PRODUCT CATEGORY RULES (PCR)
DATE 2024-01-26

MINERAL OR CHEMICALS FERTILIZERS

PRODUCT CATEGORY CLASSIFICATION: UN CPC 3461, 3462, 3463, 3464 & 3465

PCR 2010:20
VERSION 3.0.3

VALID UNTIL: 2025-02-03

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1 INTRODUCTION

This document constitutes Product Category Rules (PCR) developed in the framework of the International EPD® System: a programme for type III environmental declarations[1] according to ISO 14025:2006. Environmental Product Declarations (EPD) are voluntary documents for a company or organisation to present transparent information about the life cycle environmental impact for their goods or services.

The rules for the overall administration and operation of the programme are the General Programme Instructions, publicly available at www.environdec.com. A PCR complements the General Programme Instructions and the standards by providing specific rules, requirements and guidelines for developing an EPD for one or more specific product categories (see Figure 1). A PCR should enable different practitioners using the PCR to generate consistent results when assessing products of the same product category.

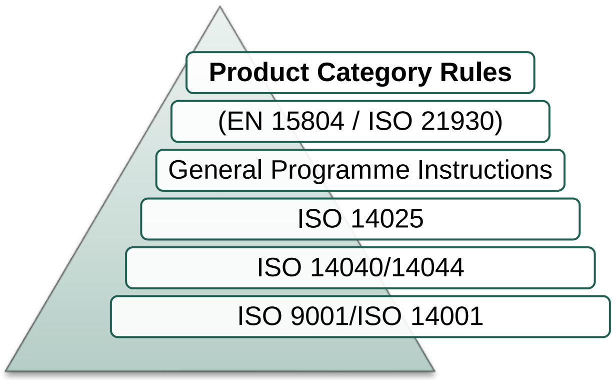

Figure 1 Illustration PCR in relation to the hierarchy of standards and other documents.

Within the present PCR, the following terminology is adopted:

- The term “shall” is used to indicate what is obligatory.
- The term “should” is used to indicate a recommendation, rather than a requirement.
- The term “may” or “can” is used to indicate an option that is permissible

For the definition of terms used in the document, see the normative standards.

A PCR is valid for a pre-determined period of time to ensure that it is updated at regular intervals. The latest version of the PCR is available via www.environdec.com. Stakeholder feedback on PCRs is very much encouraged. Any comments on this PCR document may be given via the PCR Forum at www.environdec.com or sent directly to the PCR moderator during its development or during the period of validity.

Any references to this document should include the PCR registration number, name and version.

The programme operator maintains the copyright of the document to ensure that it is possible to publish, update when necessary, and available to all organisations to develop and register EPDs. Stakeholders participating in PCR development should be acknowledged in the final document and on the website.

[1] Type III environmental declarations in the International EPD® System are referred to as EPD, Environmental Product Declarations.

2 GENERAL INFORMATION

2.1 ADMINISTRATIVE INFORMATION

Name:	Mineral or chemical fertilizers
Registration number and version:	2010:20, Version 3.0.3
Programme:	EPD® The International EPD® System
Programme operator:	EPD International AB, Box 210 60, SE-100 31 Stockholm, Sweden. Website: www.environdec.com E-mail: info@environdec.com
PCR moderator:	Francesca Falconi, francesca.falconi@lca-lab.com
PCR committee:	Federico Tonelli, SCAM S.p.A., federico.tonelli@scam.it Daniel El Chami, Roullier, Daniel.ElChami@roullier.com
Date of publication and last revision:	2024-01-26 (Version 3.0.3) Version 1.0 was published 2010-12-10. Version 2.0 was published 2016-01-11. Version 3.0 was published 2020-06-03. A version history is available in Section 8.
Valid until:	2025-02-03
Schedule for renewal:	A PCR is valid for a pre-determined period of time to ensure that it is updated at regular intervals. When the PCR is about to expire the PCR moderator shall initiate a discussion with the Secretariat how to proceed with updating the document and renewing its validity. A PCR document may be revised during its period of validity provided significant and well-justified proposals for changes or amendments are presented. See www.environdec.com for up-to-date information and the latest version.
Standards conformance:	▪ General Programme Instructions of the International EPD® System, version 3.01, based on ISO 14025 and ISO 14040/14044 ▪ PCR Basic Module, CPC Division 34 Basic chemicals, version 3.02
PCR language(s):	This PCR was developed and is available in English. In case of translated versions the English version takes precedence in case of any discrepancies.

2.2 SCOPE OF PCR

2.2.1 PRODUCT CATEGORY DEFINITION AND DESCRIPTION

This document provides Product Category Rules (PCR) for the assessment of the environmental performance of mineral or chemical fertilizers (nitrogenous, phosphatic and potassic) and the declaration of this performance by an EPD. The product category corresponds to UN CPC 3461, 3462, 3463, 3464 and 3465.

This PCR covers the product group mineral or chemical fertilizers, which is defined by UN CPC classes 3461, 3462, 3463, 3464 and 3465 categorized according to UN CPC version 2.0:

- Division: 34 - Basic chemicals -
  - Group: 346 - Fertilizers and pesticides
    - Class 3461 - Mineral or chemical fertilizers, nitrogenous
    - Class 3462 - Mineral or chemical fertilizers, phosphatic
    - Class 3463 - Mineral or chemical fertilizers, potassic
    - Class 3464 - Mineral or chemical fertilizers containing at least two nutrients of nitrogen, phosphate and potash
    - Class 3465 - Other fertilizers.

The following related UN CPC classes are not included in the scope of this PCR: Class 3466 - Insecticides, fungicides, herbicides and disinfectants.

2.2.2 GEOGRAPHICAL REGION

This PCR is applicable to be used globally.

2.2.3 EPD VALIDITY

An EPD based on this PCR shall be valid from its registration and publication at www.environdec.com and for a five year period starting from the date of the verification report ("approval date"), or until the EPD has been de-registered from the International EPD® System.

An EPD shall be updated and re-verified during its validity if changes in technology or other circumstances have led to:

- an increase of 10% or more of any of the indicators listed in Section 5.4.5.1,
- errors in the declared information, or
- significant changes to the declared product information, content declaration, or additional environmental information.

If such changes have occurred, but the EPD is not updated, the EPD owner shall contact the Secretariat to de-register the EPD.

3 PCR REVIEW AND BACKGROUND INFORMATION

This PCR was developed in accordance with the process described in the General Programme Instructions of the International EPD® System, including PCR review and open consultation.

3.1 PCR REVIEW

3.1.1 VERSION 2.0

PCR review panel:	The Technical Committee of the International EPD® System. A full list of members available on www.environdec.com. The review panel may be contacted via info@environdec.com. Members of the Technical Committee were requested to state any potential conflict of interest with the PCR moderator or PCR committee, and were excused from the review.
Chair of the PCR review:	Lars-Gunnar Lindfors
Review dates:	2015-11-04 until 2015-12-15

3.1.2 VERSION 3.0

PCR review panel:	The Technical Committee of the International EPD® System. A full list of members available on www.environdec.com. The review panel may be contacted via info@environdec.com. Members of the Technical Committee were requested to state any potential conflict of interest with the PCR moderator or PCR committee, and were excused from the review. Adriana del Borghi was excused from the review.
Chair of the PCR review:	Filippo Sessa
Review dates:	2020-04-02 until 2020-05-08

3.2 OPEN CONSULTATION

3.2.1 VERSION 1.0

This PCR was available for open consultation from 2010-07-12 until 2010-09-12, during which any stakeholder was able to provide comments by posting on the PCR forum on www.environdec.com or by contacting the PCR moderator.

Stakeholders were invited via e-mail or other means to take part in the open consultation, and were encouraged to forward the invitation to other relevant stakeholders.

3.2.2 VERSION 2.0

This PCR was available for open consultation from 2015-08-14 until 2015-10-14, during which any stakeholder was able to provide comments by posting on the PCR forum on www.environdec.com or by contacting the PCR moderator.

Stakeholders were invited via e-mail or other means to take part in the open consultation, and were encouraged to forward the invitation to other relevant stakeholders.

3.2.3 VERSION 3.0

This PCR was available for open consultation from 2020-02-05 until 2020-04-01, during which any stakeholder was able to provide comments by posting on the PCR forum on www.environdec.com or by contacting the PCR moderator.

Stakeholders were invited via e-mail or other means to take part in the open consultation, and were encouraged to forward the invitation to other relevant stakeholders. No stakeholders that contributed with comments agreed to be listed as contributors in the PCR.

