilization of manure from close-by animal husbandries'*, *'Lack of follow-on support from consultants*



*on innovative BBF application methods* and *'If a BBF application dosage is small (due to condensation), it is perceived of low quality through the prism of its content in fertiliser components'*.

Unfortunately, 6 out of 9 interviewees agreed upon the statement that they *'Cannot trust certification/authorization of BBFs - Risk of the presence of contaminants (i.e. microplastics, pharmaceutical residuals, etc.)'* one remained neutral and only 2 disagreed.

6 out of 8 interviewees were aware of *'The application of WW-based fertilisers is prohibited in crop cultivation/organic farming'*. The other two remained neutral.

7 out of 8 interviewees stated that *'No Permission is needed by landowner to spread BBFs on hired farmland'*.

5 out of 8 disagreed with the statement that *'BBF utilization is a stigmatized practice involving negative feelings about it (Food industry concerned about reputation of brand)'*. The other 3 agreed.

4 out of 7 interviewees agreed with the statement *'Farmers prefer the use of traditional fossil-based rather than bio-based fertilisers because the application of latter involves more labor and is more expensive'*. The other 3 disagreed.

4 out of 7 interviewees disagreed with the statement that *'P in sludge is bound to soil; therefore, 5 years of waiting are needed for P release'*.

4 out of 6 interviewees disagreed with the statement that *'Sales of the produced crops are destined only for export (i.e. less profit)'*.

Regarding any Policy framework implications with the BBF market, 6 out of 9 interviewees agreed that *'There has been no pressure so far for farmers to utilize BBFs'*. This number has been verified by their agreement on the statement *'Lack of promotion of BBF utilization (farmers' - agricultural associations' awareness) - No BBFs on the market'*.

Regarding the statement that *'There is conflict between P as a resource in fertiliser production or as a pollutant'*, the conflict remains as 4/8 interviewees agreed and the rest 4 disagreed. The same trend prevailed regarding the statement *'Initial capital expenditure (CAPEX) of construction and equipment for bio-based fertilisers storage, handling and spreading is prohibitive'*.



## 4.2.2 Measures and motives for the application of BBFs

The proposed motives to end-users (and the evaluation by them) to apply Bio-based fertilisers for soil fertilisation are gathered in Table 4-22. All the proposed governmental measures to unlock the barriers for BBF utilization and their evaluation by end-users are presented in Table 4-23.

Table 4-22: Motives to end-users to apply Bio-based fertilisers for soil fertilisation.

	Agree	Neutral	Disagree
<b>Network support</b>			
Expert consultation to select the correct dosage (volume) of BBF in comparison to fossil-based/conventional.	F2, AA1, AA2,F4, F6, F7, F8	F1,F3	
Enactment of a network allowing farmers to identify other businesses from the rest of the WW treatment chain (recovered nutrients providers, other end-users) next to their land will minimize the cost of logistics.	F2,F3, F8	F1, AA1, AA2, F4, F6	
Cooperation with agricultural associations (open discussions, bonuses for product promotion) that have wide distribution will assist farmers' awareness.	F2,F3, AA1, AA2,F4, F7, F8	F1, F6	
<b>Environmental friendliness</b>			
Availability and effectiveness of techniques for measuring, monitoring and regulating contaminants.	F1,F2,AA2,F4, F7, F8	F3, AA1 F6	
<b>BBF application</b>			
Integration of the products into existing solutions.	F1, AA1,AA2,F4, F6, F7	F2,F3, F8	
The application of BBFs by farmers-competitors will be a motivating factor, reducing their price.	AA1,AA2,F4, F7	3, F8	F6

Table 4-23: Governmental measures to unlock the barriers for BBF utilization

Governmental measures to unlock the barriers for BBF utilization		Agree	Neutral	Disagree
i.	Obligation in the use of recovered nutrients first instead of mineral sources for fertilisation purposes. - Enactment of minimum amount of recovered nutrients in BBFs.	AA1,AA2,F4	F7, F8	3, F6
ii.	Confidence of public authorities regarding the conformity of the products (establishment of protocol).	F2,F3, AA1, AA2,F4, F6, F7	F1, F8	
iii.	Taxes in the use of mineral sources for fertilisers.	AA2,F4, F8		4, F6, F7
iv.	Tax benefits for using BBFs.	F3, AA1, AA2,F4, F6, F7, F8		F1,F2
v.	Direct helps - financial support in innovative Fertiliser Application Technologies for the utilization of economically prime important nutrient resource based products (CAPEX / OPEX).	F1,F3, AA2,F4, F7, F8	AA1	F2, F6



### 4.2.2.1 Data assessment - conclusions

When asked to what extent should deviations from a preferred traditional fossil-based fertilising product be compensated, the French farmer (F2) chose cheaper prices by 60 %, while AA1, AA2 and F4 chose 40 %. According to F7 any deviations from a preferred product would need to be compensated by 40-60 % lower price than the traditional fossil-based fertiliser. F5 commented that farmers are not ready to pay more for BBFs since they have their budget for fertilisation/ha (about 140-180 or 200-250 €/ha) and they will not change that. Regarding the WalNUT survey statement: ‘a network allowing farmers to identify other businesses from the rest of the WW treatment chain (recovered nutrients providers, other end-users) next to their land will minimize the cost of logistics’ they commented that there is already a network like that in Charente-Maritime. Besides that they were positive that this attempt could be intensified for other regions as well because:

- Society is much more open to BBF products, recycling, back to soil practices
- Farmers are not negative in buying foreign products (from Belgium, Spain).

End – users in Hungary commented ‘very important’ regarding the integration of the products into existing solutions.

In France, there is already a “fake tax” on the utilization of mineral fertilisers, N price increased by 3 times and P by 2 times with the increase of gas prices. F2 commented ‘Not a good solution at all!’ regarding taxes in the use of mineral sources for fertilisers. In some cases the responses of farmers in France, F1 and F3 (Table 4-23) are contradictory. In France, WW-based products do not undergo a so called ‘certification process’ rather a ‘market permit’ or ‘standardization or spreading plan’. F2 actually mentioned ‘We consider “certified” = standardisation or market permit’. Industrial WW (digestate), or industrial waste for example from food industry, slaughterhouses etc. are allowed to be used in France but F2 has yet to use them. In France, STRUvite, Biochar and Incineration ash are not allowed to be used as BBFs after treatment.



## 5 Interviews of technology providers

### 5.1 The profile of technology providers

The survey on technology providers concerns:

- i) the recovery of nutrients/pollutants from urban WW and sewage sludge, food, industrial WW and brine to be used as primary and secondary macro-nutrients or micro-nutrients for the manufacturing of BBFs

and

- ii) the valorisation of products deriving from the treatment of urban WW and sewage sludge, food, industrial WW and brine, as BBFs.

The target is to address the preconditions and factors that drive or hamper the deployment of NR options in WWT facilities and allocate the lock-ins and barriers in the performance technologies targeting Nutrient and economically prime important nutrient resource-based products recovery.

The list of technology providers that participated in the WalNUT survey is presented in Table 5-24.

Table 5-24: List of technology providers that participated in the WalNUT survey

ID	Country
TP1	United Kingdom
TP2	The Netherlands
TP3	Deutschland
TP4	Hungary
TP5	Belgium
TP6	France
TP7	Spain
TP8	Greece

### 5.2 Factors that hamper the deployment of NR options

The main obstacles in designing, developing and distributing NR technologies and the TPs that also consider them as obstacles are presented in Table 5-25. Nutrient density in BBFs is considered to be a Key performance indicator (KPI).

Table 5-25: Main obstacles in designing, developing and distributing NR technologies.

Design of NR practices (pilot scale)		
50 % of the interviewed TPs agree on barriers 1 and 2	1. Not consistent influent composition can affect NR process' yield. (TP4 TP5 TP6 TP8)/8	2. Low concentration of nutrients affects the yield → intensified work/research towards the optimization of the process. (TP5 TP6 TP7 TP8)/8
37.5 % of the interviewed TPs agree on barriers 3 and 4	3. Lack of funds by EU/government/private sector/companies (WW producers, WWTP) for intensive research on process optimization.	4. A pre-treatment step necessary in order to concentrate the influent, to increase yield, which increases the CAPEX/OPEX. (TP4 TP6 TP5)/8



	(TP2 TP6 TP8)/8	
25 % of the interviewed TPs agree on barriers 5 and 6	5. A post-treatment step needed to be included in NR units to ensure the quality and safety of recovered nutrients. (TP4 TP6)/8	6. Testing the agronomic performance of BBFs is a difficult task: finding a testing crop, producing enough fertiliser, others_____ (TP4 TP8)/8
<b>BBF composition</b>		
50 % of the interviewed TPs agree on barrier 7	7. Low concentration of nutrients in WW (in/effluents) can make NR uneconomical. E.g. Low N concentrations of only 30 mg per litre NH <sub>4</sub> -N in average Dutch wastewater may make NH <sub>4</sub> recovery uneconomical (TP4 TP5 TP6 TP8)/8	

<b>Recovered nutrients</b>		
62.5 % of the interviewed TPs agree on barrier 8	8. There is limited accessible commercialization pathway/market for nutrient recovery products. There is no demand from fertiliser manufacturers, agricultural associations and farmers for recovered nutrients from the valorisation of WW streams due to complexity of utilization (TP3 TP4 TP5 TP7 TP8)/8	
50 % of the interviewed TPs agree on barrier 9	9. There is no demand from fertiliser manufacturers, agricultural associations and farmers for recovered nutrients from the valorisation of WW streams due to complexity of utilization. TP4 TP6 TP7 TP8 /8	
37.5 % of the interviewed TPs agree on barrier 10	10. Lack of awareness of the Circular Economy concept of the valorisation of WW - Lack of social acceptance of utilization of recovered nutrients & implementation of NR practices. TP4 TP6 TP7/8	
x	11. WW composition affects the quality and the safety of Recovered Nutrients (Contamination risk due to PTEs, PAHs, pharmaceutical residuals, microbiological pathogens) - transfer to food chain) and their marketability.	
<b>Upscaling of NR practices</b>		
50 % of the interviewed TPs agree on barrier 12	12. Certain types of industries (i.e. paper industry) are not interested in NR practices due to their influent composition (low nutrient concentration, fluctuations in supply, presence of contaminants). TP4 TP5 TP6 TP8 /8	
37.5 % of the interviewed TPs agree on barriers 13 and 14	13. Lack of interest from WW producers for NR practices: WW producers prefer disposing of the effluents after meeting the legal disposal limits, as an established practice, instead of investing in research projects by technology providers for NR practices that will ultimately get them their	14. If NR is not law enforced there will not be interest from WWTP and WW producers for NR practices. TP6 TP7 TP8 /8



	investment money back in terms of 'circular economy by valorisation of nutrient rich products' . TP1 TP2 TP8 /8	
12.5 % of the interviewed TPs agree on barrier 15	15. NR Technologies need technological assistance (training-high level of operator attention-expertise & follow -on operational support). TP4 /8	

<b>Financial barriers in up-scaling</b>		
62.5 % of the interviewed TPs agree on barrier 16	16. Lack of direct helps - financial support of WW producers and WWTP in innovative Nutrient Recovery/BBF manufacturing practices for the utilization of economically prime important nutrient resource-based products (CAPEX / OPEX). TP3 TP4 TP6 TP7 TP8 /8	
37.5 % of the interviewed TPs agree on barriers 17 and 18	17. Lack of funds by EU / national government. TP1 TP3 TP8 /8	18. Lack of funds by private sector / companies (WW producers, WW Treatment Plants) for intensive research on process optimization. (TP3 TP5 TP8 /8)
25 % of the interviewed TPs agree on barriers 19 and 20	19. Initial capital expenditure (CAPEX) of construction and equipment for advanced equipment. TP6 TP8 /8	20. Prohibitive Whole Life Cost (WLC, CAPEX + (Annual OPEX x 14) of Nutrient recovery Technologies for a life span of 40 years). TP6 TP8 /8
12.5 % of the interviewed TPs agree on barrier 21	21. Not sustainable extra total operational expenditure (OPEX) (maintenance costs (2.5 % of CAPEX) – power/energy consumption costs – chemical/consumables costs – labor costs – treatment and disposal costs). TP6 /8	

<b>Difficulties in the commercialization of NR practices</b>		
75 % of the interviewed TPs agree on barrier 22	22. While exiting recovered product sale price does not make the NR process economically feasible, price of recovered nutrients is considerably higher than price of fossil-based fertilisers. TP2 TP3 TP4 TP5 TP6 TP8 /8	
62.5 % of the interviewed TPs agree on barrier 23	23. If recovered nutrients are not used on-site, distribution and transport have to be organized (geographical and temporal discrepancies between supply and demand, lack of infrastructure TP4 TP5 TP6 TP8 TP7 /8 (TP5 disagrees on the lack of infrastructure as a barrier).	
25 % of the interviewed TPs agree on barriers 24 and 25	24. Not fast returning of investment to make the NR practice profitable. TP6 TP8 /8	25. Lack of awareness of the Circular Economy concept of the valorisation of WW. TP2 TP8 /8
12.5 % of the interviewed TPs agree on barrier 26	26. After-sales support / Service support is necessary. TP5 /8	



<b>Random factors</b>	
25 % of the interviewed TPs agree on barrier 27	27. Extra space requirements to install a NR unit. TP5 TP8 /8
12.5 % of the interviewed TPs agree on barrier 28	28. Shock and peak WW loads can upset NR process. TP6 /8

### 5.2.1 Data assessment - conclusions

Lack of funds by EU/government/private sector/companies (WW producers, WWTP) for intensive research on process optimization seems to be a constraint preoccupying the majority of TPs.

Moreover, attention must be paid so that they do not have a reduced C balance. Testing the agronomic performance of BBFs is actually not a difficult task rather a long and complicated one to implement these days. It is needed to put forward added value distinct from sole fertiliser: biocontrol products, biostimulant products; effects on the root development, on the rapidity of microbial development in the soil, on the fauna, growth improver, aerial biomass, rhizosphere. Trials must be done in the laboratories on plants, to follow the weight of roots and they are very expensive processes.

Regarding BBF composition, TP6 added that acceptability of people using the products: ‘not ready to pay for these products, depends a lot on regions. A lot of weight is put on what neighbouring farmers are doing’.

TP5 agreed that low concentration of nutrients can result in process unfeasibility, while TP6 explained that it depends on the price which would be the problem were it required to spread a fertiliser more times than usual.

TP5 did not agree that WW composition affects the quality and the safety of Recovered Nutrients. Regarding struvite, they commented that only a few heavy metals interfere with the process and their concentration needs to be considerably high to affect the quality. TP6 agreed with them mentioning that the challenges are different: ‘It is a matter of sanitary, homogenous stable products over time’.

Even though 5 of the 8 interviewed TPs agreed that there is a limited accessible commercialisation pathway/market for nutrient recovery products, TP6 partly disagrees mentioning: ‘It is a small market with a few major distributors, but there are still spots to take’. They also commented that the lack of awareness of the Circular Economy concept of the valorisation of WW and the lack of social acceptance of utilisation of recovered nutrients & implementation of NR practices are major problems. They agreed that there is no demand from fertiliser manufacturers, agricultural associations and farmers for recovered nutrients from the valorisation of WW streams due to complexity of utilization and added that this is the reason why concentrated dried pellets are the most popular fertilising product. TP6 disagreed with the statement that there is lack of interest from WW producers for NR practices and added regarding the statement that ‘Certain types of industries (i.e. paper industry) are not interested in NR practices due to their influent composition (low nutrient concentration, fluctuations in supply, presence of contaminants)’ the example of coagulants that are not very beneficial for the plants.

TP5 commented that they have designed bench/lab scale innovative NR processes but cannot find financial support for up-scaling agreeing with TP1 and TP3.

TP6 added that the initial capital expenditure (CAPEX) of construction and equipment for advanced equipment is a barrier, especially at the conceiving phase. It is difficult to take into account from the very start the Whole Life Cost (WLC, CAPEX + (Annual OPEX x 14) of Nutrient recovery Technologies for a life span of 40 years). Moreover, the return on investment needs to be fast. Currently, the return of investment to make the NR practice profitable is over 5 to 7 years. TP6 commented that they have designed bench/lab scale innovative NR processes but cannot find financial support for up-scaling. Lastly, as TP6 commented, microalgae in WW treatment could be interesting, especially for biostimulant effects. It could be a good way to sell the product at a higher price; the aim is to increase the added value in order to increase the research efforts.



None of the interviewees selected the statement 'WW composition affects the quality and the safety of Recovered Nutrients (Contamination risk due to PTEs, PAHs, pharmaceutical residuals, microbiological pathogens) - transfer to food chain) and their marketability' as an obstacle in NR deployment which indicates that they have faith in the validity of the certification procedures.

To conclude with, currently, (March 2023) 75 % of the interviewed TPs agree that while exiting recovered product sale price does not make the NR process economically feasible, price of recovered nutrients is considerably higher than price of fossil-based fertilisers.

62.5 % of the interviewed TPs agree that there is limited accessible commercialization pathway/market for nutrient recovery products and that there is no demand from fertiliser manufacturers, agricultural associations and farmers for recovered nutrients from the valorisation of WW streams due to complexity of utilization. They also agreed that if recovered nutrients are not used on-site, distribution and transport have to be organized (geographical and temporal discrepancies between supply and demand, lack of infrastructure. 62.5 % of the interviewed TPs agreed on the lack of direct helps - financial support of WW producers and WWTP in innovative Nutrient Recovery/BBF manufacturing practices for the utilization of economically prime important nutrient resource-based products (CAPEX / OPEX) as barriers for NR practice.

50 % of the interviewed TPs agree on

- Not consistent influent composition can affect NR process' yield
- Certain types of industries (i.e. paper industry) are not interested in NR practices due to their influent composition (low nutrient concentration, fluctuations in supply, presence of contaminants)
- There is no demand from fertiliser manufacturers, agricultural associations and farmers for recovered nutrients from the valorisation of WW streams due to complexity of utilization
- Low concentration of nutrients affects the yield → intensified work/research towards the optimization of the process
- Low concentration of nutrients in WW (in/effluents) can make NR uneconomical. E.g. Low N concentrations of only 30 mg per litre  $\text{NH}_4\text{-N}$  in average Dutch wastewater may make  $\text{NH}_4$  recovery uneconomical

as barriers for the practice of nutrients' recovery.



### 5.3 Factors that drive the deployment of NR options

The motives for technology providers to get involved in NR and their attitude towards them are presented in Table 5-26.

Table 5-26: Motives for technology providers in NR involvement

	Agree	Neutral	Disagree
i. Direct help - financial support in scaling-up innovative NR Technologies (CAPEX / OPEX).	TP2, TP3,TP4, TP5 TP6 TP8	TP2	TP7
ii. Easily patented custom-designed NR options.	TP4, TP5 TP8	TP2	TP3, TP6 TP7
iii. Economies of scale in the scaling -up from the expanded clientele in case of NR-law enforcement.	TP2, TP3,TP4 TP5 TP6 TP7 TP8		
iv. WWTP – institutes interaction - Incorporation of market-leading NR technologies in the educational curriculum, (MSc programs) for expertise in WWT specialties.	TP4 TP5 TP8	TP2, TP3, TP7	
v. A network allowing close cooperation of technology providers on NR know-how with WW stream owners and WWTP (open discussions, bonuses for technology promotion, etc.).	TP1 TP4 TP5 TP6 TP8	TP2, TP7	
vi. Simultaneous treatment of many same WW streams clients' is necessary.	TP4, TP7 TP8	TP1	TP2, TP5
<b>Direct governmental measures to increase the demand for NR solutions, for technology providers to increase supply and profit</b>			
i. Circular Economy Regulation: Obligation to NR regardless the nutrient content from all WW streams.	TP1 TP4, TP5 TP6 TP7 TP8	TP2	
ii. Tax benefits for industries when applying NR options in their WW streams.	TP2 TP4 TP3 TP6 TP7 TP8	TP1	TP5
<b>Indirect governmental measures to increase the demand for NR solutions, for technology providers to increase supply and profit</b>			
i. Increasing in the confidence towards public authorities with the establishment of protocols for the certification of Recovered Nutrients.	TP1 TP4 TP5 TP6 TP7 TP8	TP2	
ii. Tax in the use of fossil-based sources for fertilisers.	TP3 TP4 TP5 TP6 TP8 TP7	TP1, TP2	

#### 5.3.1 Data assessment - conclusions

The level of agreement of the interviewed TPs with the proposed measures to promote the practice of NR has been visualised in the graph presented in Figure 5-4



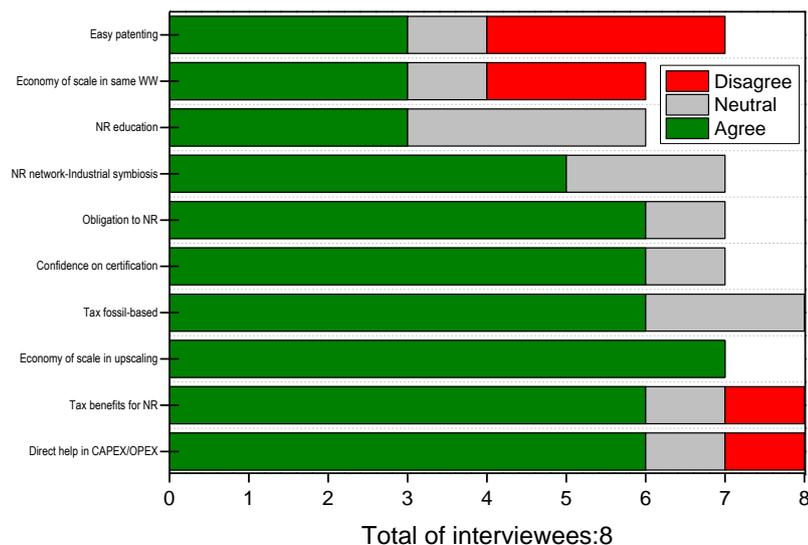


Figure 5-4: Factors that drive the deployment of NR options (Total of interviewees: 8)

All 7 interviewees agreed that the economies of scale in the scaling –up from the expanded clientele in the case of NR-law enforcement would be highly beneficial for the development and expansion of a nutrient recovery conscience. Quite interestingly, all of the interviewees responded on the evaluation of direct help and tax benefits for the application of NR with 75 % agreeing on them. The proposed measures:

- i. Easily patented custom-designed NR options.
- ii. WWTP – institutes interaction - Incorporation of market-leading NR technologies in the educational curriculum, (MSc programs) for expertise in WWT specialties and
- iii. Simultaneous treatment of many same WW streams clients' is necessary

were received with some scepticism by the interviewees who responded to the survey.

In the Nutrient Recovery processes, the nutrient concentration's operation costs depend on the respective yield and risk the system's economic feasibility. The market price of the recovered materials, along with the economic benefits from the Nutrient Recovery processes should be enough to cover the operational costs.

To conclude with, the problem around NR development is not a technological problem. NR Technologies do not always need technological assistance (training-high level of operator attention-expertise & follow –on operational support) and once the process is working there is no need for monitoring more than any other process. A pre-treatment step is not always needed. It depends on the type of stream. It also depends on the degree of inconsistency of an influent's composition whether it would affect the NR process' yield, since within a range it is ok. After-sales support / Service support as well as extra space requirements to install a NR unit are not always necessary. The objective is to manufacture complemented NPK turnkey products, while knowing that farmers are saturated and not willing to pay more. Moreover, patents are developed but need industries to back them up. To get them into innovative projects they need to see a value for money in it, need to believe in the project. Last but not least, while exiting recovered product sale price does not make the NR process economically feasible and the price of recovered nutrients is considerably higher than the price of fossil-based fertilisers, all the changes regarding Life-cycle analysis, climate change, storage, carbon and recycling should be taken into account.



## 6 Conclusions

### 6.1 Regarding the spread of Nutrient Recovery awareness

- The dependence on import of mineral fertilisers and the price of mineral fertilisers makes the independence for nutrient a necessity, in the after COVID-19 era.
- The communication around WWTP, NR and BBFs is ever more positive. This is quite promising regarding the fact that demand has always been stronger than supply.
- The communication discourse of those at the beginning of the value chain (i.e. WWTP) is not so beneficial to BBF products because only the nutritive properties of WW products and not their soil-enhancing properties are discussed, which does not serve the credibility of the process.
- The development of BBF products will depend on the communication to the larger society. Since it should be preferable to employ nutrient-resource-based goods from the UWWTP than primary matter from other European nations or the rest of the world, the EU27 should retain a positive attitude toward the openness and strength of the market for this sort of valorisation. Therefore, it is crucial to fund research projects that will transform the perception of waste material into primary matter.
- Consumer information/education on nutrients from NR practices, is crucial to create demand. (NR awareness (recognition of mineral resources depletion/scarcity, P, Mg as Critical Raw materials) to motivate the engagement with circular economy concept for WW valorisation)

### 6.2 Regarding the target of D1.4: ‘report the identified preconditions and factors that drive or hamper the deployment of Nutrient Recovery options in WW Treatment facilities’.

According to the quantitative and qualitative analysis of the presented data in

Table 3-13, the barrier that most WWP and WWTP face (35.7 %) is the ‘*Limited accessible commercialization pathway/market of recovered nutrients*’. The second most important barrier (28.6 %) with at least one representative from WWP, IWWTP and UWWTP agreed on is the ‘*Total operational expenditure (OPEX) (i.e. maintenance costs (2.5 % of CAPEX) – power/energy consumption costs – chemical/consumables costs – labour costs – treatment and disposal costs)*’. At least one UWWTP also agreed with WWP on the following three barriers:

1. *Questionable quality and safety of Recovered Nutrients (Contamination risks due to effluent composition)(PTEs, PAHs, pharmaceutical residuals, microbiological pathogens) - transfer to food chain).*
2. *Initial capital expenditure (CAPEX) of construction and equipment for advanced WW Treatment Technologies (Nutrient recovery).*
3. *Different nutrient reuse standards, which is the primary cost driver, in every Member States.*

All WWP (28.6 % of the total interviewees) agreed on

1. ‘*Unawareness of regulatory updates framework of nutrient recovery*’ and
2. ‘*Unaware of future restrictions on mineral fertilisers utilisation*’

Since indeed currently (March 2023) there is no forthcoming future restriction on mineral fertilisers utilization it seems that this would be a ‘convincing’ measure to apply at the altar of nutrient recovery practice.