3.3 EXISTING PCRS FOR THE PRODUCT CATEGORY

As part of the development of this PCR, existing PCRs were considered in order to avoid overlaps in scope. The existence of such documents was checked in the public PCR listings of the following programmes based on ISO 14025 or similar:

- International EPD® System. www.environdec.com.

No existing PCRs with overlapping scope were identified.

3.4 REASONING FOR DEVELOPMENT OF PCR

This PCR was developed in order to enable publication of Environmental Product Declarations (EPD) for this product category based on ISO 14025, ISO 14040/14044 and other relevant standards to be used in different applications and target audiences.

3.5 UNDERLYING STUDIES

The methodological choices made during the development of this PCR (functional unit/declared unit, system boundary, allocation methods, impact categories, data quality rules, etc.) in this PCR were primarily based on the following underlying studies:

- Life Cycle Assessment (LCA) of granular and liquidi organo-mineral fertilizers, RT-176, LCA-lab SRL, 2018-07-05.
- Effect of different organic matrices on the flow of N, P, K in the soil-plant system, Coppola E., 1993.
- Organo-mineral fertilizers for corn, Tassan Mazzocco G., Contin M. 2000.
- Life Cycle Assessment (LCA) of different fertilizer product types, K.Hasler, S.Broring, S.W.F.Omta, H.-W.Olfs, 2015.
- Life Cycle Assessment of organic and mineral fertilizers in a crop sequence of cauliflower and tomato, R. Quiros, G.Villalba, X. Gabarrell, P.Munoz, 2015.
- Melone e pomodoro da industria: efficienza della concimazione con Organo Minerali liquidi, P.P.Pasotti, M. Pelliconi, V.Tisselli, S. Tagliavini, 2017 Colture Protette N° 4 aprile 2017

4 GOAL AND SCOPE, LIFE CYCLE INVENTORY AND LIFE CYCLE IMPACT ASSESSMENT

The goal of this section is to provide specific rules, requirements and guidelines for developing an EPD for the product category as defined in Section 2.2.1.

4.1 DECLARED UNIT

The declared unit shall be defined as 1000 kg of product and its packaging. The reference flow shall be defined the at the customer gate, at the shelf or the retailer or at the market place.

The declared unit shall be stated in the EPD. The environmental impact shall be given per declared unit. In the EPD a statement should be added to specify that the declared unit may have different functionality depending on the composition of the product that is declared.

4.2 REFERENCE SERVICE LIFE (RSL)

Not applicable for this product category.

4.3 SYSTEM BOUNDARY

The International EPD® System uses an approach where all attributional processes from “cradle to grave” should be included using the principle of “limited loss of information at the final product”. This is especially important in the case of business-to-consumer communication.

The scope of this PCR and EPDs based on it is cradle to grave.

4.3.1 LIFE CYCLE STAGES

For the purpose of different data quality rules and for the presentation of results, the life cycle of products is divided into three different life cycle stages:

- Upstream processes (from cradle-to-gate)
- Core processes (from gate-to-gate)
- Downstream processes (from gate-to-grave)

In the EPD, the environmental performance associated with each of the three life-cycle stages above shall be reported separately. The processes included in the scope of the PCR and belonging to each life cycle stage are described in Sections 4.3.1.1 to 4.3.1.3.

4.3.1.1. Upstream processes

The following attributional processes are part of the product system and classified as upstream processes:

- Extraction of non-renewable resources (e.g. operation of oil platforms and pipelines)
- Growing and harvesting of renewable resources (e.g. agricultural planting)
- Refining, transfer and storage of extracted or harvested resources into feedstock for production
- The production processes of energy wares used in the extraction and refinement
- Impacts due to the production of electricity and fuels used in the upstream module
- Manufacturing of primary and secondary packaging

Upstream processes not listed may also be included. All elementary flows at resource extraction shall be included, except for the flows that fall under the general cut-off rule in Section 4.5.

4.3.1.2. Core processes

The following attributional processes are part of the product system and classified as core processes:

- External transportation to the core processes
- Production processes
- Recycling of waste or secondary materials for use in production
- Storage
- Maintenance (e.g. of the machines)
- Waste treatment of waste generated during manufacturing;
- Impacts due to the production of electricity and fuels used in the core module

Manufacturing processes not listed may also be included. The production of the raw materials used for production of all product parts shall be included. A minimum of 99% of the total weight of the declared product including packaging shall be included.

The technical system shall not include:

- Manufacturing of production equipment, buildings and other capital goods.
- Business travel of personnel.
- Travel to and from work by personnel.
- Research and development activities.

4.3.1.3. Downstream processes

The following attributional processes are part of the product system and classified as downstream processes:

- Transportation from preparation to an average retailer/distribution platform
- The customer or consumer use of the product.
- End-of-life processes of packaging waste.

4.3.2 OTHER BOUNDARY SETTING

4.3.2.1. Boundary towards nature

Boundaries to nature are defined as flows of material and energy resources from nature into the system. Emissions to air, water and soil cross the system boundary when they are emitted from or leaving the product system.

4.3.2.2. Boundaries in the life cycle

See Section 4.3.1. The EPD may present the information divided into additional sub-divisions.

4.3.2.3. Boundaries towards other technical systems

See Section 4.6.2.

4.4 SYSTEM DIAGRAM

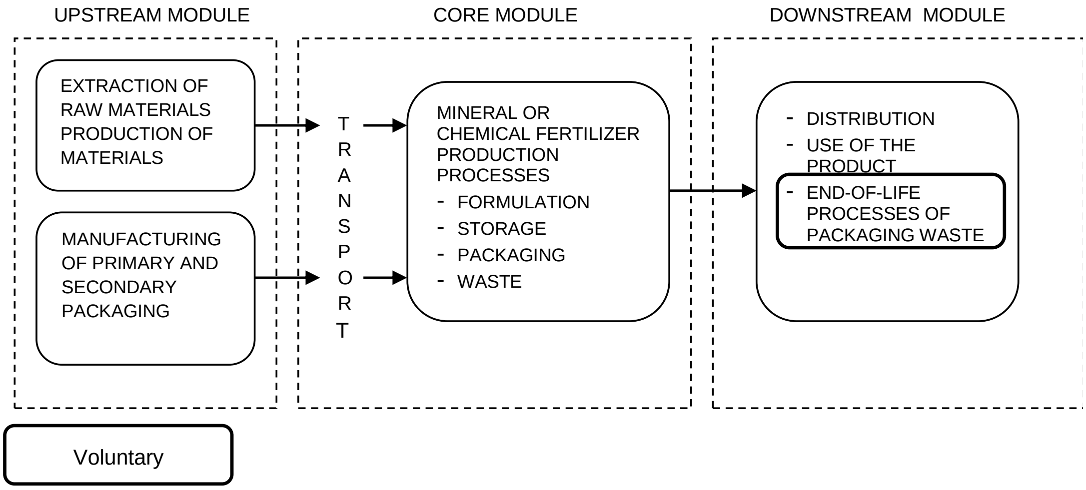

Figure 2 System diagram illustrating the processes that are included in the product system, divided into upstream, core and downstream processes.

4.5 CUT-OFF RULES

Data for elementary flows to and from the product system contributing to a minimum of 99% of the declared environmental impacts shall be included (not including processes that are explicitly outside the system boundary as described in Section 4.3).

The check for cut-off rules in a satisfactory way is through the combination of expert judgment based on experience of similar product systems and a sensitivity analysis in which it is possible to understand how the un-investigated input or output could affect the final results.

4.6 ALLOCATION RULES

4.6.1 CO-PRODUCT ALLOCATION

The following step-wise procedure shall be applied for multifunctional products and multiproduct processes:

1. Allocation shall be avoided, if possible, by dividing the unit process into two or more sub-processes and collecting the environmental data related to these sub-processes.
2. If allocation cannot be avoided, the inputs and outputs of the system shall be partitioned between its different products or functions in a way that reflects the underlying physical relationships between them; i.e. they should reflect the way in which the inputs and outputs are changed by quantitative changes in the products or functions delivered by the system.

4.6.2 REUSE, RECYCLING, AND RECOVERY

In the framework of the International EPD® System, the methodological choices for allocation for reuse, recycling and recovery have been set according to the polluter pays principle (PPP). This means that the generator of the waste shall carry the full environmental impact until the point in the product's life cycle at which the waste is transported to a scrapyard or the gate of a waste processing plant (collection site). The subsequent user of the waste shall carry the environmental impact from the processing and refinement of the waste but not the environmental impact caused in the "earlier" life cycles. See General Programme Instruction for further information and examples.

4.7 DATA QUALITY REQUIREMENTS

An LCA calculation requires two different kinds of information:

- data related to the **environmental aspects** of the considered system (such materials or energy flows that enter the production system). These data usually come from the company that is performing the LCA calculation.
- data related to the **life cycle impacts** of the material or energy flows that enter the production system. These data usually come from databases.

Data on environmental aspects shall be as specific as possible and shall be representative of the studied process.

Data on the life cycle of materials or energy inputs are classified into three categories – specific data, selected generic data, and proxy data, defined as follows:

- **specific data** (also referred to as "primary data" or "site-specific data") – data gathered from the actual manufacturing plant where product-specific processes are carried out, and data from other parts of the life cycle traced to the specific product system under study, e.g. materials or electricity provided by a contracted supplier that is able to provide data for the actual delivered services, transportation that takes place based on actual fuel consumption, and related emissions, etc.,
- **generic data** (sometimes referred to as "secondary data"), divided into**:**
  - **selected generic data** – data from commonly available data sources (e.g. commercial databases and free databases) that fulfil prescribed data quality characteristics for precision, completeness, and,
  - **proxy data** – data from commonly available data sources (e.g. commercial databases and free databases) that do not fulfil all of the data quality characteristics of "selected generic data".

As a general rule, specific data shall always be used, if available, after performing a data quality assessment. It is mandatory to use specific data for the core processes as defined above. For the upstream processes, downstream processes, and infrastructure, generic data may also be used if specific data are not available.

For raw materials of the upstream process specific data should be used for the materials that contributes more than 20% of the fertilizers formula.

Any data used should preferably represent average values for a specific reference year. However, the way these data are generated could vary, e.g. over time, and in such cases they should have the form of a representative annual average value for a specified reference period. Such deviations should be declared.

4.7.1 RULES FOR USING GENERIC DATA

The attributional LCA approach in the International EPD® System forms the basic prerequisites for selecting generic data. To allow the classification of generic data as "selected generic data", they shall fulfil selected prescribed characteristics for precision, completeness, and representativeness (temporal, geographical, and technological), such as:

- the reference year must be as current as possible and preferably assessed to be representative for at least the validity period of the EPD,
- the cut-off criteria to be met on the level of the modelled product system are the qualitative coverage of at least 99% of energy, mass, and overall environmental relevance of the flows,
- completeness in which the inventory data set should, in principle, cover all elementary flows that contribute to a relevant degree of the impact categories, and
- the representativeness of the resulting inventory in the given temporal, technological, and geographical reference should, as a general principle, be better than ±5% of the environmental impact of fully representative data.

If selected generic data that meets the requirements of the International EPD® System are not available as the necessary input data, proxy data may be used and documented. The environmental impacts associated with proxy data shall not exceed 10% of the overall environmental impact from the product system.

The EPD may include a data quality declaration to demonstrate the share of specific data, selected generic data and proxy data for the environmental impacts.

4.8 RECOMMENDED DATABASES FOR GENERIC DATA

No specific databases are recommended for generic data. Admissible data has to respect the system boundaries set in the PCR as well as to meet the requirements of the International EPD® System for data quality, representativeness, review and scope of documentation. If specific data, selected generic data that meets the requirements of the International EPD® System is not available as the necessary input data, proxy data may be used and documented. The environmental impacts associated to proxy data must not exceed 10% of the overall environmental impact from the product system.

4.9 IMPACT CATEGORIES AND IMPACT ASSESSMENT

The EPD shall declare the default impact categories as described in the General Programme Instructions. The characterisation models and factors to use for the default impact categories are available on www.environdec.com/indicators and shall be updated on a regular basis based on the latest developments in LCA methodology and ensuring the market stability of EPDs. The source and version of the characterisation models and the factors used shall be reported in the EPD. Alternative regional life cycle impact assessment methods and characterisation factors are allowed to be calculated and displayed in addition to the default list. If so, the EPD shall contain an explanation of the difference between the different sets of indicators, as they may appear to the reader to display duplicate information.

4.10 OTHER CALCULATION RULES AND SCENARIOS

4.10.1 UPSTREAM PROCESSES

The following requirements apply to the upstream processes:

- Data referring to processes and activities upstream in a supply chain over which an organisation has direct management control shall be specific and collected on site.
- Data referring to contractors that supply main parts, packaging, or main auxiliaries should be requested from the contractor as specific data, as well as infrastructure, where relevant.
- The transport of main parts and components along the supply chain to a distribution point (e.g. a stockroom or warehouse) where the final delivery to the manufacturer can take place based on the actual transportation mode, distance from the supplier, and vehicle load.
- In case specific data is lacking, selected generic data may be used. If this is also lacking, proxy data may be used.
- For the electricity used in the upstream processes, electricity production impacts shall be accounted for in this priority when specific data are used in the upstream processes:
    1. Specific electricity mix as generated, or purchased, from an electricity supplier, demonstrated by a Guarantee of Origin (or similar, where reliability, traceability, and the avoidance of double-counting are ensured) as provided by the electricity supplier. If no specific mix is purchased, the residual electricity mix from the electricity supplier shall be used.[2]
    2. National residual electricity mix or residual electricity mix on the market
    3. National electricity production mix or electricity mix on the market.

    The mix of electricity used in upstream processes shall be documented in the EPD, where relevant.
- Packaging: specific data shall be used for the consumer packaging production if it is under the direct control of the organization or if the environmental impact related to the consumer packaging production is more than 10% of the total product environmental indicators. In other cases, generic data may be used. When consumer packaging shows the organization's logo, the LCA report should report the exerted/non exerted direct control on the production of consumer packaging by the organization.

4.10.2 CORE PROCESSES

The following requirements apply to the core processes:

- Specific data shall be used for the assembly of the product and for the manufacture of main parts as well as for on-site generation of steam, heat, electricity, etc., where relevant.
- For the electricity used in the core processes, electricity production impacts shall be accounted for in this priority:

[2] The residual electricity mix is the mix when all contract-specific electricity that has been sold to other customers has been subtracted from the total production mix of the electricity supplier.

1. Specific electricity mix as generated, or purchased, from an electricity supplier, demonstrated by a Guarantee of Origin (or similar, where reliability, traceability, and the avoidance of double-counting are ensured) as provided by the electricity supplier. If no specific mix is purchased, the residual electricity mix from the electricity supplier shall be used.[3]
2. National residual electricity mix or residual electricity mix on the market
3. National electricity production mix or electricity mix on the market.

The mix of electricity used in the core processes shall be documented in the EPD, where relevant.

- Transport from the final delivery point of raw materials, chemicals, main parts, and components (see above regarding upstream processes) to the manufacturing plant/place of service provision should be based on the actual transportation mode, distance from the supplier, and vehicle load, if available.
- Waste treatment processes of manufacturing waste should be based on specific data, if available.

4.10.3 DOWNSTREAM PROCESSES

The following requirements apply to the downstream processes:

- Use phase:

Modelling of the use phase consists of quantifying emissions (to air and water) from managed soils, due to fertilizer application.

For the use phase, the nitrogen quantity that is released in the environment has to be calculated considering the average value of UI (Uptake Index) (see Annex 1). If this approach is not possible because there is no experimental test data, it is possible to use the approach of the PCR for Arable and vegetable crops of the International EPD® System, which in any case is the approach for all the default data provided in the PCRs.

For the phosphorus emissions, if there are not specific data, it is possible to use the approach of PCR for Arable and vegetable crops of the International EPD® System.

For the nitrogen, as a reference for the repartition, it is necessary to keep into consideration the following nitrogen cycle (Figure 3) according to which in case of manuring with 100 nitrogen units the 68% of the nitrogen is present in different form in the soil (organic , unstable, immobilized) in the ground, the 27% is absorbed by the plant and the 5% is dispelled in the environment (reference: "Nitrogen uptake by crops soil distribution and recovery of urea-N in a sorghum whit rotation in different soils under Mediterranean conditions di P. Nannipieri et al., Plant and soil, 208: 43-56, 1999).

The unstable value is the 27% that will be replaced with the assimilation range (UI) indicated in the product description. The percentage that is released into the environment will be equally divided into air under form of NH_3, NO, N_2O and into water under form of organic N (N org), NH_{4+} , NO_{3-} .

EXAMPLE: If the assimilation average value is equal to 60%, it means that the remaining 40% will be divided according to the following relation: 73:5 = 40:x

therefore x, nitrogen percentage that is released into the environment, is equal to 2.7%. It will be considered a hypothetic 2.7 to be equally distributed into air under form of NH_3, NO, N_2O and into water under form of N org, NH_{4+} , NO_{3-}.