One of the main challenges is about to become the homogenous implementation on regional level of the European policies. Although farmers from France commented that the ownership of nutrients in WW streams after they have been recovered in the WWTP (or unit) should not be considered as a limitation in practicing NR, UWWTP10 asked for clarifications regarding which part is responsible for the quality of the final NR-based product, which would also solve the case of questionable quality and safety of recovered nutrients



(contamination risks due to effluent composition). Another preoccupation that was highlighted by both a WWP (WWP3) and an UWWTP (UWWTP10) is to eliminate the perception that a WWTP is nothing but a waste processing/producing company and that 'WW should be defined as a (possible) resource, not as waste', as UWWTP10 commented. This involves overcoming the low end-user awareness/acceptance for the application of nutrients from NR practices as well as handling the new line of products in the portfolio (certification, marketing, etc.) which is linked to the clarification of who the responsible for the quality of these products is.

In Italy, the barriers that have drawn the most attention are:

- the impossibility to classify the products from nutrient recovery within the Italian law
- the considerations regarding the production costs,
- the included quality risks, and
- the expectedly small productions to play a significant role in the market.

Last but not least, the development of decentralised WW treatment for nutrient recovery can greatly reduce CAPEX and OPEX. (ex. Placing small treatment plants at the point of need (WW producer), CAPEX can be cut by as much as two-thirds, and OPEX can be reduced, too – all with no sacrifice in quality of treatment.)

### 6.3 Regarding the target of D1.4: 'allocation of the lock-ins and barriers in the performance technologies targeting the synthesis of Bio-based fertilisers'

At the process design level, the appropriate decisions must be made to lower process costs, recover products that are safe and ecologically friendly, or guarantee that recovered materials meet quality standards.

It takes managerial choices outside the purview of technical process design to remove bottlenecks in the distribution and transport of recovered resources, as well as to identify applications and utilisation options.

The volumes of recovered resources may be constrained by technical process factors, such as process yields, or by the fact that the wastewater stream contains only small quantities of a resource. When this is acknowledged, it may still be possible to increase the output of a resource by incorporating other waste streams into the recovery process.

In summary, the issue with NR development is not a technical one. Technology support for NR Technologies is not always required (training, a high degree of operator focus, competence, and follow-up operational support), and once a process is operational, monitoring is not any more necessary than for other processes. Sometimes a pre-treatment procedure is not required. The kind of stream determines this. The yield of the NR process also depends on how inconsistently the influent's composition is distributed, since this is acceptable within a certain range. It's not always required to use additional space for installation of an NR unit or to provide after-sales maintenance or service support.

As farmers are saturate and unwilling to pay more, the goal is to manufacture complementing NPK turnkey goods. Moreover, patents are created but require support from industries. They must understand the value in investing in innovative ideas and have faith in them in order to do so. Last but not least, even though the cost of recovered nutrients is significantly higher than the cost of fossil-based fertilizers and the current sale price of recovered products does not make the NR process economically viable, all changes related to life-cycle analysis, climate change, storage, carbon, and recycling should be taken into consideration.

### 6.4 Regarding the target of D1.4: 'allocation of the lock-ins and barriers that hamper the final use of Bio-Based fertilisers'

It seems than the notion that farmers have the final word in creating the demand for BBF is verified in the context of D1.4.



To begin with, farmers consider the analysis of soil composition to be quite expensive or they have not had the soil quality tested by any certified organisation and have difficulty in addressing the problems regarding soil composition.

Regardless the long list of benefits of BBFs over conventional fossil-based fertilisers, the primary criterion for BBF utilization by farmers is the achievement of a competitive price in comparison to conventional fertilisers', and the obligation/duty/willingness to comply with global requirements and with the environment.

The main preoccupation of end-users is regarding the replacement of commercially available synthetic mineral fertilisers with BBFs. They are concerned about experiencing crop yield reductions. They have also expressed the need of support regarding matters of BBF dosage to reach better yields.

End-users are also preoccupied with the applicability of BBFs in organic farming.

NR products should be compatible with their manufacturing processes. As an example, a BBF in liquid form could not be applied on field since farmers only have the equipment to process pellets

All farmers mentioned that they would check the content in nutrients and the instructions for the BBF application, even though it was a concern raised during the preparation of the end-users' survey that if a BBF application dosage is small (due to condensation), it would be perceived as being of low quality through the lens of its content in fertiliser components. The quality of life of the increasing number of urban people moving to the countryside could be affected by mal odour problems after spreading of WW-based fertilisers

BBFs based on nutrients recovered from WWT are essentially sewage sludge (especially in France) – applied directly in the fields as part of a spreading plan established according to the environmental code – and compost made of sludge mixed with green waste. The portion of France's useable agricultural area that is currently spread out with these goods is less than 3%.

The demand for organic matter has been increasing over the past fifteen years and some farmers are convinced of the beneficial effects of using BBFs. This is the situation with the farmers who took part in the WalNUT surveys. BBFs still do not, however, currently enjoy a positive reputation among many French farmers. They dread the existence of heavy metals, pharmaceutical residues, and any other kind of harmful residue, so they pay close attention to the hygienic quality of these items, which are regarded as garbage from an administrative point of view. They pay close attention to the product's quality/benefit ratio, but they are also somewhat dubious of the marketing and communication tactics used by for-profit businesses. Some even analyse them themselves. Problems related to odours and storage can be a real obstacle to the use of these materials. Finally, some farmers consider the spreading of sludge as an offense from the urban sphere.

Farmers are generally unwilling to pay for these materials, regardless of whether they are in favor of employing BBFs based on nutrients recovered through wastewater treatment. It would be important to demonstrate that using BBFs has major benefits beyond fertilization, such as bio-control or soil stimulation, in order to successfully commercialize new BBFs. The use of these goods may have various effects on how work is organized (in terms of storage/spreading) depending on the kind of BBFs that farmers will have access to in the future. The potentially lower concentration of nutrients in BBFs is not a hindrance as long as the changes in practices imposed are not excessive, hence the desire to mostly keep concentrated, dried pellets. Farmers remain open to experimenting with innovative products based on the recovery of nutrients from wastewater treatment, as long as the product is promising and authorised by the administration. In some cases, the lack of confidence in conformity assessment or product certification could be a barrier to the use of innovative BBF products. For some farmers, the origin of the materials used (i.e., foreign products) could be a hindrance. Usually, sewage sludge and sludge composts are spread locally, sometimes up to a few hundred kilometers. Overall, most farmers reject the idea of being compelled to use of BBFs based on nutrients recovered from wastewater treatment over traditional conventional fertilisers. Since the first criterion for using a certain type of fertiliser remains the price, conjectural events affecting the price for mineral nitrogen fertilisers could be favourable for the use of these BBFs, for example the current situation of rising prices for mineral nitrogen fertilisers due to the war in Ukraine. In any case, any financial incentive to use such products should at least



cover the cost of conventional mineral fertilisers. The role of cooperatives and trader businesses remains very important for the development of the BBF market in the whole Europe.

To conclude with, all interviewed FMs do not have negative a priori thoughts but they all supported that if WW-based fertilising products are not compatible with their existing manufacturing processes (to this date, they manufacture composts and pellets); they question whether it will be possible to produce BBFs.

## 6.5 Regarding the supply-demand of Bio-based fertilisers

- Until recently (March 2022), in high livestock density European regions (e.g. in Denmark, in Belgium (Flanders), in France (Brittany), in Italy (Po Valley), in Spain (Catalonia)), **the demand in BBFs was scarce due to the abundance in animal metabolism - based fertilisation products**. These regions were (and remain) high risk for water bodies' pollution (eutrophication) due to on-farm N and P surpluses. Currently (March 2023), **the price of fertilisers has highly increased**. Therefore, the demand for fertiliser alternatives has also increased. It is no longer economical to utilize phosphate rock and industrial ammonium for fertiliser manufacturing rather than struvite or calcium phosphate precipitates as supplementary fertiliser in agriculture or as the raw materials, respectively. Unfortunately, economic incentives for nutrient recovery remain scarce.
- The directly identified barriers regarding the valorisation of bio-based input streams concern the low nutrient concentration that affects Nutrient Recovery technology's yield, and the presence of contaminants (heavy metals, organic micro pollutants, potentially toxic elements, poly aromatic hydrocarbons, pharmaceutical residuals, hormones, illicit drugs, microbiological pathogens etc.). Effective handling of **farmers' skepticism** towards monitoring/controlling/restricting such residual substances, whose **accumulation to the soil can contaminate the food crops and enter the food chain**, through BBFs, will increase their liability in public organizations for BBF certification. The European Commission has made a breakthrough towards this end with the final application of Reg. (EU) 2019/1009, which entered into force on July 16<sup>th</sup>, 2022.
- Supply for BBFs can be created, by:
  - raising Nutrient Recovery and ore depletion awareness;
  - WW producers' initiatives to not manage bio-based input streams and economically prime important nutrient resource-based products indiscriminately;
  - the close-cooperation of WW treatment plants with technology providers to develop innovative, high yield (adapted to the low nutrient content in input streams), low OPEX, economically feasible and sustainable Nutrient Recovery technologies;
  - the involvement of policy makers in stricter effluent disposal limits and
  - the reliable certification of BBFs.

## 6.6 Regarding the waste water value chain symbiosis

- Implementing WW-based fertilisers successfully will require fertiliser manufacturers to extend their engineering expertise and to become market participants actively engaged with all aspects relevant to farmers.
- Implementing WW-based fertilisers successfully will require technology providers to extend their engineering expertise and to become market participants actively engaged with all aspects relevant to the creation of value chains for recovered nutrients, without losing sight of their primary focus on treating wastewater to meet legal effluent standards.
- Early consideration in the planning phase of NR-oriented wastewater treatment processes is crucial to increase any chance of developing successful NR routes.



- Close cooperation of WWTP with technology providers is crucial for WWTP to have any influence over the design of a NR process that meets all these requirements, since they both traditionally possess substantial expertise in process engineering and operations.
- Joining forces to apply a common NR strategy across multiple WWTPs and thus exploit economies of scale – could well enhance economic competitiveness.
- Though it is more difficult to leverage positive change at this level, all WalNUT stakeholders can develop strategies to convince policy makers or users about the necessity or harmlessness of BBFs.



## 7 References

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## 8 Annex I

### 8.1 Interviews of Policy makers

#### 8.1.1 Policy makers

Decision-making persists to be fragmented in local or national governments, as highlighted in WalNUT – D6.1. Most nations still do not have regulations requiring recovery of nutrients and/or other sources or providing subsidies.

In WalNUT's contribution in bridging the gap between WW Producers and policy makers, along with the rest of the actors amongst them, each interviewee were asked to comment on mutual territory questions with policy makers. WW producers in particular were asked to specify any obstacles they experienced during/because of/in order to apply nutrient recovery due to complexity and/or frequent updates of policies (e.g. recycling is mostly governed by fragmented decision-making in regional administrations).

In Spain, WWP1 responded that their difficulty focused on non-homogenized End-of-Waste criteria in Europe and the compliance of Spanish End-of-Waste criteria with the European ones.

The survey regarding the evaluation of the proposed motives/measures by policy makers for the implementation of Nutrient Recovery practices per actor is presented in Table 8-27.

Unfortunately, it was not possible to interview policy makers. They avoided responding due to the transitional state of the European future, given that energy prices have raised by 700 %, fertiliser import has fully stopped.



Table 8-27: Evaluation of the proposed motives/measures for the implementation of Nutrient Recovery practices per actor

	This has been successfully implemented (What are the barriers that had to be overcome?)	There is a MS plan towards this direction (What?)	An attempt has already been made to implement and failed (How?)	This measure is not feasible (Why?)
<b>WW producers</b>				
Direct help - financial assistance into scaling-up innovative <b>NR</b> Technologies investment (CAPEX / OPEX).				
Strategy development for long-term supply stability.				
<b>WW aggregators</b>				
Financial support for the implementation of <b>NR</b> practices, that requires a high technological and capital investment.				
If several WW treatment plants/units recover the same nutrient, value-chain development could be facilitated by acting as one supplier of the recovered nutrient, thus increasing their collective market power.				
<b>Technology providers</b>				
Strategy development for coordination of Network and Research.				
Academia-End-users-Industry involvement and coordination to ensure scientific collaboration, to promote NR approaches and technologies and to avoid duplication.				
Strategy development to speed-up innovation-product development and implementation of new technologies.				
Research support (funding, pilot projects) ( <b>NR</b> technologies, analysis, understanding and risk assessment of contaminants in recovered nutrients' utilization).				
<b>WW-based Bio-Fertilisers End-users: Fertiliser manufacturers – Agricultural associations – Farmers</b>				
Minimum content of Recovered Nutrients in blend and dosages.				
Consumer information/education on nutrients from NR practices, to create demand. (NR awareness (recognition of mineral resources depletion/scarcity, P, Mg as Critical Raw materials) to motivate the engagement with circular economy concept for WW valorisation)				
Strategy development for long-term fertiliser security - Enactment of fertiliser compliance / certification entities. (Establishment of protocols (monitor/avoid contaminants) to increase WW-based BBF consumer liability to increase demand in nutrients from NR practices)				
Development of a farmer's rewarding system (e.g. tax exemption) for application of WW-based BBF in EU-27 soil.				



Involvement of non-governmental organisations.				
Development of a nutrient management-transportation network (Link farms with nutrient crop needs with neighboring <b>NR</b> operation sites)				
Assist farmers in addressing soil amendment needs				
Financial support of logistical issues (transportation from NR source to BBF market)				
<b>Policy makers</b>				
Enactment of Circular Economy Regulation: Obligation to recover nutrients from WW streams.				
Enactment of Circular Economy Regulation: Obligation to fertiliser manufacturing companies to include certain amount of WW recovered nutrients to recover nutrients from WW streams.				
Job creation in the NR/WWT circle.				
Obligation in the use of Recovered Nutrients first instead of mineral.				
Tax on the use of non-renewable sources for fertilisers.				
Enactment of stricter WW disposal criteria will increase the number of WW treatment facilities to then upgrade to <b>NR</b> practices.				



## 8.2 Interview of Industrial WW Producers

### Contact details of the interviewer

Country	
Partner	

### Contact details of the interviewee

Can we contact you in order to register in the WalNUT platform?

(In this platform, urban and industrial WW streams will be tracked and traced from their production, to their collection, treatment and valorization as fertilizing products)

YES

NO

If yes, please fill-in your contact details:

Company Name	
Address	
Email/Site	
Phone number	
LinkedIn (company/personal)	
Company Capacity	1-10, 11-50, 50-100, 100-200 personnel

Unless stated otherwise, please highlight the text that best describes your answer or mark with an 'X'.



8.2.1 Part A

Purpose of Part A: Mapping of the bio-based waste water streams produced by European industries and their valorization status

What is the NACE code of your company?

What <u>EWC</u> best describes the produced waste water streams (the influent for the WW treatment plant/unit) (*even the first 4 digits)?		Physical/chemical parameters of the WW streams (*a qualitative approach to available information (Toxicity <sub>ISO 6341:2013</sub> , Electrical conductivity, Soluble sodium percentage, COD, BOD, TOC, etc.))	Content in nutrients/pollutants (composition (N, P, K, Ca, Mg, concentration (mg/l))
Influent 1	EWC <sub>1</sub> :		
Influent 2	EWC <sub>2</sub> :		
Influent 3	EWC <sub>3</sub> :		
Influent 4	EWC <sub>4</sub> :		
Influent 5	EWC <sub>5</sub> :		
Influent 6	EWC <sub>6</sub> :		

Which option best describes the Waste Water Treatment (WWT) status in your company?
WW is gathered and treated on –site (WW Treatment Unit developed by WWTP or technology provider)
WW is gathered and collected by a WW aggregator to treat outside the premises of the company
Other (*please specify)



What WW Treatment Technology (WWTT) do you or the WWT company apply on each influent for nutrient/pollutant **re-moval** to meet with the legal effluent standards before disposal?

WWTT <sub>Influent 1</sub> :
WWTT <sub>Influent 2</sub> :

What **EWC** best describes the effluent (i.e. sludge, biochar, etc) after WW treatment?

Effluent 1	EWC:	Description:
Effluent 2	EWC:	Description:

If the effluent is in sludge form, please specify if it is:

a) applied in agriculture	b) applied in land reclamation
c) applied in the cultivation of plants intended for compost production	d) applied in the cultivation of energy plants
e) anaerobically digested	f) aerobically digested
g) applied as an alternative fuel in cement plants	h) incinerated
i) landfilled	j) stored at the WW Treatment Plant
k) composted	l) mechanically/naturally dried
m) Other (*please specify)	

What is the utilization of each effluent?

Who is in charge of the effluent utilization?



**What are the public administration legal effluent standards in your industrial sector for WW disposal?**

Information regarding -Potentially Toxic Elements (PTEs: Zn, Cu, Ni, Pb, Cd, Cr, As, Tl or Hg), -Polycyclic aromatic hydrocarbons (PAHs), -Organic micropollutants (OMPs: Pharmaceutical residuals - addictive substances-pesticides) -Microbiological pathogens

**Are there any differentiations between regional/national/EU regulations regarding the aforementioned criteria for WW disposal?**

End of Part A!

### 8.2.2 Part B

**Purpose of Part B: Identifying the preconditions or factors that drive or hamper the deployment of Nutrient Recovery (NR) options in industrial WW streams**

- In case you practice NR after WW or brine treatment, before the disposal of economically prime important nutrient resource based effluents please go to **Block 1** 'Mapping the status on Nutrient Recovery (NR) options from industrial bio-based waste-water streams
- In case you only practice components removal until the legal effluent standards are met, please go directly to **Block 5** 'Identifying the preconditions or factors that drive or hamper the deployment of recovered nutrients and of economically prime important nutrient resource-based products in BBFs'



### 8.2.2.1 Block 1 'Mapping the status on Nutrient Recovery (NR) options from industrial bio-based waste-water streams in Europe'

#### 8.2.2.1.1 1/4. Understanding Nutrient Recovery (NR) practices in WW streams

Specify your P recovery technology	From which stream	P recovered (tn/y - kg/d - kg/m <sup>3</sup> WW)	Is recovered P handled by you or the WWTP? (YES (how (e.g. used in the produc- tion)/NO(where (e.g. stored etc.)	Do you have a market for the recovered P? (YES (what) / NO (why))
Name of Technology 1	Effluent No: ....			
Name of Technology 2				
Name of Technology 3				

Specify your N recovery technology	From which stream	P recovered (tn/y - kg/d - kg/m <sup>3</sup> WW)	Is recovered N handled by you or the WWTP? (YES (how (e.g. used in the produc- tion)/NO(where (e.g. stored etc.)	Do you have a market for the recovered P? (YES (what) / NO (why))
Name of Technology 1	Effluent No: ....			
Name of Technology 2				
Name of Technology 3				



What other nutrients are recovered?	From which Effluent(s)	Which NR Technology do you apply?	What amount do you recover (tn/y - kg/d - kg/m <sup>3</sup> WW)	Are the recovered nutrients handled by you or the WWTP? (YES (how (e.g. used in the production)/NO(where (e.g. stored etc.))	Do you have a market for the recovered nutrients? (YES (what) / NO (why))	Could the recovered nutrients be used for Bio Based Fertilizers manufacturing? (YES/NO/I do not know)
K	No: ....					
Ca						
Mg						
Na						
S						
B						
Zn						
Mn						
Fe						
Cu						
Mo						
Cl						



## 8.2.2.1.2 2/4. What are the main barriers you had to deal with NR and how did you cope?

2/4. What are the main barriers you had to deal with NR and how did you cope?	Obstacles/barriers	Proposed solution to unlock the barriers
1. Initial capital expenditure (CAPEX) of construction and equipment for NR in WWT		
2. Total operational expenditure (OPEX) (maintenance costs (2.5 % of CAPEX) - power/energy consumption costs - chemical/consumables costs - labour costs - treatment and disposal costs)		
3. Lack of governmental support (Direct help - financial support in scaling-up innovative Nutrient Recovery Technologies (CAPEX / OPEX))		
4. Access to reliable economic feasibility assessments of NR option in my industry		
5. Land use availability e.g. Limitation of land generally increases the capital cost of the technology		
6. Policy framework implications (Complexity of policies, frequent updates) (e.g. recycling is mostly governed by fragmented decision-making in regional administrations)		
7. Ownership of nutrients in WW streams after they have been recovered in a WWTP		
8. Engineering expertise and knowledge of the available NR practices after WWT science and technologies		
9. Follow on operational support from technology providers		
10. Establishment of certification procedures for recovered nutrient products		
11. Recovered nutrients utilization on site or storage		
12. External interactions (Distribution & transport of recovered compounds - Exports to other countries, Approach of other WW production industries, WW treatment technology providers, recovered nutrients collectors)		
13. New line of products in the portfolio		
14. Accessible commercialization pathway/market for recovered nutrients fertilizer manufacturing industries		
15. Small window of profit from selling WW based BBF so it will take long time to get the money back from the investment.		
16. Consistency of influent composition (Shock and peak WW loads can upset NR process)		



17. Low concentration of nutrients in economically prime important nutrient resource based products (fermenter effluents, sludges etc.)		
18. Quality and safety of Recovered Nutrients (Contamination risks due to effluent composition)		
19. Establishment of traceability protocols for recycled nutrient products which could contain (organic) contaminants (the level of impurities which could be a threat to health, safety and environment, and product quality and application techniques)		
20. User acceptance for the application of recovered nutrients		
21. Other *please specify		

### 8.2.2.1.3 3/4 Have you been preoccupied with any of the following statements?

3/4 Have you been preoccupied with any of the following statements?	Strongly agree	Agree	Partially agree	Disagree	Strongly disagree	Proposed solution
Implementation of stricter NR policies in WW will require access of WWTP to extend their territory in urban, industrial and agricultural areas laying longer pipelines. <i>Negotiations over rights of way - multiple litigation processes - rerouting due to difficult terrain or sensitive archaeological or cultural sites - waste time and resources</i>						
Development of decentralised WW treatment for nutrient recovery can greatly reduce CAPEX and OPEX. <i>Placing small treatment plants at the point of need (WW producer), CAPEX can be cut by as much as two-thirds, and OPEX can be reduced, too - all with no sacrifice in quality of treatment.</i>						
P recovery costs exceed conventional P ore costs. <i>Assuming a load of 660 g P per capita per year, recovery costs would be 3.600-8.800 € per tonne recovered P under German market conditions.</i>						



## 8.2.2.1.4 4/4. Potential measures to unlock the barriers

Potential measures to unlock the barriers	Strongly agree	Agree	Partially agree	Disagree	Strongly disagree	Comments
<b>Economic barriers</b>						
<i>Government measures will make the process economically feasible:</i>						
<i>Direct help - financial support in scaling-up innovative Nutrient Recovery Technologies (CAPEX / OPEX)</i>						
<i>Minimum amount of NR in BBFs and price guarantee.</i>						
<i>Obligation in the use of NR first instead of mineral.</i>						
<i>Tax on the use of mineral sources for fertilizers</i>						
<i>Competition will be a motivating factor to perform NR. Reducing access price to technology and reducing the price of NR.</i>						
<i>A network allowing me to identify other businesses from the rest of the WW chain (end users and fertilisers manufacturers) next to my business will minimise the cost of logistics.</i>						
<b>Regulation</b>						
<i>Stricter disposal waste water criteria will increase the number of treatment facilities</i>						
<i>Circular economy Regulation: Obligating to recover nutrients from WW streams.</i>						
<i>If several WW producers recover the same nutrient, value-chain development could be facilitated by acting as one supplier of the recovered nutrient, thus increasing their collective market power.</i>						





This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 101000752.



Please address any obstacles, gaps or shortcomings in policies you comply with concerning:	Regulations	Obstacles, gaps or shortcomings
Waste water treatment	- Water framework Directive (2000/60/EC) - establishes a framework for the protection of surface and groundwater in the EU 2000 Urban Waste Water Directive (91/271/EEC) - requires the collection of waste water and the implementation of secondary treatment for agglomerations with more than 2000 person equivalents. More advanced treatments for populations > 10000 person equivalents (1991)	
Effluent disposal regulatory standards	- nutrient discharge limits require effluents to contain less than 0.1 mgP/L and 1-3 mgN/L - Nitrates Directive (91/676/EEC) - limits nitrates in water to 50 mg/l (1991) - Groundwater Directive (2006/118/EC) - sets a quality standard of 50 mg/l of nitrates (2006)	
End-of-waste criteria *certain waste ceases to be waste and becomes a product or a secondary raw material	- Waste Framework Directive	
Nutrient recovery	- Critical raw materials list (CRM). List of 20 raw materials for which “supply security is at risk and economic importance is high”. Phosphate rock was added to the list in 2014	
Distribution of recovered nutrients	- Fertiliser regulation EC under revision 2019/1009 to be implemented 16 <sup>th</sup> July 2022) - The current version defines and lists inorganic fertilisers and micro-nutrients and regulates their market placement (2003). - Nitrates Directive (91/676/EEC) - limit of 170 kg N/ha/yr from livestock manure in NVZ (1991) - Sludge Directive (86/278/ EEC) - regulates the use of sewage sludge in agriculture (1886)	
Do you have enough access to innovative nutrients recovery technologies?	YES (My source is.....)	NO (Why)



*Do you have any additional comments, suggestions or questions?*

*Thank you for your feedback. We really appreciate your time.*



### 8.3 Interview of Urban WW Treatment Plants and other type E- WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES industries

#### Contact details of the interviewer

Country	
Partner	

#### Contact details of the interviewee

Can we contact you in order to register in the WALNUT platform?

(In this platform, urban and industrial WW streams will be tracked and traced from their production, to their collection, treatment and valorization as bio-fertilizing products)

YES

NO

If yes, please fill-in your contact details:

Company Name	
Address	
Email/Site	
Phone number	
LinkedIn (company/personal)	
Company Capacity	1-10, 11-50, 50-100, 100-200 personnel

\* What is the [NACE](#) code of your company?

.....

Unless stated otherwise, please highlight the text that best describes your answer or mark with an 'X'.



### 8.3.1 Part A 'Mapping the status of Nutrient Recovery (NR) options in centralized urban WWTP or in on-site WW treatment units of WW produced from type C- MANUFACTURING industries, in EU-27'

What WW streams does your company treat?	a) Urban WW	b) Industrial WW	c) Both
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What <b>EWC</b> best describes the WW streams your company treats (*even the first 4 digits)?	Description	Physical/chemical parameters of the WW streams (*a qualitative approach to available information (Toxicity <sub>ISO 6341:2013</sub> , Electrical conductivity, Soluble sodium percentage, COD, BOD, TOC, etc.))	Content in nutrients/pollutants (composition (N, P, K, Ca, Mg, etc., concentration (mg/l))
Urban WW			
Influent 1	EWC <sub>1</sub> :		
Influent 2	EWC <sub>2</sub> :		
Influent 3	EWC <sub>3</sub> :		
Influent 4	EWC <sub>4</sub> :		

Please describe the WW treatment procedure you follow for pollutant/nutrient **removal**.