Making a numerical example, if we have a fertilizer with 1000 titles of nitrogen, 27 migrate in the environment as elementary N, of what, considering the atomic numbers of the single elements (N=7, O=8 e H=1) and calculating the due proportions:

- 4.5 (given by 27:6) of elementary nitrogen will become 6.42 of NH3 (10:7 = x:4.5)
- 4.5 (given by 27:6) of elementary nitrogen will become 9.64 ofi NO (15:7 = x:4.5)
- 4.5 (given by 27:6) of elementary nitrogen will become 15.42 of N2O (22:7 = x:4.5)
- 4.5 (given by 27:6) of elementary nitrogen will become 4.5 of N org
- 4.5 (given by 27:6) of elementary nitrogen will become 7.07 of NH4 (11:7 = x:4.5)
- 4.5 (given by 27:6) of elementary nitrogen will become 19.92 of NO3 (31:7 = x:4.5)

[3] The residual electricity mix is the mix when all contract-specific electricity that has been sold to other customers has been subtracted from the total production mix of the electricity supplier.

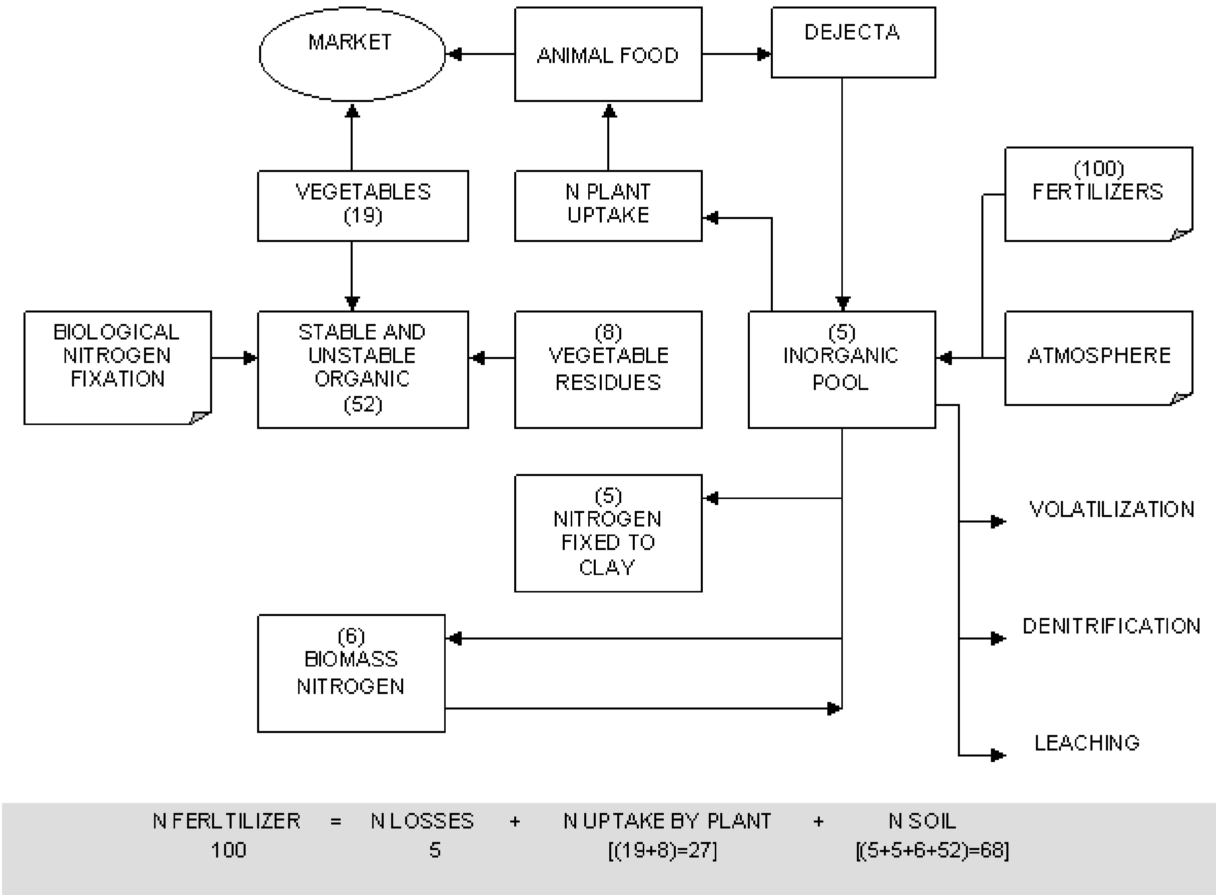

Figure 3 Nitrogen cycle

- End of life of packaging:

  This phase is voluntary. End-of-life scenarios for packaging could be calculated taking into account a typical scenario (statistics of the area in which the product is mainly distributed, compliant with current regulations). The hypotheses used for this estimation shall be declared in the EPD.

  Recommendations for the responsible and correct recycling of packaging materials, as well as recommendations for other waste treatment of product parts, if relevant, shall be provided (e.g. recycling declaration).

- The transport of the product to the customer shall be described in the reference PCR, which should reflect the actual situation to the best extent possible. The following priority should be used:

  1. Actual transportation distances and types.
  2. Calculated as the average distance of a product of that product type transported by different means of transport modes.
  3. Calculated as a fixed long transport, such as 1 000 km transport by lorry or 10 000 km by airplane, according to product type

- Scenarios for the end-of-life stage shall be technically and economically practicable and compliant with current regulations in the relevant geographical region based on the geographical scope of the EPD. Key assumptions regarding the end-of-life stage scenario shall be documented.

- If data of chemicals is lacking stoichiometry way may be used to model chemical processes.

5 CONTENT AND FORMAT OF EPD

EPDs based on this PCR shall contain the information described in this section. Flexibility is allowed in the formatting and layout provided that the EPD still includes the prescribed information. A generic template for EPDs is available via www.environdec.com

As a general rule the EPD content:

- shall be in line with the requirements and guidelines in ISO 14020 (Environmental labels and declarations - General principles),
- shall be verifiable, accurate, relevant and not misleading, and
- shall not include rating, judgements or direct comparison with other products.

An EPD should be made with a reasonable number of pages for the intended audience and use.

5.1 EPD LANGUAGES

EPDs should be published in English, but may also be published in additional languages. If the EPD is not available in English, it shall contain an executive summary in English including the main content of the EPD. This summary is part of the EPD and thus subject to the same verification procedure.

5.2 UNITS AND QUANTITIES

The following requirements apply for units and quantities:

- The International System of Units (SI units) shall be used, e.g., kilograms (kg), Joules (J) and metres (m). Reasonable multiples of SI units may be decided in the PCR to improve readability, e.g., grams (g) or megajoules (MJ). The following exceptions apply:
  - Resources used for energy input (primary energy) should be expressed as kilowatt-hours (kWh) or megajoules (MJ), including renewable energy sources, e.g., hydropower, wind power and geothermal power.
  - Water use should be expressed in cubic metres (m^3)
  - Temperature should be expressed in degrees Celsius (°C),
  - Time should be expressed in the units most practical, e.g., seconds, minutes, hours, days or years.
- Three significant figures[4] should be adopted for all results. The number of significant digits shall be appropriate and consistent.
- The thousand separator and decimal mark in the EPD shall follow one of the following styles (a number with six significant figures shown for illustration):
  - SI style (French version): 1 234,56
  - SI style (English version): 1 234.56

  In case of potential confusion or intended use of the EPD in markets where different symbols are used, the EPD shall state what symbols are used for thousand separator and decimal mark.
- Dates and times presented in the EPD should follow the format in ISO 8601. For years, the prescribed format is YYYY-MM-DD, e.g., 2017-03-26 for March 26th, 2017.
- The result tables shall:
  - Only contain values or the letters “INA” (Indicator Not Assessed). It is not possible to specify INA for mandatory indicators. INA shall only be used for voluntary parameters that are not quantified because no data is available.[5]
  - Contain no blank cells, hyphens, less than or greater than signs or letters (except “INA”).

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[4] Significant figures are those digits that carry meaning contributing to its precision. For example with two significant digits, the result of 123.45 shall be displayed as 120, and 0.12345 shall be displayed as 0.12. In scientific notation, these two examples would be displayed as $1.2*10^2$ and $1.2*10^{-2}$.

[5] This requirement does not intend to give guidance on what indicators are mandated (“shall”) or voluntary.

- Use the value 0 only for parameters that have been calculated to be zero.
- Footnotes shall be used to explain any limitation to the result value.

5.3 USE OF IMAGES IN EPD

Images used in the EPD, especially pictures featured on the cover page, may in themselves be interpreted as an environmental claim. Images such as trees, mountains, wildlife that are not related to the declared product should therefore be used with caution and in compliance with national legislation and best available practices in the markets in which the EPD is intended to be used.