Urban WW:
WWTT <sub>Influent 1</sub> :
WWTT <sub>Influent 2</sub> :
WWTT <sub>Influent 3</sub> :
WWTT <sub>Influent 4</sub> :

Do the influents you treat contain any of the following contaminants?	NO	YES (what), but the legal effluent standards for disposal are met	YES (what), I remove them by applying this technology:
Potentially Toxic Elements (PTEs: Zn, Cu, Ni, Pb, Cd, Cr, As, Tl or Hg)			
Polycyclic aromatic hydrocarbons (PAHs)			
Organic micropollutants (OMPs: Pharmaceutical residuals - addictive substances-pesticides)			



Microbiological pathogens			
Petroleum residues from automobiles, and road deicing chemicals			
Other contaminants (*please specify)			

What **EWC** best describes the non-hazardous industrial effluents (sludges) from WW treatment?

	EWC	Description (form, characteristics, etc.)	Management (examples in the following table)
Effluent 1			
Effluent 2			
Effluent 3			
Effluent 4			
Effluent 5			
Effluent 6			

How do you handle the removed pollutants/nutrients

N		
P		
Other (*Please specify)		

Examples of effluent management

a) applied in agriculture	b) applied in land reclamation
c) applied in the cultivation of plants intended for compost production	d) applied in the cultivation of energy plants
e) anaerobically digested	f) aerobically digested
g) applied as an alternative fuel in cement plants	h) incinerated
i) landfilled	j) stored at the WWTP
k) composted	l) other (*please specify)

What are the public administration legal effluent standards (for nutrients and contaminants) in your industrial sector for WW disposal?

Information for pollutants/nutrients and Potentially Toxic Elements (PTEs: Zn, Cu, Ni, Pb, Cd, Cr, As, Tl or Hg), Polycyclic aromatic hydrocarbons (PAHs), Organic micropollutants (OMPs: Pharmaceutical residuals - addictive substances-pesticides), Microbiological pathogens



Please specify any differentiation between regional/national/EU regulations regarding the aforementioned criteria for WW disposal?

End of Part A



### 8.3.2 Part B

**Purpose of Part B: Identifying the preconditions or factors that drive or hamper the deployment of NR options in WW treatment**

- In case you practice NR in WW treatment, please go to **Block 2** ‘Mapping the status on NR options from bio-based input streams in European WW treatment plants (WWTP)’
- In case you do not practice NR in WW treatment, please go to **Block 3** ‘Identifying the preconditions or factors that drive or hamper the deployment of NR options in WWTP’



### 8.3.2.1 Block 2 'Mapping the status on NR options from bio-based input streams in European WW treatment plants (WWTP)'

#### 8.3.2.1.1 1/5. Understanding Nutrient Recovery (NR) practices in WW

What other nutrients are recovered?	NR source (Effluent No)	NR Technology	NR design capacity (tn/y - kg/d - kg/m <sup>3</sup> WW)	How and by whom are the recovered nutrients managed? (e.g. used in the production, stored, certified, sold, etc.)	Do you have a market for the recovered nutrients? (YES (what) / NO (why))
P					
N					
K					
Ca					
Mg					
Na					
S					
B					
Zn					
Mn					
Fe					
Cu					
Mo					
Cl					



## 8.3.2.1.2 2/5. What are the main barriers you had to deal with NR and how did you cope?

## 2/5. What are the main barriers you had to deal with NR and how did you cope?

	Obstacles/barriers	Proposed solution to unlock the barriers
1. <i>Initial capital expenditure (CAPEX) of construction and equipment for NR in WWT</i>		
2. <i>Total operational expenditure (OPEX) (maintenance costs (2.5 % of CAPEX) - power/energy consumption costs - chemical/consumables costs - labour costs - treatment and disposal costs)</i>		
3. <i>Governmental support (Direct help - financial support in scaling-up innovative Nutrient Recovery Technologies (CAPEX / OPEX))</i>		
4. <i>Access to reliable financial feasibility assessments of NR option in WWT</i>		
5. <i>Land use availability e.g. Limitation of land generally increases the capital cost of the technology</i>		
6. <i>Policy framework implications (Complexity of policies, frequent updates) (e.g. recycling of nutrients is mostly governed by fragmented decision-making in regional administrations)</i>		
7. <i>Ownership of nutrients in WW streams after they have been recovered in the WWTP (or unit)</i>		
8. <i>Environmental safety of Nutrient Recovery Technology</i>		
9. <i>Lack of engineering expertise and knowledge of the available NR practices</i>		
10. <i>Follow on operational support from technology providers</i>		
11. <i>Establishment of certification procedures for recovered nutrients and WW-based products</i>		
12. <i>Recovered nutrients utilization on site (production) or storage</i>		
13. <i>External interactions (Distribution &amp; transport of recovered compounds - Exports to other countries, Approach of other WW treatment companies, WW treatment technology providers, recovered nutrients collectors)</i>		
14. <i>Handling of this new line of products in the portfolio (certification, marketing, etc.)</i>		
15. <i>Accessible commercialization pathway/market of recovered nutrients for fertilizer manufacturing industries</i>		
16. <i>Low exiting product sale price postpones the time when this NR technology will render profit</i>		
17. <i>Implementation of NR practices from competitor companies</i>		
18. <i>Fluctuations of influent composition (Shock and peak WW loads can upset NR process)</i>		
19. <i>Low concentration of nutrients on influents/effluents</i>		
20. <i>Questionable quality and safety of Recovered Nutrients (Contamination risks due to effluent composition)</i>		
21. <i>Establishment of traceability protocols for recovered nutrient products which could contain (organic) contaminants (the level of impurities which could be a threat to health, safety and environment, and product quality and application techniques)</i>		
22. <i>User awareness/acceptance for the application of recovered nutrients</i>		



<i>23. Other *please specify</i>		
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## 8.3.2.1.3 3/5 Have you been preoccupied with any of the following statements?

3/5 Have you been preoccupied with any of the following statements?

	Strongly agree	Agree	Partially agree	Disagree	Strongly disagree	Proposed solution
Implementation of stricter NR policies in WW will require access of WWTP to extend their territory in urban, industrial and agricultural areas laying longer pipelines. <i>Negotiations over rights of way - multiple litigation processes - rerouting due to difficult terrain or sensitive archaeological or cultural sites - waste time and resources</i>						
Development of decentralized WW treatment for nutrient recovery can greatly reduce CAPEX and OPEX. <i>Placing small treatment plants at the point of need (WW producer), CAPEX can be cut by as much as two-thirds, and OPEX can be reduced, too - all with no sacrifice in quality of treatment.</i>						
P recovery costs exceed conventional P ore costs. <i>Assuming a load of 660 g P per capita per year, recovery costs would be 3.600-8.800 € per tonne recovered P under German market conditions.</i>						



## 8.3.2.1.4 4/5. Potential measures to unlock the barriers

<b>Economic barriers</b>		Strongly agree	Agree	Partially agree	Disagree	Strongly disagree	Comments
<i>Government measures will make the process economically feasible</i>							
<i>i</i>	<i>Direct help - financial support in scaling-up innovative Nutrient Recovery Technologies (CAPEX / OPEX)</i>						
<i>ii</i>	<i>Minimum amount of NR in BBFs and price guarantee.</i>						
<i>iii</i>	<i>Obligation in the use of NR first instead of mineral.</i>						
<i>iv</i>	<i>Tax on the use of mineral sources for fertilizers.</i>						
<i>Implementation of NR practices will be a motivating factor to perform NR, reducing access price to technology and reducing the price of recovered nutrients.</i>							
<i>A network allowing me to identify other businesses from the rest of the WW chain (end-users and fertilizer manufacturers) next to my business will minimize the cost of logistics.</i>							
<b>Regulation</b>							
<i>Stricter disposal of WW criteria will increase the number of WWT facilities</i>							
<i>Circular economy Regulation: Obligation to recover nutrients from WW streams.</i>							
<i>Common fertilizer regulation in Europe</i>							
<i>If several WW producers recover the same nutrient, value-chain development could be facilitated by acting as one supplier of the recovered nutrient, thus increasing their collective market power.</i>							



## 8.3.2.1.5 5/5 Please address any obstacles, gaps or shortcomings in policies you comply with concerning

Please address any obstacles, gaps or shortcomings in policies you comply with concerning:	Regulations	Obstacles, gaps or shortcomings
Waste water treatment	<ul style="list-style-type: none"> <li>- Water framework Directive (2000/60/EC) - establishes a framework for the protection of surface and groundwater in the EU</li> <li>2000 Urban Waste Water Directive (91/271/EEC) - requires the collection of waste water and the implementation of secondary treatment for agglomerations with more than 2000 person equivalents. More advanced treatments for populations &gt; 10000 person equivalents (1991)</li> </ul>	
Effluent disposal regulatory standards	<ul style="list-style-type: none"> <li>- Nutrient discharge limits require effluents to contain less than 0.1 mgP/L and 1-3 mgN/L</li> <li>- Nitrates Directive (91/676/EEC) - limits nitrates in water to 50 mg/l (1991)</li> <li>- Groundwater Directive (2006/118/EC) - sets a quality standard of 50 mg/l of nitrates (2006)</li> </ul>	
End-of-waste criteria *certain waste ceases to be waste and becomes a product or a secondary raw material	<ul style="list-style-type: none"> <li>- Waste Framework Directive</li> </ul>	
Nutrient recovery	<ul style="list-style-type: none"> <li>- Critical raw materials list (CRM). List of 20 raw materials for which “supply security is at risk and economic importance is high”. Phosphate rock was added to the list in 2014</li> </ul>	

Do you have enough access to innovative nutrients recovery technologies?	YES (My source is.....)	NO (Why)



*Do you have any additional comments, suggestions or questions on Nutrient Recovery and valorization of Waste Water streams for Bio-fertilization purposes?*

*Thank you for your feedback. We really appreciate your time.*



### 8.3.2.2 Block 3 'Identifying the preconditions or factors that drive or hamper the deployment of NR options in WWTP'

#### 8.3.2.2.1 1/4. What has kept you from already practicing NR?

<b>NR: why &amp; how?</b>		
<i>Unaware of NR perception as a possibility to my influents - Unaware of NR benefits - Unaware of social impact of NR</i>	<i>Lack of interest from WW producers</i>	<i>I do not have access to economic evaluation of nutrient recovery economical sustainability</i>
<i>Lack of engineering expertise and knowledge of the available NR practices after WWT science and technologies</i>	<i>Variance &amp; Constant evolution in NR Technologies (NRTs) - Cannot decide which NRT to apply</i>	<i>NRTs need technological assistance (training-high level of operator attention-expertise &amp; follow -operational support)</i>
<b>Financial barriers</b>		
<i>Initial capital expenditure (CAPEX) of construction and equipment for advanced WW Treatment Technologies (Nutrient recovery).</i>	<i>Not sustainable extra total operational expenditure (OPEX) (maintenance costs (2.5 % of CAPEX) - power/energy consumption costs - consumables - labour - disposal costs)</i>	<i>Prohibitive Whole Life Cost (WLC, INITIAL CAPEX + (Annual OPEX x 14) of Nutrient recovery Technologies for a life span of 40 years</i>
<i>Due to the low quality of the effluents, non-selective incineration or land burying are more economically solutions.</i>	<i>I have designed bench/lab scale innovative NR processes but cannot find financial support for up-scaling.</i>	<i>There is limited accessible commercialization pathway/market for recovered nutrients fertilizer manufacturing industries</i>
<b>Regulation</b>		
<i>Unaware of future restrictions on mineral fertilizers utilization</i>	<i>Unaware of regulatory updates framework of nutrient recovery</i>	<i>Every Member State has different nutrient reuse standards, which is the primary cost driver</i>
<b>Effluent composition</b>		
<i>Low concentration of nutrients in economically prime important nutrient resource based products (fermenter effluents, sludges etc.) can make NR uneconomical. E.g. Low N concentrations of only 30 mg per litre NH<sub>4</sub>-N in average Dutch wastewater may make NH<sub>4</sub> recovery uneconomical</i>	<i>I cannot guarantee the marketability of the recovered nutrients because the product contains pathogens, heavy metals and/or other contaminants to enter the market</i>	<i>Not consistent influent composition</i>
<b>Recovered nutrients</b>		
<i>If recovered nutrients are not used on site, distribution and transport have to be organized (geographical and temporal discrepancies between supply and demand, lack of infrastructure, or cost)</i>	<i>While exiting recovered product sale price does not make the NR process economically feasible, price of recovered nutrients is considerably higher than price of mineral fertiliser.</i>	<i>Quality and safety of Recovered Nutrients (Contamination risk due to effluent composition (PTEs, PAHs, pharmaceutical residuals, microbiological pathogens) - transfer to food chain)</i>



<b>Random factors</b>		
<i>Extra space requirements to install WWT unit in the premises of my company</i>	<i>Shock and peak WW loads can upset NR process</i>	<i>Other (please specify)</i>