5.4 EPD REPORTING FORMAT

The reporting format of the EPD shall include the following sections:

- Cover page (see Section 5.4.1)
- Programme information (see Section 5.4.2)
- Product information (see Section 5.4.3)
- Content declaration (see Section 5.4.4)
- Environmental performance (see Section 5.4.5)
- Additional environmental information (see Section 5.4.6)
- References (see Section 5.4.9)

The following information shall be included, when applicable:

- Information related to Sector EPDs (see Section 5.4.7)
- Differences versus previous versions (see Section 5.4.8)
- Executive summary in English (see Section 5.4.10)

5.4.1 COVER PAGE

The cover page shall include:

- Product name and image,
- Name and logotype of EPD owner,
- The text “Environmental Product Declaration” and/or “EPD”
- *Programme: The International EPD® System, www.environdec.com,*
- *Programme operator: EPD International AB*
- Logotype of the International EPD® System,
- EPD registration number as issued by the programme operator[6],
- *Date of publication (issue): 20XX-YY-ZZ,*
- *Date of revision: 20XX-YY-ZZ*, when applicable,
- *Date of validity; 20XX-YY-ZZ*
- A note that “*An EPD should provide current information, and may be updated if conditions change. The stated validity is therefore subject to the continued registration and publication at www.environdec.com*.”

[6] The EPD shall not include a “registration number” if such is provided by the certification body, as this may be confused with the registration number issued by the programme operator.

- A statement of conformity with ISO 14025,

5.4.2 PROGRAMME INFORMATION

The programme information section of the EPD shall include:

- Address of programme operator: *EPD International AB, Box 210 60, SE-100 31 Stockholm, Sweden, E-mail: info@environdec.com*
- The following mandatory statement from ISO 14025: "*EPDs within the same product category but from different programmes may not be comparable*."
- A statement that the EPD owner has the sole ownership, liability and responsibility of the EPD
- Information about verification[7] and reference PCR in a table with the following format and contents:

Product category rules (PCR): *<name, registration number, version and UN CPC code(s)>*
PCR review was conducted by: *<name and organisation of the review chair, and information on how to contact the chair through the programme operator>*
Independent third-party verification of the declaration and data, according to ISO 14025:2006: ☐ EPD process certification ☐ EPD verification
Third party verifier: *<name, organisation and signature of the third party verifier>* *In case of certification bodies:* Accredited by: *<name of the accreditation body and accreditation number, if applicable>.* *In case of individual verifiers:* Approved by: The International EPD® System Technical Committee, supported by the Secretariat
Procedure for follow-up of data during EPD validity involves third party verifier: ☐ Yes ☐ No

5.4.3 PRODUCT INFORMATION

The product information section of the EPD shall include:

- Address and contact information to EPD owner,
- Description of the organisation. This may include information on products- or management system-related certifications (e.g. ISO 14024 Type I environmental labels, ISO 9001- and 14001-certificates and EMAS-registrations) and other relevant work the organisation wants to communicate (e.g. SA 8000, supply-chain management and social responsibility),
- Name and location of production site,
- Product identification by name, and an unambiguous identification of the product by standards, concessions or other means,
- Identification of the product according to the UN CPC scheme system. Other relevant codes for product classification may also be included, e.g.
    - Common Procurement Vocabulary (CPV),
    - United Nations Standard Products and Services Code® (UNSPSC),

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[7] If the EPD has been verified by an approved individual verifier who has received contractual assistance from a certification body that is not accredited, this certification body shall not be included in this table.

  - Classification of Products by Activity (NACE/CPA) or
  - Australian and New Zealand Standard Industrial Classification (ANZSIC),
- Description of the product, its application/intended use and technical functions, e.g. expected service life time,
- Geographical scope of the EPD, i.e., for which geographical location(s) of use and end-of-life the product's performance has been calculated,
- Functional unit or declared unit,
- Declaration of the year(s) covered by the data used for the LCA calculation and other relevant reference years,
- Reference to the main database(s) for generic data and LCA software used, if relevant,
- System diagram of the processes included in the LCA, divided into the life cycle stages,
- Description if the EPD system boundary is "cradle-to-gate", "cradle-to-gate with options" or "cradle-to-grave",
- Information on which life cycle stages are not considered (if any), with a justification of the omission,
- Relevant websites for more information or explanatory materials.
- The trade name and concentration of product shall be declared, if relevant. Relevant Type I and Type II environmental labels awarded to the product may be stated.

Fertilizer produced by the company must be described as follows:

For Organo-Mineral Fertilizers (OMF) all the mandatory parameters considered in the national legislation for Organo-Mineral Fertilizers (OMF) must be considered. If a national legislation is not available you must refer to the Italian Legislative Decree 75/2010.

- Furthermore the following parameters have to be declared:
- Formulation matrix
- Total Organic Carbon standard TOC %
- Humus acid standard (C HA+FA)
- Humus rate (HR)
- For fertilizers with polymers all the mandatory parameters considered in the national legislation must be considered. If a national legislation is not available you must refer to the Italian Legislative Decree 75/2010.

Also the Agronomic Efficiency Index (AEI), and the Uptake Index (UI) shall be indicated (see Section 5.4.3.1 and 5.4.3.1). Any claims made about the product must be verifiable

The section may also include:

- Name and contact information of organisation carrying out the underlying LCA study
- Additional information about the underlying LCA-based information, such as assumptions, cut-off rules, data quality and allocation.
- Environmental policy of the EPD owner
- Manufacturer's logotype.

5.4.3.1. Agronomic Efficiency Index (AEI)[8]

The AEI expresses the increase of the production of useful dry substance for each given Fertilizing Unit (FU). The AEI allowsevaluating the efficiency of the fertilization of the ground/plant system in order to define the right input of nutrients for the specific ground/plant system. AEI is calculated as follows:

AEI = (yeld nC – yeld 0C)/nFU

[8] Refers to Annex 1 of this PCR

where:

nC = yelds obtained in fertilized parcels

0C = yelds obtained in unfertilized parcels

nFU = applied Fertilizing Units

5.4.3.2. Uptake Index (UI)

The Uptake Index constitutes the easiest methodology to face the evaluation of the nutritive capacities of a fertilizer. It is based on the calculation of the plant uptakes, for the specific nutrient, with relation to what is established in the unfertilized witness.

UI is calculated as follows:

UI = [nutrient element up-taken from the cultivation in the fertilized option (kg/ha) – nutrient element ep-taken from the cultivation in the unfertilized option (kg/ha)]/nutrient unit (kg/ha) * 100.

The AEI and UI indexes will have to be determined for at least two or three herbaceous cultivations through the methodologies included in Annex 1. Such tests must be carried out by bodies and with personnel who is expert in the agriculture experimentation field.

In accordance with the fertilizer technical characteristics, that often influence the use, the scattering modalities (localized or at full field), the possible split modalities in the administration (for instance for in-door fertilization) must be declared. For UI an average value must be declared while for AEI the values of each single must be declared.

The UI index must be determined for nitrogen (N), phosphorus (P_2O_5) and potassium (K2O) when present.

If the EPD includes more than one formulation of the same kind of fertilizer (refer to paragraph 10), the IE average index will be the same and calculated according to the above mentioned tests. Such tests can be carried out with one or more formulations, declared in the EPD, and will be representative of all the declared formulations. Relevant information such as specific manufacturing processes beneficial from the environmental point of view can be described. Self-declared environmental claims about environmental performance of the product cannot be declared within the EPD document. In applicable cases information about the concentration of the product shall be included

5.4.4 CONTENT DECLARATION

The content declaration shall have the form of a list of materials and chemical substances including information on their environmental and hazardous properties. The gross weight of material shall be declared in the EPD at a minimum of 99 % of one unit of product.

Information on the hazardous properties of materials and chemical substances should follow the requirements given in the latest revision of the Globally Harmonized System of Classification and Labelling of Chemicals (GHS)[9], issued by United Nations or national or regional applications of the GHS.

As an example, the following regulations should be used for EPDs intended to be used in the European Union:

- 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 (REACH)
- Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures

5.4.4.1. Information about recycled materials

Not relevant for this product category.

[9] The GHS document is available on www.unece.org.

5.4.4.2. Information about packaging

As packaging is strongly connected with the product, the producer shall provide information about packaging in the EPD, when applicable. Packaging may be classified as:

- Distribution Packaging: packaging designed to contain one or more articles or packages, or bulk materials, for the purposes of transport, handling and/or distribution (ISO 21067-1:2016, Par. 2.2.6)
- Consumer Packaging: packaging constituting, with its content, a sales unit for the final user or consumer at the point of retail (ISO 21067-1:2016, Par. 2.2.7).