#### 8.3.2.2.2 2/4. Have you ever taken any of the following steps to apply NR?

	YES/NO	What BARRIER(S) did you meet.
Regulation framework analysis (effluent, NR quality)		
Business/process feasibility assessment (Technical / economical)		
Identify / Characterise the composition of WW-based nutrient rich resources		
Find technology provider		
Install a NR facility		
Contact BBF manufacturer		
Find end-user		
Other (*please specify)		

#### 8.3.2.2.3 3/4. Motives to be considered in the implementation of an NR technology

Rate with 1 (Yes, I would implement NR for this) -2 (Maybe I would consider NR options) -3 (No, I would not implement NR for this)	
1. Techno economically feasible (CAPEX, OPEX)	
2. Available space e.g. Limitation of land generally increases the capital cost of the technology	
3. Motivation to be environmentally friendly	
4. High quality of Recovered Nutrients due to influent's composition (No risk of contamination of food chain )	
5. Obligation to comply with relevant policy and legislative frameworks	
6. Financial support from political institutions to share the risks of innovation implementation	
7. The competitor's companies have already implemented NR in their WW treatment process	
8. Market place and guaranteed value of recovered nutrients	
9. User acceptance for the application of recovered nutrients	
10. New line of products in the portfolio	
11. External interactions (Exports to other countries, Approach of new partners (other companies producing the same WW influent, WW treatment companies, WW treatment technology providers, recovered nutrients collectors))	
12. Other	



## 8.3.2.2.4 4/4. Potential measures to unlock the NR barriers

<b>Economic barriers</b>	Strongly agree	Agree	Partially agree	Disagree	Strongly disagree	Comments
<i>Government measures will make the process economically feasible:</i>						
<i>Direct help - financial support in scaling-up innovative NR Technologies (CAPEX / OPEX)</i>						
<i>Minimum amount of NR in BBFs and price guarantee.</i>						
<i>Obligation in the use of NR first instead of mineral.</i>						
<i>Tax in the use of mineral sources for fertilizers</i>						
<i>Competition will be a motivating factor to perform NR. Reducing access price to technology and reducing the price of NR.</i>						
<i>A network allowing me to identify other businesses from the rest of the WW chain (end users and fertilisers manufacturers) next to my business will minimise the cost of logistics.</i>						
<b>Regulation</b>						
<i>Stricter disposal of waste water criteria will increase the number of treatment facilities</i>						
<i>Circular economy Regulation: Obligating to recover nutrients from WW streams.</i>						
<i>Common fertiliser regulation in Europe</i>						
<i>If several WW producers recover the same nutrient, value-chain development could be facilitated by acting as one supplier of the recovered nutrient, thus increasing their collective market power.</i>						



*Do you have any additional comments, suggestions or questions on Nutrient Recovery and valorization of Waste Water streams for Bio-fertilization purposes?*

*Thank you for your feedback. We really appreciate your time.*



## 8.4 Interview on technology providers for nutrient recovery and utilization as Bio-based fertilizers (BBFs)

Before we begin:

This questionnaire concerns:

the synthesis of Bio-based fertilizers (BBFs) i.e. fertilizers that contain primary and secondary macro nutrients and micronutrients deriving from the implementation of nutrient recovery practices after or during WW treatment

and

the valorisation of urban and industrial influents and effluents (sewage sludge (*ash, compost*), *landfilled or incinerated products, biochar, anaerobically digested bio-waste (compost), industrial waste water (digestate), landfill leachate, food industry waste*) as Bio-based fertilizers (BBFs). (BBFs are not to be confused with animal metabolism -derived Fertilizers).

Contact details of the interviewer

WalNUT consortium country	
WalNUT consortium partner	

*\*Unless stated otherwise, please highlight the text that best describes your **answer**.*



Are you a WalNUT stakeholder (Grant agreement) or outside partner?	YES/NO
Can we contact you in order to register in the WalNUT platform?	YES/NO
If yes, please fill-in your contact details:	
Company Name	
Address	
Email/Site	
Phone number	
LinkedIn (company/personal)	
Company Capacity	1-10, 11-50, 50-100, 100-200 personnel

To what WW treating industries have you introduced the nutrient recovery technologies? (i.e. urban WWTP, food processing, brewery, paper industry, etc)	
Can you provide us with a brief description of the nutrient recovery technologies you have developed?	
What are the most representative influent/effluent <a href="#">EWC codes (except for urban WW)</a> your technologies recover nutrients from? (Sewage sludge, Anaerobically digested bio-waste (compost), Biochar, Incineration ash, landfill leachate, Industrial waste water (digestate), Industrial WW (food industry, slaughterhouses etc.) Other (*please specify))	
What nutrients do you recover? (i.e. P as apatite-like quality, N as a high-quality ammonium sulphate solution, residual water used in farmlands or discharged, biomass as a low-nutrition soil conditioner, etc.)	



According to the main obstacles in nutrient recovery technologies you had to deal with (i.e. variations in influent/effluent composition, yield, etc.)....

What should technology providers focus on for innovations in nutrient recovery/BBF manufacturing practices?

	Decisive factor	High significance	Neutral	Low significance	Not at all important	Comments
i.	Modern product portfolio to attract farmers/agricultural associations					
ii.	Homogeneity - Uniform nutrient distribution in recovered products (BBFs)					
iii.	Add a stage in the process for the formulation of products with controlled release rate					
iv.	Easy blending of recovered products (BBFs) with other fertilizers					
v.	Application of recovered products (BBFs) by farmers with existing equipment					
vi.	Effectiveness of recovered products (BBFs) in improvement of soil health & <i>crop yield</i>					
vii.	Profitability of technologies					
viii.	<i>A cut in water and energy consumption</i>					
ix.	<i>Other (*please specify)</i>					



	YES	NO	Comments
Do WW producing industries prefer delivering untreated forms of WW (BBFs) to farms in the areas near the plant?			
Will the implementation of Reg. EU 1009/2019 (16th July 2022) make this type of delivery more complicating?			
Has it been easy to convince farmers to take up the practice of BBFs?			
Has the demand for nutrient recovery technologies - <i>perception of recovered nutrients as a raw material for fertilizers - awareness of social impact of recovered nutrients</i> increased over the years?			
How do you certify the quality of nutrient recovery products?			
What traceability protocols do you follow for the recovered products?			
How do you deal with uncertain influent/effluent composition, quality and safety of recovered products (presence of contaminants (i.e. microplastics, pharmaceutical residuals, etc.))?			

<p>Please rate the way the listed factors would affect a customer to implement a nutrient recovery technology:</p> <p>1 decisive factor,                  2 high significance,                  3 Neutral,                  4 low significance,                  5 Not at all important</p>	i. Consulting with them during process design	
	ii. Quantity of recovered nutrients (yield)	
	iii. Initial capital expenditure (CAPEX) of construction and equipment	
	iv. Fast return of investment	
	v. (OPEX) Operation/Maintenance costs	
	vi. Necessity for feedstock pre-treatment	
	vii. Necessity for experienced personnel	
	viii. Recovery of clear water	
	ix. Form of recovered nutrients (i.e. compact nutrient-rich dry matter, pellets → increased value per unit → reduced transport & storage costs)	
	x. After-sales/Service support	
	xi. Environmental friendliness	
	xii. Implementation of nutrient recovery by competitors	
	xiii. Upgrade into marketable products (i.e. easier to handle, smell less, etc.)	
	xiv. Standardization of recovered products → new sales markets (private gardens) & new distribution channels (garden centres)	

Governmental measures to unlock the barriers for implementation of Nutrient recovery & BBF utilization

Agree	Neutral	Disagree	Comments



i.	Confidence of end-users regarding the conformity of the products with the presence of contaminants limits.				
ii.	Confidence of public authorities regarding the conformity of the products (establishment of protocols).				
iii.	<i>Prohibition of/increase in charges for storage and non-selective effluent incineration</i>				
iv.	<i>Price guarantee of recovered nutrients/nutrient rich influents/effluents (BBFs)</i>				
v.	<i>Tax in the use of mineral sources for fertilizers.</i>				
vi.	<i>Tax benefits for using BBFs.</i>				
vii.	<i>Tax on the use of higher doses of fertilizers.</i>				
viii.	<i>Direct helps - financial support in innovative Nutrient recovery/BBF manufacturing practices for the utilization of economically prime important nutrient resource based products (CAPEX / OPEX).</i>				
ix.	<i>Commercial agreements for exclusivity of next-generation BBF manufacturing technologies to introduce to the marketplace.</i>				
x.	<i>Direct subsidies for products commercialization, through building awareness among farmers and consumers, produced on the basis of eco-raw materials.</i>				
xi.	<i>R&amp;D grants for elaboration of new nutrient recovery/BBF manufacturing practices</i>				
xii.	Exploitation of related work under previous research framework programmes and other EU-funded programmes.				
xiii.	Transitional period is needed to allow industry and end-users to adapt.				



*Do you have any additional comments, suggestions or questions?*

*Thank you for your feedback. We really appreciate your time.*



## 8.5 Interview of end-users (farmers and agricultural associations) of fertilizing products from the valorization of waste water

Before we begin:

This questionnaire concerns:

- i. the utilization of Bio-based fertilizers (BBFs) i.e. fertilizers that contain primary and secondary macro nutrients and micronutrients that have been recovered from waste water streams
- and
- ii. the valorization of urban and industrial waste water streams and waste water treatment plants' effluents (sewage sludge (*ash, compost*), *landfilled or incinerated products, biochar, anaerobically digested bio-waste (compost), digestate, landfill leachate, food industry waste* as Bio-based fertilizers (BBFs).

\*BBFs are not to be confused with animal metabolism -derived Fertilizers.

Contact details of the interviewer

WalNUT consortium country	
WalNUT consortium partner	

\*Unless stated otherwise, please highlight the text that best describes your **answer**.



8.5.1 PART A (for agricultural associations)

Can we contact you in order to register in the WALNUT platform?

(In this platform, WW streams will be tracked and traced from their production, to their collection, treatment and valorization as fertilizing products)

YES	NO
-----	----

If yes, please fill-in your contact details:	
Company Name	
Address	
Email/Site	
Phone number	
LinkedIn (company/personal)	
Company Capacity	1-10, 11-50, 50-100, 100-200 personnel

PART A (for agricultural associations): Mapping the current supply-demand status of waste water-based fertilizers

Have you been presented by fertilizer manufacturers the option of WW-based fertilizing products?	YES	NO	Comments:	
Do your suppliers (i.e. fertilizer manufacturing companies) utilize nutrients after valorisation of waste water streams (instead of fossil-based ones) as a nutrients' source for their products?	YES	NO	UNAWARE	Comments:
Have you included fertilizing products from the valorisation of waste water in your portfolio?	YES	NO	Comments:	

If yes, what fertilizing products from waste water valorisation have you distributed in your clients?	(Product description, certification, WW origin, WW treatment/BBF production technology, storage requirements If you are aware, please specify the <a href="#">EWC code</a> of the product)
Sewage sludge	
Anaerobically digested bio-waste (compost)	
Biochar	
Incineration ash	
Landfill leachate	



Industrial WW (digestate)	
Industrial WW (food industry, slaughterhouses etc.)	
Other (*please specify)	

Will you continue promoting the application of waste water -based fertilizing products?	YES	NO	Comments:
Has it been easy to convince farmers to take up the practice of WW-based fertilizers?	YES	NO	Comments:
Has the demand for WW-based fertilizers by farmers increased over the years?	YES	NO	Comments:
Do you import fossil-based fertilizers?	YES	NO	Country, -ies/Nutrient:
Will you ask for more waste water -based fertilizing products options?	YES	NO	Comments:
- If yes, please specify	Comments:		
What do you believe the benefits of BBFs utilization are?	Comments:		

End of Part A (for agricultural associations, please proceed with Part B)



Can we contact you in order to register in the WALNUT platform?  
(In this platform, WW streams will be tracked and traced from their production, to their collection, treatment and valorization as fertilizing products)

YES/NO

If yes, please fill-in your contact details:

Name	
Address	
Phone number	
Email	

(for farmers)

### 8.5.2 Part A (for farmers)

In your role as arable land farmer:

Are you involved in organic farming?															
Do you have an animal husbandry on land?															
Who supplies you with fertilizers (more than one choice)?	<table border="1"> <tr> <td>i)</td> <td>Fertilizer manufacturer</td> </tr> <tr> <td>ii)</td> <td>Agricultural association</td> </tr> <tr> <td>iii)</td> <td>I use animal - metabolism products</td> </tr> <tr> <td>iv)</td> <td>Waste water based products (i.e sludge) managing company</td> </tr> <tr> <td>v)</td> <td>I import</td> </tr> <tr> <td></td> <td>Country:</td> </tr> <tr> <td></td> <td>Quantity:</td> </tr> </table>	i)	Fertilizer manufacturer	ii)	Agricultural association	iii)	I use animal - metabolism products	iv)	Waste water based products (i.e sludge) managing company	v)	I import		Country:		Quantity:
i)	Fertilizer manufacturer														
ii)	Agricultural association														
iii)	I use animal - metabolism products														
iv)	Waste water based products (i.e sludge) managing company														
v)	I import														
	Country:														
	Quantity:														

Have you ever had the soil quality (nutrient and organic content) tested by a certified organisation?	YES	NO
- If yes, please let us know of the results (optional).		
- If yes, did you report the results on a public database?	YES	NO
Do you have difficulty in addressing the problems in soil composition?	YES	NO
- If yes, please specify		
Have you ever partnered with a consultant on soil enrichment?	YES	NO



- If yes, please describe your experience		
Have you ever been presented by a fertilizer company or agricultural association the option of waste water-based fertilizers?	YES	NO
To what extent do you (still) depend on fossil-based fertilizers?		
Do you plan to (further) reduce dependency on fossil-based fertilizers in the future?	YES	NO

Do you use WW based effluents (i.e. sludge) for arable land fertilization?	If YES, please answer 'Block 1'	If NO, please proceed with 'Part B'
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### 8.5.2.1 Block 1

If you have applied fertilizing products from waste water valorization to your arable land, please answer the next 6 questions:

(\*BBFs are not to be confused with animal metabolism products -derived fertilizers)

1. Is/Was the waste water-based product you use(d) certified?	YES	NO
- If yes, please specify your experience		
2. Is/Was the BBF stored on-site?	YES (for ___months)	NO
- If yes, please specify your experience		
3. Will you continue using BBFs?	YES	NO
4. Will you ask for more BBF options?	YES	NO
- If yes, please specify		
5. What do you believe are the benefits of BBFs utilization?		



6. What fertilizing products from waste water valorization have you used?	(Short description, Origin, WW treatment/BBF production technology) If you are aware, please specify (EWC code <a href="https://ec.europa.eu/eurostat/documents/342366/351806/Guidance-on-EWCStat-categories-2010.pdf/0e7cd3fc-c05c-47a7-818f-1c2421e55604">https://ec.europa.eu/eurostat/documents/342366/351806/Guidance-on-EWCStat-categories-2010.pdf/0e7cd3fc-c05c-47a7-818f-1c2421e55604</a> )	Annual spread
Sewage sludge		_____ t (m <sup>3</sup> )/ha/yr
Anaerobically digested bio-waste (compost)		_____ t (m <sup>3</sup> )/ha/yr
Biochar		_____ t (m <sup>3</sup> )/ha/yr
Incineration ash		_____ t (m <sup>3</sup> )/ha/yr
Landfill leachate		_____ t (m <sup>3</sup> )/ha/yr
Industrial waste water (digestate)		_____ t (m <sup>3</sup> )/ha/yr
Industrial WW (food industry, slaughterhouses etc.)		_____ t (m <sup>3</sup> )/ha/yr
Other (*please specify)		_____ t (m <sup>3</sup> )/ha/yr

End of **Block 1**

End of Part A (**for farmers**, please proceed with Part B)



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 101000752.



## 8.5.3 PART B (for all interviewees): Allocation of lock-ins and barriers regarding the utilization of BBFs.

Why is the utilization of Bio Based Fertilizers so limited?	Agree	Partially agree	Neutral	Partially disagree	Disagree	Comments
<b>BBF application</b>						
Farmers prefer the use of traditional fossil-based rather than bio-based fertilizers because the application of the latter involves more labor and is more expensive						
Collection/transport/distribution of BBFs is challenging						
The application of waste water based fertilizers is prohibited in crop cultivation/organic farming						
Sales of the produced crops are destined only for export (i.e. less profit)						
Permission is needed by landowner to spread BBFs on hired farmland						
BBF utilization is a stigmatized practice involving negative feelings about it (Food industry concerned about reputation of brand)						
Fertilization with BBFs is not popular in my area (excess manure from animal husbandry)						
Lack of follow-on support from consultants on innovative BBF application methods						
Spreading of BBFs requires dry weather to allow driving through the arable land						
Lack of science-based knowledge on the evaluation of the BBFs performance effect on soil quality and crop yield in greenhouses and full field scale settings						
Crop yield variations associated with changes in fertilization practices						
Spreading of waste water-based fertilizers leads to mal odor problems						
If a BBF application dosage is small (due to condensation), it is perceived of low quality through the prism of its content in fertilizer components						
P in sludge is bound to soil, therefore 5 years of waiting are needed for P release						
Uncertain composition, quality and safety (contamination risks due to effluent composition) of BBFs						
Cannot trust certification/authorization of BBFs - Risk of the presence of contaminants (i.e. microplastics, pharmaceutical residuals, etc.) There are no reliable traceability protocols for recycled nutrient products which could contain (organic) contaminants (the level of impurities which could be a threat to health, safety and environment, and product quality and application techniques)						
Lack of storage space availability Complaints about odor from storage (and spreading)						
<b>Policy framework implications</b>						
There has been no pressure so far for farmers to utilize BBFs						
There is conflict between P as a resource in fertilizer production or as a pollutant						



<i>BBF market</i>						
The quantity of BBFs is insufficient for fertilization of larger portions of land						
Lack of promotion of BBF utilization (farmers' - agricultural associations' awareness) - Cannot find BBFs on the market						
<i>Financial barriers</i>						
<i>Initial capital expenditure (CAPEX) of construction and equipment for bio-based fertilizers storage handling and spreading</i>						
<i>Other (*please specify)</i>						



Motives for fertilization with BBFs	Agree	Neutral	Disagree	Comments
<i>Network support</i>				
Expert consultation to select the correct dosage (volume) of BBF in comparison to mineral/conventional fertilizer.				
<i>Enactment of a network allowing farmers to identify other businesses from the rest of the WW treatment chain (recovered nutrients providers, other end-users) next to their land will minimize the cost of logistics.</i>				
Cooperation with agricultural associations (open discussions, bonuses for product promotion) that have wide distribution will assist farmers' awareness.				
<i>Environmental friendliness</i>				
Availability and effectiveness of techniques for measuring, monitoring and regulating contaminants				
<i>BBF application</i>				
Integration of the products into existing solutions.				
The application of BBFs by farmers-competitors will be a motivating factor, reducing their price.				
<i>Other (*please specify)</i>				

<i>Economical motives</i>
Deviations from a preferred product would need to be compensated by i) same ii) -20 % iii) - 40% iv) - 60 % cheaper prices as traditional fossil-based fertilizer?

Governmental measures to unlock the barriers for BBF utilization	Agree	Neutral	Disagree	Comments
xiv. Obligation in the use of recovered nutrients first instead of mineral sources for fertilization purposes. - Enactment of minimum amount of recovered nutrients in BBFs.				
xv. Confidence of public authorities regarding the conformity of the products (establishment of protocol).				
xvi. Tax in the use of mineral sources for fertilizers.				
xvii. Tax benefits for using BBFs.				
xviii. Direct helps - financial support in innovative Fertilizer Application Technologies for the utilization of economically prime important nutrient resource based products (CAPEX / OPEX).				

End of part B!



*Do you have any additional comments, suggestions or questions?*

*Thank you for your feedback. We really appreciate your time.*



### 8.6 Interview of Fertiliser Manufacturers Before we begin:

This questionnaire concerns:

the incorporation of nutrients recovered from urban WW and sewage sludge, food, industrial WW and brine as primary and secondary macro-nutrients or micro-nutrients in bio-based fertilizers (BBFs) and

the valorisation of products deriving from the treatment of urban WW and sewage sludge, food, industrial WW and brine, as bio-based fertilizers (BBFs).

\*BBFs are not to be confused with animal metabolism -derived Fertilizers.

#### Contact details of the interviewer

WalNUT consortium country	
WalNUT consortium partner	

#### Contact details of the interviewee

Can we contact you in order to register in the WalNUT platform?

(In this platform, WW streams will be tracked and traced from their production, to their collection, treatment and valorization as fertilizing products)

YES	NO
-----	----

If yes, please fill-in your contact details:

Company Name	
Address	
Email/Site	
Phone number	
LinkedIn (company/personal)	
Company Capacity	1-10, 11-50, 50-100, 100-200 personnel

*\*Unless stated otherwise, please highlight the text that best describes your answer or mark with an 'X'.*



- In case you use recovered nutrients or WW Treatment (WWT)/Nutrient Recovery (NR)-based products (i.e. economically prime important nutrient resource based products such as STRUvite, biochar, etc.) please fill-in **PART B (for all interviewees)**
- In case you have never utilized nutrients deriving from NR options for BBF manufacturing or WWT (NR)-based products (i.e. economically prime important nutrient resource based products such as STRUvite, biochar, etc.), please go directly to **Block 5 ‘Identifying the preconditions or factors that drive or hamper the deployment of recovered nutrients and of economically prime important nutrient resource-based products in BBFs’**



8.6.1 Block 4 Allocation of lock-ins and barriers from the utilization of recovered nutrients that hamper the performance technologies targeting the synthesis and the final use of BBFs

Get to know you

What is the origin of your recovered nutrients or nutrient-rich WWT (NR)-based products (i.e. economically prime important nutrient resource based products such as STRUvite, biochar, etc.)?

- i. Urban WW or industrial WW (what industry)?
- ii. Type of effluent: STRUvite, Biochar, Incineration ash, Anaerobically digested bio-waste (compost), Landfill leachate, digestate, Sewage sludge (ash) or other?
- iii. The WW treatment technology (if available)?
- iv. The supply (t/yr or L/yr)?

---

Can you describe the commercial fertilizing end-product? (characterization, conversion/manufacturing/certification processes)

---

What is your experience with end-user acceptance of BBFs?

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Do the raw materials or recovered nutrients or WW based effluents you use for fertilizer manufacturing contain any of the following contaminants?			
	NO	YES (what), but the legal fertilizing standards for fertilizer manufacturing are met so I do not need to remove them	YES (what), I apply this technology for the purification
Potentially Toxic Elements (PTEs: Zn, Cu, Ni, Pb, Cd, Cr, As, Tl or Hg)			
Polycyclic aromatic hydrocarbons (PAHs)			
Organic micropollutants (OMPs: Pharmaceutical residuals - addictive substances-pesticides)			



Microbiological pathogens			
Other (*please specify)			

Harmonization of regional/national and European policy development directions for target pollutants that may affect CE marketable fertilizing products.

Do you comply with any regional/national/EU regulations concerning the aforementioned contaminants?

Are you aware of any differentiation of EU regulations with corresponding regulations in your country/region regarding the aforementioned substances?

Has this differentiation caused any problems to your entrepreneurial impetus? How would you describe them?



Please select the main obstacles you had to deal with utilization of recovered nutrients or WWT-derived products and how did you cope?

	Check if yes	Proposed solution
<b>1. Nutrient Composition</b>		
a. low or uncertain concentration of nutrients in WWT-derived products		
b. unstable (quality, quantity) supply from WW producers		
c. quality and safety of Recovered Nutrients (Contamination risks due to effluent composition)		
d. collection/transport/distribution of effluents/recovered nutrients from WW producers/WWTP		
<b>2. Marketability</b>		
a. exiting product sale price		
b. unreliable certification/authorization of BBFs (regional/national/EU regulations)		
c. complicated export of BBFs to other countries		
d. farmers are not willing to change their fertilizing practices (dose/equipment/product). No demand = no offer		
<b>3. Economical sustainability</b>		
a. initial capital expenditure (CAPEX)		
b. total operational expenditure (OPEX) (maintenance costs (2.5 % of CAPEX) - power/energy consumption costs - chemical/consumables costs - labour costs - treatment and disposal costs)		
c. lack of economic incentives for waste valorization - governmental support (Direct helps - subsidies or tax breaks - financial support with CAPEX / OPEX))		
d. not granted access to reliable Life Cycle Analyses (LCA) for the determination of environmental and economic advantages and disadvantages related to BBF manufacturing		
<b>4. Policy framework implications</b>		
a. conflict between legislation for P as a resource in fertilizer production or as a pollutant in WWT		
b. ownership of nutrients in effluents after they have been recovered in a WWTP		
c. other complexity of policies (fragmented decision-making, regional dependence (*please specify))		
d. Different regulation across the different MS		
<b>5. Random factors</b>		
a. lack of science-based knowledge on the evaluation of the BBFs performance on soil quality and crop yield in greenhouse and full field scale		
b. lack of science-based knowledge on utilization of BBFs as N fertilizers and their potential effect on nitrate leaching. (The measured nitrate residue gives an estimation of the nitrate amount that can potentially leach to ground and surface water).		



c. farmers prefer the use of chemical rather than bio-based fertilizers because the application of the latter involves more labor		
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<b>Governmental <u>measures to unlock the barriers</u></b>		Strongly agree	Agree	Partially agree	Disagree	Strongly disagree	Comments
xix.	<i>Enactment of minimum amount of recovered nutrients in BBFs.</i>						
xx.	<i>Obligation in the use of recovered nutrients first instead of minerals.</i>						
xxi.	<i>Prohibition of/increase in charges for storage and non-selective effluent incineration</i>						
xxii.	<i>Price guarantee of recovered nutrients/nutrient rich WWT derived effluents</i>						
xxiii.	<i>Tax benefits for using renewable raw materials. / Tax in the use of mineral sources for fertilizers.</i>						
xxiv.	<i>Commercial agreements for exclusivity of next-generation BBF production technology to introduce to the marketplace.</i>						
xxv.	<i>R&amp;D grants for elaboration of new BBF manufacturing technologies</i>						
xxvi.	<i><b>Process innovation:</b> Direct helps - financial support in more demanding pre-treatment (purification - removal of contaminants) processes of the recovered nutrients from WW streams (CAPEX / OPEX)</i>						
xxvii.	<i><b>Process &amp; product innovation:</b> Direct helps - financial support in innovative Fertilizer Manufacturing Technologies for the utilization of economically prime important nutrient resource based products (CAPEX / OPEX)</i>						
<b>Other measures</b>							
Due to the nature of nutrient rich effluents after WW treatment, building small scale fertilizer installations (by a technology provider) on the generation site, managed by fertilizer manufacturers would be a practical solution to the problem of collection, sanitation and downgrading during transport.							