Consumer packaging is generally the outcome of eco-design processes, or other activities, under direct control of the organisation. Many critical categories with strict legal requirements belong to consumer packaging category like food contact packaging and pharmaceutical packaging.

The type and function of packaging shall be reported in the EPD.

A statement of the source of the materials (pre-consumer or post-consumer) shall be presented in the EPD when the packaging is made in whole or in part by recycled materials.

5.4.5 ENVIRONMENTAL PERFORMANCE

5.4.5.1. Environmental impacts

The EPD shall declare the environmental impact indicators, per declared unit and per life cycle stage, using the default impact categories, characterisation models and factors available on www.environdec.com/indicators. The source and version of the characterisation models and the factors used shall be reported in the EPD. Alternative regional life cycle impact assessment methods and characterisation factors are allowed to be calculated and displayed in addition to the default list. If so, the EPD shall contain an explanation of the difference between the different sets of indicators, as they may appear to the reader to display duplicate information.

5.4.5.2. Use of resources

The EPD shall declare the mandatory, and may declare the optional, indicators for resource use listed at www.environdec.com/indicators per declared unit, per life-cycle stage and in aggregated form.

5.4.5.3. Waste production and output flows

Waste generated along the whole life cycle production chains shall be treated following the technical specifications described in the GPI. The EPD may declare the optional indicators for waste production and output flows as listed at www.environdec.com/indicators per declared unit, per life-cycle stage and in aggregated form.

5.4.5.4. Other environmental indicators

Any other important environmental indicators related to the mineral or chemical fertilizers product should be listed in the EPD. Other environmental indicators shall be based on international standards or similar methodologies developed in a transparent procedure. Reference to the chosen indictors and methodologies shall be reported.

5.4.6 ADDITIONAL INFORMATION

Additional environmental information is voluntary.

Additional environmental information is such information that is not derived from the LCA, LCI or information modules, but relevant to include in the EPD® , e.g. impact on biodiversity, impact on health, technical life length, maintenance, the final use of product, hazard and risk assessment, preferred waste management option for used products, etc. Methods used to report such information shall be specified or referenced.

5.4.7 INFORMATION RELATED TO SECTOR EPDS

For sector EPDs, the following information shall also be included:

- a list of the contributing manufacturers that the Sector EPD covers,
- a description of how the selection of the sites/products has been done and how the average has been determined, and
- a statement that the document covers average values for an entire or partial product category (specifying the percentage of representativeness) and, hence, the declared product is an average that is not available for purchase on the market.

5.4.8 DIFFERENCES VERSUS PREVIOUS VERSIONS

For EPDs that have been updated, the following information shall also be included:

- a description of the differences versus previously published versions, e.g. a description of the percentage change in results and the main reason for the change;
- a revision date on the cover page

5.4.9 REFERENCES

A reference section shall include a list of references, including references to the General Programme Instructions (including version number), standards and PCR (registration number, name and version). The source and version of the characterisation models and the factors used shall be reported in the EPD.

5.4.10 EXECUTIVE SUMMARY IN ENGLISH

For EPDs published in another language than English, an executive summary in English shall be included.

The executive summary should contain relevant summarised information related to the programme, product, environmental performance, additional information, information related to sector EPDs, references and differences versus previous versions.

6 GLOSSARY

AEI	Agronomic Efficiency Index
CO_2	Carbon dioxide
CPC	Central product classification
EPD	Environmental product declaration
HA	Humus acid standard
ISO	International Organization for Standardization
kg	kilogram
LCA	Life cycle assessment
nC	yields obtained in fertilized parcels
nFU	applied Fertilizing Units
PCR	Product Category Rules
SI	The International System of Units
SO_2	Sulphur dioxide
UI	Uptake Index
UN	United Nations

7 REFERENCES

CEN (2013), EN 15804:2012+A1:2013, Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products.

EPD International (2017) General Programme Instructions for the International EPD® System. Version 3.0, dated 2017-12-11. www.environdec.com

ISO (2000), ISO 14020:2000, Environmental labels and declarations – General principles

ISO (2004), ISO 8601:2004 Data elements and interchange formats – Information interchange – Representation of dates and times

ISO (2006a), ISO 14025:2006, Environmental labels and declarations – Type III environmental declarations – Principles and procedures

ISO (2006b), ISO 14040:2006, Environmental management – Life cycle assessment – Principles and framework

ISO (2006c), ISO 14044: 2006, Environmental management – Life cycle assessment – Requirements and guidelines

ISO (2013), ISO/TS 14067:2013, Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification and communication

ISO (2014), ISO 14046:2014, Environmental management – Water footprint – Principles, requirements and guidelines

ISO (2017), ISO 21930:2017, Sustainability in buildings and civil engineering works -- Core rules for environmental product declarations of construction products and services.

Life Cycle Assessment (LCA) of granular and liquidi organo-mineral fertilizers, RT-176, LCA-lab SRL, 2018-07-05.

Effect of different organic matrices on the flow of N, P, K in the soil-plant system, Coppola E., 1993.

Organo-mineral fertilizers for corn, Tassan Mazzocco G., Contin M. 2000.

Life Cycle Assessment (LCA) of different fertilizer product types, K.Hasler, S.Broring, S.W.F.Omta, H.-W.Olfs, 2015.

Life Cycle Assessment of organic and mineral fertilizers in a crop sequence of cauliflower and tomato, R. Quiros, G.Villalba, X. Gabarrell, P.Munoz, 2015.

Melone e pomodoro da industria: efficienza della concimazione con Organo Minerali liquidi, P.P.Pasotti, M. Pelliconi, V.Tisselli, S. Tagliavini, 2017 Colture Protette N° 4 aprile 2017

Nitrogen uptake by crops soil distribution and recovery of urea-N in a sorghum whit rotation in different soils under Mediterranean conditions di P. Nannipieri et al., Plant and soil, 208: 43-56, 1999).

8 VERSION HISTORY OF PCR

VERSION 1.0, 2010-12-10

- Original document replacing the expired PCR 2006:08 Fertilizers.

VERSION, 2013-07-23

- Update of UN CPC classification to version 2.0 (UN CPC 3461, 3462, 3463, 3464 & 3465)
- Minor editorial changes
- Use of the PCR template

VERSION 2.0, 2016-01-11

- Compliance with to the PCR Basic module UN CPC 34, Basic Chemicals version 2.0 dated 2013-10-24
- Compliance with to the General Programme Instructions, Version 2.5.
- Use of the latest template

VERSION 2.1, 2019-01-30

- Updated in accordance with GPI 3.0 and new PCR basic module.

VERSION 2.11, 2019-09-06

- Clarified terms of use
- Editorial changes

VERSION 3.0, 2020-06-02

- Compliance with to the PCR Basic module UN CPC 34, Basic Chemicals version 3.02.
- Compliance with to the General Programme Instructions, Version 3.01.
- Editorial changes
- Added some references

VERSION 3.0.1, 2022-04-06

- Editorial changes in Sections 5.4.5.1 to 5.4.5.3, to clarify the indicator list at www.environdec.com applies also for the indicators of resource use, waste production and other output flows.

VERSION 3.0.2, 2023-09-06

- Editorial changes in Sections 5.4.5.2 and 5.4.5.3 and updated E-mail address of the PCR Moderator in Section 2.1.

VERSION 3.0.3, 2024-01-26

- Prolonged validity period with eight months following the initiation of an updating process.

ANNEX 1

Author: Prof. Elio Coppola – Department of Environmental, Biological and Pharmaceutical Sciences and Technologies – II University of Naples

This Annex is informative and not normative. It was formulated on the basis of knowledge, experience and literature about the fertilizers sector. It is published with the author's consent.

FOREWORD

The formulation of high efficiency fertilizers is one of the focal points for the reduction of agriculture productions environmental impact.

A right approach for their evaluation give both a wider and detailed comprehension of the mechanisms which rule the nutrients mobility of the ground and also the elaborations of indexes that, through the use of specific methodologies, give an exhaustive diagnostic picture about their availability for cultivation purposes and about their dynamic in the ground/environment system.
On such matters, basic and applies researches have been developing since the second half of cent. XIX.

In such a sense, it is worth to have a look at the many reviews and numerous references that, through time, have been cited by Hesse (1971), Walsh and Beaton (1973), Page (1982), Marschner (1986), Mengel and Kirkby (1987), Wild (1988), Westerman (1990), Black (1993), Carter (1993), Brady and Weil (1996), Buurman et al. (1996), Sparks (1996).

THE CONCEPT OF ELEMENTS BIO-AVAILABILITY

It is immediately necessary to clarify that quite soon are used and sometimes even confused both the term “availability” and the term “bio-availability”. The first one is clearly meant in a wider meaning and can be referred to any phases of the whole bio-geo-chemical cycle of an element.

The second term is more properly referred to those cycle phases wherein there is the intervention of assimilation processes of a specific element by a living organism, as for instance, a nutrient translocation from the ground compartment to the vegetable one.

Therefore, in the context of the present document, we shall use the term “bio-availability”, even if sometimes the Authors here following mentioned have also used the term “availability”.

With a different approach, more suitable for the interpretation of the “ bio-availability” as expression of biotic phase of the bio-geo-chemical cycle, Wolt (1994) links the concept of “bio-availability” to the concept of “transference” of a chemical kind from the ground matrix to the biota one, independently from the physiologic role of the considered element. Wolt (1994) defines “bio-available… that part of an element which is present in the ground and that is, or has been, involved in a determined metabolic process”.

An even more synthetic definition of “bio-available” nutrients in the ground, when specifically referred to the vegetable nutrition, was given by Black (1993), who stated that for “bio-availability … it is meant an element able to be absorbed by a vegetable”.

Considering that the nutritional necessities, for a specific chemical type, are widely varied for the different biota that take development on the ground body, it is not possible to evaluate an absolute “bio-availability”. It is definitely easier and of major practical use to evaluate the “relative bio-availability” for a specific element.

For such a purpose, specific methodologies are applied and they are able to transfer into solution some meaningful fractions of the whole of the parts of a nutrient associated to the ground matrix in different measures and manners.

The quantities of the element, which are extracted according to a determined procedure, are set into relation, or “calibrated”, with the vegetable development and production. In such a way we can get the identification of some reference “indicators”, which define the variability fields of the “bio-availability” of a specific element in the ground in accordance to the answer of the vegetable.

FACTORS AND PROCESSES THAT CONDITION THE BIO-AVAILABILITY OF THE NUTRIENTS IN THE GROUND.

It is known that only a fraction, generally small, of the total contents of a specific element in the ground is bio-available. Amongst the main factors and processes which influence the bio-availability of the elements we must consider (Buondonno, 1989):

- The pedo-climatic conditions and the bio-chemical-physical properties of the ground and of the rhizo-sphere in the specific;
- In the liquid phase, the concentration of the soluble forms of the nutrients;
- The quantity and the nature of the fractions associated to the solid matrix (ground, rocks) into easily changeable forms or as differently available reserves;

- The phenomenon of the nutrients mobilization that, because of the processes of alteration of the prime minerals, of dissolution, desorption or of mineralization of the organic substance, make available the reserve typologies;

The phenomenon of immobilization that, for processes of selective adsorption, of fixation, of precipitation or of transformation into organic compounds, retrograde the available forms towards the non-available reserves.

Other variability factors are of anthropical nature: the agronomic practices may modify the ground structure and level of reaction, changing the balance among the different phases; the plant of selected cultivar, the use of amenders, phytosanitary products and phyto-regulators and the integrated leaf fertilization modify the nutrients assimilation and, as a consequence, the efficiency of the same fertilizers.

INDEXES, INDICATORS AND PARAMETERS

An “index” is a numerical expression, preferably simple and dimensionless, with few variability limits, that gives a synthetic value to one or more “indicators”, represented by specific “parameters”, or by moderate and/or continued variables, qualitative and/or quantitative ones, which measure or define one or more characteristics of a specific system.

In short, a good index is able to resume and express different characteristics of a system, even if defined by heterogeneous dimensions and measures. For example, an index of atmospheric pollution can take into consideration different indicators, such as the oxide concentrations of S an of N in the air, the intensity of the vehicular flux, the temperature, the wind direction and intensity, the irradiation, and so on.

When it is possible to fix a standard value of reference, an *index* allows not only to express a qualitative synthetic judgement, but also to give a quantitative value to specific characteristics, or to variations of these ones, of the studied system. In such a sense, a good indicator must have specific characteristics that make it be (Benedetti and De Bertoldi, 2000):

1. representative, that is to say related to the phenomenon or the characteristic that must be put into evidence, with a minimum statistical dispersion; not easily concealable by surrounding factors; generally usable with similar systems even if not in identical situations;

2. accessible, that is to say easy to measure and monitor through space and time; easy to sample; with a low level of analytic perceivable elements and consequently that can be determined with easily feasible techniques;

3. reliable, that is to say with minimum possibility of systematic errors; not in the least influenced by the nature of the system it is applied to;

4. operative, that is to say immediately applicable to dimension and evaluate, also from an economic aspect, plans and works of intervention.

CRITERIA FOR THE DEFINITION OF THE BIO-AVAILABILITY INDEXES.

Through years, the bio-availability of the nutrients in the ground has been evaluated according to various and different indicators, each one developed on analytic criteria and procedures which are substantially different, from the easiest to the most elaborated (Buondonno, 1989).

In general terms, we can identify two main methodological tendencies; one is based on the evaluation of the ground/ plant system on the whole and the other one is based on the only ground analysis (Table 1).

Table 1 Main methodological criteria for the evaluation of the nutrients bio-availability

A) ANALYSIS OF THE GROUND/PLANT SYSTEM	- physiologic tests of assimilation of the nutrient in an interned environment; - productivity analysis in plain field; - radio-isotopic techniques.
B) ANALYSIS OF THE SOIL	- specific reagents; - "Quantity/Intensity Factors" and "Buffering Capacity"; - "multi-elements" reagents; - adsorbent systems, resins with cationic/anionic exchange, cellulose supports impregnated with oxid-hydroxid of Fe (paper-strips); - equipment for fractional extraction

The ground/plant system analysis, in its complex (criteria type A), is surely highly indicative of the ground fertility status, as it allows to directly define the “agronomic and biologic efficiency” of the cultivation related to the effective nutrients availability (Talibudeen, 1974; Buondonno, 1989; Coppola, 1993; Craswell and Godwin, 1984; Fageria, 1992).

In the specific, for specific ground/plant system, the compared analysis of specific efficiency indexes allows to determine the limit conditions necessary to reach the productive potential with relation to different fertilizing strategies.

Even if not that suitable to be employed as routine methods, as they are quite expensive because of the enquiries duration and of the management costs, the evaluation methods of the ground/plant system represent, in any case, the only objective and univocal survey about the answer of a specific cultivation to a specific ground fertility status.

On the other hand, the methods for only analysing the ground (criteria type B) only allow a quantitative and indirect evaluation of the nutrients availability, which is often based on criteria of conventional survey and partially transferable; nevertheless they are part of the routine section in a laboratory for both the rapidity and the simplicity of the procedures. Moreover, the laboratory surveys are obviously indispensable to dimension and compare indicators and indexes.

Effectively, the most correct methodological approach consists, *in primis*, in preparing adequate experiments in full field, using the simplest retrogression models, thus identifying the most meaningful co-relations among the quantitative and qualitative indexes of the cultivations and laboratory analytic parameters got according to different methods (Black, 1993; Cope e Evans, 1985; Coppola, 1993; Hauser, 1973; Little e Hills, 1978; Westerman, 1990).

Such a procedure, indispensable for characterising ground/plant systems not experimented yet, allows to chose, on the base of analytic congruence criteria, of reliability and simplicity, the best indicators and the consequent parameters to be employed in the routine analysis to check the variations of the ground nutrients availability. Subsequently, the enquiries, compared with other parameters and indicators and/or with other ground/plant systems, may allow to define the applicable field of the index and of the related indicators when applied to different cultivations and/or pedo-climatic environments.

The development of such indexes is particularly elaborated, as long experimentations are necessary as much as a quite high number of replies to get results which may be statistically reliable and, as a consequence, generalizable. In full field the experimentations should be carried out for a period not lesser than three cultivation cycles, thus to assure the conditioning of the experimental parcels.
Nevertheless, such an exigency is often in contrast to the general schemes of the agronomic tests that, most o times, do not foresee the mono-cultivation and insert the fertilizing tests, for cultivations with yearly cycle, in more generalized contests of multi-yearly rotations. In such a case, it I necessary that the fertilizing plan, object of the evaluation, is in any case homogeneous for the whole examined rotation.

Nevertheless, the necessity of an experimentation activity that is prolonged in several years might be overcome if some precautions are respected during the planning of the unbalancing agronomic test of the fertility conditions. In fact, if during the preparatory phase we use exigent cultivations from a nutritional point of view (generally cereals, better if well-watered), just to level and reduce the differences of residual fertility of the ground, the multi-yearly bond of the experimentation may be duly reduced to two years (for details see annex 1A).