Modern product portfolio will attract new customers (e.g. private households)						
Access to open science repositories with innovative available information ready to use.						
Involvement of technology providers in transformation of economically prime important nutrient resource based products into BBFs						



## Compliance with Reg (EU) 2019/1009

How will your entrepreneurship benefit from Reg (EU) 2019/1009?			
How long will the transitional period in your enterprise last for the smooth implementation of the Reg (EU) 2019/1009 from 16th July 2022?	1 year	2-4 years	>5 years
Please describe the challenges you will face during the compliance with Reg (EU) 2019/1009 (to be implemented 16 <sup>th</sup> July 2022) regarding:			
New product definitions			
Lack of product definitions			
Other (*please specify)			
Do you have any proposed measures to facilitate the implementation of Reg (EU) 2019/1009?			

**Annotation of 'Notified Body':** Does your product portfolio contain any CE labelled products? If yes, what is the current procedure followed for evaluation - certification - authorization? How will this procedure be affected by the implementation of Reg (EU) 2019/1009?

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*Do you have any additional comments, suggestions or questions on Nutrient Recovery and valorization of Waste Water streams for Bio-fertilization purposes?*

*Thank you for your feedback. We really appreciate your time.*



### 8.6.2 Block 5 'Identifying the preconditions or factors that drive or hamper the deployment of recovered nutrients and of economically prime important nutrient resource-based products in BBFs'

What has kept you from already using recovered nutrients or economically prime important nutrient resource-based products in BBFs manufacturing?

<b>NR: why &amp; how?</b>		
Unaware of recovered nutrients perception as a raw material for fertilizers - Unaware of nutrient-rich effluents' benefits - Unaware of social impact of recovered nutrients	I do not have access to economic feasibility data for recovered nutrients utilization for BBF manufacturing	Lack of engineering expertise and knowledge of purification processes after WWT
Lack of engineering expertise and open knowledge of alteration/adaption of manufacturing processes for bio-based fertilizers' synthesis	Need for technological assistance (training-high level of operator attention-expertise & follow-on operational support)	
<b>Financial barriers</b>		
Initial capital expenditure (CAPEX) of construction and equipment for bio-based fertilizers manufacturing processes.	Not sustainable extra total operational expenditure (OPEX) (maintenance costs (2.5 % of CAPEX) - power/energy consumption costs - chemical/consumables costs - labour costs - treatment and disposal costs)	Prohibitive Whole Life Cost (WLC, INITIAL capex + (Annual OPEX x 14) of bio-based fertilizers manufacturing processes for a life span of 40 years
I have designed (bench/lab scale innovative or adaptive) processes for the utilization of recovered nutrients but cannot find financial support for up-scaling.	There is limited accessible commercialization pathway/market for bio-based fertilizers.	
<b>Regulation</b>		
Unaware of future restrictions on mineral fertilizers utilization	Unaware of regulatory updates framework on inclusivity of economically prime important nutrient resource-based products	Every Member State has different nutrient reuse standards, which is the primary cost driver
<b>Effluent composition</b>		
Low nutrient/economically prime compounds concentrations in WW/fermenter effluent/sludges can make BBF synthesis uneconomical.	I cannot guarantee the quality of the recovered nutrients because of the low effluent purity (pathogens, and/or other contaminants) to enter the market.	Not consistent effluent composition.



<b>Recovered nutrients</b>		
If recovered nutrients/nutrient rich effluents are not used on site, distribution and transport have to be organized (geographical and temporal discrepancies between supply and demand, lack of infrastructure, or cost).	Price of recovered nutrients is considerably higher than price of mineral raw materials.	Existing BBF product sale price does not make the BBF synthesis economically feasible.



Have you ever taken any of the following steps to use recovered nutrients or economically prime important nutrient resource-based products in BBF manufacturing?

	YES/NO	What BARRIER(S) did you meet?
Regulation framework analysis (Recovered nutrients or effluent quality)		
BBF manufacturing process / business feasibility assessment (Technical / economical)		
Identification / Characterization of recovered nutrients / effluents composition		
Find technology provider for innovative BBF synthesis or adaption of existing manufacturing processes		
Survey on potential market for BBF products (farmers, agricultural associations)		
Other (elaborate) _____		

Motives to be considered for the utilization of recovered nutrients or economically prime important nutrient resource-based products in BBF manufacturing

Rate with 1 (Yes, I would implement it for this) -2 (Maybe I would consider these options) -3 (No, I would not implement it for this)	
13. Techno economically feasible BBF manufacturing (CAPEX, OPEX)	
14. Motivation to be environmentally friendly (valorization of effluents, depletion of minerals'ores) / User acceptance for the application of BBFs	
15. High purity of Recovered Nutrients due to effluent's composition (No risk of contamination of food chain)	
16. Financial support from political institutions to share the risks of innovation/alteration/implementation	
17. Market place and guaranteed value of BBFs	
18. New line of sustainable products in portfolio	
19. External interactions (Exports to other countries, Approach of new partners (WW production/treatment companies, BBF synthesis technology providers)	
20. Direct helps - financial support in scaling-up innovations or adaptations for BBF manufacturing (CAPEX / OPEX)	
21. Enactment of minimum amount of recovered nutrients in fertilizers and price guarantee.	
22. Tax in the use of mineral sources for fertilizers	
23. Adaption of NR practices by competitors will be a motivating factor also reducing access price to technology and reducing the price of BBFs.	



24. A network allowing me to identify other businesses from the rest of the WW chain (recovered nutrients providers - effluent producers, end-users) next to my business will minimise the cost of logistics.	
25. Other (*please specify)	



Compliance with Reg (EU) 2019/1009

How will your entrepreneurship benefit from Reg (EU) 2019/1009?			
How long will the transitional period in your enterprise last for the smooth implementation of the Reg (EU) 2019/1009 from 16th July 2022?	1 year	2-4 years	>5 years
Please describe the challenges you will face during the compliance with Reg (EU) 2019/1009 (to be implemented 16 <sup>th</sup> July 2022) regarding:			
New product definitions			
Lack of product definitions			
Other (*please specify)			
Do you have any proposed measures to facilitate the implementation of Reg (EU) 2019/1009?			

**Annotation of ‘Notified Body’:** Does your product portfolio contain any CE labelled products? If yes, what is the current procedure followed for evaluation - certification - authorization? How will this procedure be affected by the implementation of Reg (EU) 2019/1009?



*Do you have any additional comments, suggestions or questions on Nutrient Recovery and valorization of Waste Water streams for Bio-fertilization purposes?*

*Thank you for your feedback. We really appreciate your time.*



## 9 Annex II

### 9.1 Non-disclosure agreement for WalNUT Questionnaires

This informed consent form and non-disclosure agreement (the “Agreement”) is entered into, by and between the interviewee (“Disclosing Party”) and the Unit of Environmental Science and Technology (NTUA), located at the School of Chemical Engineering of the National Technical University of Athens, 9, Iroon Polytechniou St., Zographou Campus, Athens, 157 73, Greece, (“Receiving Party”) for the purpose of preventing the unauthorized disclosure of Confidential Information as defined below. The parties agree to enter into a confidential relationship with respect to the disclosure of certain proprietary and confidential information (“Confidential Information”).

Project acronym: WalNUT

Project name: Closing waste water cycles for nutrient recovery

Grant Agreement reference number: 101000752

Start date of the project: 1<sup>st</sup> September 2021

Expected end date of the project: 28<sup>th</sup> February 2026

Whereas Receiving Party would like to ask Disclosing Party to participate in this interview, whose objective is to gain information and a better understanding of using novel fertilising products against mineral fertilisers. Receiving Party highly value Disclosing Party opinion: Disclosing Party answers will be considered and help Receiving Party in the course of the assessment and validation process of the WalNUT project results. WalNUT aims to develop the necessary concepts and technological solutions to re-design the value and supply chains of nutrients from waste water and brine. The involvement of



representatives covering the whole supply chain of waste water, brine and nutrient recovery will provide an excellent opportunity to showcase the full potential of waste water and brine as a raw material for biofertilisers production.

For more information about the project, it can be visited the webpage <https://walnutproject.eu/>.

Whereas the Disclosing Party participation is entirely voluntary. Completing the interview should take around 15 minutes.

Whereas the information Disclosing Party provides is entirely confidential. The data or any other personal identifying information will not appear in any publications resulting from this research without Disclosing Party explicit consent. The information gained from this interview will only be used for the above objectives, and will not be exploited for any other purpose or recorded in excess of what is required for this research. There are no known or anticipated risks to you as a participant in this study.

Whereas by filling in this interview, Disclosing Party states to understand its purpose and consent to the use of the data as indicated above. Should Disclosing Party decide not to complete the interview until its end, the data previously entered up to that point will be used, unless Disclosing Party indicates otherwise in the questions below.

Whereas this Privacy Statement regulates the collection and processing of Disclosing Party data for the development of the WALNUT project, and storage in the server of the Unit of Environmental Science and Technology at the School of Chemical Engineering of the National Technical University of Athens, 9, Iroon Polytechniou St., Zographou Campus, Athens, 157 73, Greece, e-mail [jelica@central.ntua.gr](mailto:jelica@central.ntua.gr), Tel. +30 210 772 3154, which acts as **Data Controller and Data Processor**.

The Data Protection Officer's e-mail is [elke\\_dpo@mail.ntua.gr](mailto:elke_dpo@mail.ntua.gr).

Whereas all the recommended security measures have been implemented for the protection of the servers and the collected data.

The Contracting Parties agree to the following terms and conditions:



1. Purpose: The purpose of this informed consent form is to provide information about our compliance with the General Data Protection Regulation (hereinafter GDPR)/ GR laws 4624/2019 and 3471/2006. Under the condition of your prior written consent to provide feedback for the project, we would like to use the information to develop our research; but all the personal data provided will remain confidential. Confidential Information” shall include all information or material that has or could have the utility of any kind in the present project in which Receiving Parties are engaged.
2. Receiving Parties: The data processed in the project can be accessed by the consortium members of WalNUT project. For the dissemination purposes of the WalNUT project, the data after assessment can be used anonymously (except for the country of origin) in publications and in conferences. Likewise, your data may be communicated to the European Commission as the public organism that provides funding for the project. International data transfers: No international data transfers are expected, thus being not applicable Chapter V of the GDPR.
3. Automated decisions: No automated decisions are planned regarding the data collected (article 22 of the GDPR).
4. Conservation time: In application of current regulations, the data collected will be stored for the shortest time possible:
  - -While the WalNUT project lasts (Expected end date of the project: 28th February 2026).
  - -After the end, your data will be kept for the fulfilment of the legal obligations that are applicable to those responsible for the treatment that, in each case, corresponds.
5. Rights of Disclosing Party: This informed consent form guarantees that participation in the project is voluntary. If you have any questions you can at any moment exercise the rights recognised in Chapter III of GDPR (articles 15 and so on); including but not limited to: the right to access, right to be forgotten or right to object. For the exercise of these rights please contact [kyriazimaria@mail.ntua.gr](mailto:kyriazimaria@mail.ntua.gr).

If Disclosing Party would like to know more or exercise their rights, may contact:

- the Unit of Environmental Science and Technology (NTUA): phone +30 210 772 3154
- the NTUA Project Manager for WalNUT: Dr Maria Kyriazi, [kyriazimaria@mail.ntua.gr](mailto:kyriazimaria@mail.ntua.gr)
- the responsible for the Unit of Environmental Science and Technology (NTUA) Database, Dr Maria Kyriazi, [kyriazimaria@mail.ntua.gr](mailto:kyriazimaria@mail.ntua.gr)

Obligations of Receiving Party. Receiving Party shall hold and maintain the Confidential Information in strictest confidence for the sole and exclusive benefit of the Disclosing Party. Receiving Party shall carefully restrict access to Confidential Information to employees, contractors and third parties as is reasonably required and shall require those persons to sign nondisclosure restrictions at least as protective as those in this Agreement. Receiving Party’s obligations under this Agreement do not extend to information that is: (a) publicly known at the time of disclosure or subsequently becomes publicly known through no fault of the Receiving Party; (b) discovered or created by the Receiving Party before disclosure by Disclosing Party; (c)



learned by the Receiving Party through legitimate means other than from the Disclosing Party or Disclosing Party's representatives, or (d) is disclosed by Receiving Party with Disclosing Party's prior written approval.

6. Rights of Receiving Parties:

- Receiving Parties can, after signing of this Agreement, use for Receiving Party's benefit, publish, copy, or otherwise disclose to others, or permit the use by others for their benefit or to the detriment of Disclosing Party, any Confidential Information.
- Receiving Party shall return to Disclosing Party any records, notes, and other written documents in its possession pertaining to Confidential Information immediately if Disclosing Party requests it in writing.
- Receiving Party shall hold and maintain the Confidential Information in strictest confidence.
- Receiving Party shall carefully restrict access to Confidential Information to employees, contractors and third parties not engaged in the present project.

7. Legitimation basis: WalNUT project requests your express consent to use your inputs for the implementation of our project (article 6.1.a of the GDPR).



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