AGRONOMIC EFFICIENCY

The term “efficiency” related to the vegetable production, is defined, in the easiest meaning, as the “quantity of useful dry substance (commercial production) got from each nutrient unit that is given or from each nutrient unit that is assimilated” (Coppola, 1993; Buondonno et al., 1994, 1997; Coppola et al., 1997).

The concept of efficiency has been differently used to characterize the relations that link the contribution of nutrients to the productive yield in different situations (full field, checked environment, cultivations under glass) with relation to the specific experimental exigencies or to the different application fields. In the context of full field experimentation, which purpose is to calibrate a ground/fertilizer/plant system for the elaboration of fertilizing models with a high yield and a low environmental impact, first of all it is suitable to take into consideration two different indexes: the Index of Agronomic Efficiency (I.A.E.) and the Uptake Index (U.I.) (Talibudeen, 1974; Craswell and Godwin, 1984; Coppola, 1993; Buondonno et al., 1994, 1997; Coppola et al., 1997).

AGRONOMIC EFFICIENCY INDEX (A.E.I.)

The Agronomic Efficiency Index (A.E.I.) expresses the increase of the production of useful dry substance for each given Fertilizing Unit (F.U.). The (A.E.I.) allows, in particular, to evaluate the production/economic aspects of the efficiency of ground/plant systems wherein the yield of the cultivation is the consequence of the different use of technical means or of cultivation techniques.

For example, the (A.E.I.) is applied in the comparison amongst fertilizing plans that are different for given doses (in multiples of definitive relations among nutritive elements expressed in kg/ha), for fertilizer typology (mineral, organic-mineral, organic), for administration typology (fractioned, integrated), for cultivation treatments and techniques (improvement of the soil, works, use of phyto-sanitary products and herbicides, irrigation), for characteristics of the vegetable (cultivar, graft holder), or in the comparison among the yields in different pedo-climatic environments, or in the comparison among the yield of different cultivar grown at same conditions.

For the calculation, the comparison must be done among the yields that have been got through the use of fertilized parcels (nC) and through the use of unfertilized parcels (0C), with relation to the nutrient units or, more exactly, to the applied F.U. Fertilizing Units (nF.U.). The F.U. represent, as already remembered, multiples of relations defined among nutritive elements expressed in kg/ha (for example one F.U. got by the relation N: 2P2O5:K2O=1:1,5:2 represents an administration of 100, 150 and 200 kg/ha for N, P2O5 and K2O) and translatable into easy numbers (1, 2, 3).
The A.E.I., according to the expression of Craswell and Godwin, (1984) and subsequently drawn by Coppola (1993), Buondonno and coll. (1997) and by Coppola and coll. (1997) is calculated as follows:

$$A.E.I. = (\text{yield nC} - \text{yield 0C})/nF.U.$$

The variations of the A.E.I. are related to the increase of the nF.U. (from Craswell and Goodwin, 1984; Coppola, 1993).
The A.E.I. presents a parabolic trend, characterized by initial large positive variations, for small increases of the administrated fertilizing units. In the right experimental conditions, the top point of the curve identifies the *optimum* of the relation between A.E.I. and nF.U.

Such a type of index represents one of the conceptual basis, together with the calculation of the uptakes, for the drawing up of the fertilizing plans adopted in the production regulations of the single cultivations. Therefore, its adoption is useful to define the efficiency of the fertilizing intervention. Such an efficiency is even underlined by meaningful increases of the productions with which presence the A.E.I. allows to evaluate the increase or decrease of the production marginal growth related to the increase of the fertilizing *input*.

UPTAKES OF THE CULTIVATION

In most cases, as for the cereals or for the most common fruit vegetables, only a part of the plant is the real aim of the fertilizing intervention. The other parts of the plant (roots, trunk, leaves) constitute a physiologic framework, which is functional for the production, but they are not quite often object of the production evaluation and represent a residue which weight on uptakes should be evaluated each time.

Nevertheless, a part of such residues and thus of the contained nutrient elements is nor generally removed from the ground (just think of the roots) or is intentionally given back (with planting of the stubbles and, partially, with the burning of the straws and of other cultivation residues).

From the other hand, the administration of a fertilizer to the ground has not the only purpose to increase the quantity of one or more nutritive elements of the ground. In fact, the ground has a considerable quantity of the same elements in more or less available types. Such quantities may be used by the plant in synergy with the other quotas that have been added of fertilizer and determine uptakes that, in the whole, can even overcome the administrated quantities.
The rationality of the fertilizing intervention consists in reaching the balance point that is made of the minimum difference, in quantitative terms, of the input/output, which aim is not to decrease the inherent potential of the ground chemical fertility.

UPTAKE INDEX (U.I.)

The uptake index constitutes the easiest methodology to face the evaluation of the nutritive capacities of a fertilizer. It is based on the calculation of the plant uptakes, for the specific nutrient, with relation to what is established in the unfertilized witness.
U.I. (x) = nutrient element (x) up-taken from the cultivation in the fertilized option (kg/ha) - nutrient element up-taken from the cultivation in the unfertilized option (kg/ha) / nutrient unit (kg/ha) * 100.

For a right calculation, it is necessary to compare the up-takes, referred to the single element, in the plant parts that have been considered as to be taken away from the system, got in fertilized parcels (nC) with those got in unfertilized parcels (0C), with relation to the applied nutrient units.

In most case, during the agronomic tests, of conventional type, there is not the execution of the analysis, about the vegetable composition, in order to evaluate the up-takes as they are excessively expensive. Nevertheless, such information can be got from bibliographic fonts and can be used, mentioning the font, for the up-takes calculation (for example “Plant Analisys – an interpretation manual” – ed. D.J. Reuter and J.B. Robinson – Inkata Press).

ANNEX 1A

DEFINITION OF THE EXPERIMENTAL TESTS

The experimental scheme for full field tests must use a scheme with randomized blocks with a sufficient number of repetitions (3 as a minimum) on cultivable surfaces which are homogeneous as morphology (flat or sub-flat) and as typology of ground profile (with particular reference to the width and to the physical, chemical and physical-chemical characteristics of the superficial and deep horizons) into the limits of the special variability, typical of the area (and in any case verified and declaimed through specific pedological study).

The parcels must have a suitable dimension and able to get enough vegetable material to carry out those samplings that will be useful for the following analysis on the plant and the evaluation of the productions.
In accordance with the fertilizer technical characteristics, that often condition the use, the scattering modalities (localized or at full field) must be declared, as much as the possible fractioning modalities in the administration (for example indoor fertilizing).

In any case, together with the fertilizing test, also the execution of an equivalent number of observations on control parcels (witnesses) wherein no fertilization is applied must be foreseen. Such witnesses represent a irremissibly part of the test itself and are indispensable for the right calculation of the proposed indexes.

It is superfluous to remember that the cultivation actions (irrigation, phytosanitary treatments), even if not completely linked to the test purpose, must be as homogeneous as possible on the enquiry area.

In any case, it is necessary to avoid the placement of the single replies and, as a consequence, of the tested areas, in the external strips of the used surface (thus close to the longitudinal ditching or of the transversal heads of the cultivated surfaces).
In fact, these strips are subject to strong variations of the ground conditions, due to the draining effects of the drains, to the major compression due to the frequent crossing of the farming vehicles and, not least, due to the different administration of fertilizers, phytosanitary products and irrigation water as an effect of the difficult operative conditions of the single farming vehicles.

Generally, these indications are respected during the agronomic tests correctly carried out (under such an aspect it is preferable to carry out these tests by bodies and personnel with a long experience and practise in the field of the farming experimentation).

Nevertheless, it is better to point out the necessity of having a preconditioning of the surface to be used for the experimentation, thus to get the most possible homogeneous fertility levels, intrinsic to the soil. In fact, generally such tests are carried out on surfaces appointed to such a use in the agronomic experimentation bodies where the adoption of plans of differentiation of the answer for the use of technical means are a repeated practise and soon strongly penalized for the conditions of homogeneity of the experimental surfaces.

Such an aim can be reached in making the test, object of the evaluation, precede by cultivations with highly impoverishing yearly cycle. As an alternative, the fertilizing conditions which have been prepared for the test must be repeated for various years (three at least) and the evaluation must be led at the end of the tesJust as an example here following are the information got for the characterization of the soil used for the experimental test carried out on corn cultivation for the triennium 1991-1993 (Coppola, 1993).

"The described pedon can be ascribed to the order fo the Entisols, with profile type A-C.

The particular water system, with temporary hydro-morphism due to the resilient of the aquifer during the winter period (Buondonn et al. 1987), together with the climatic characteristics of the territory, define the taxonomic level of the big group "Xerofluvent". The high presence of deep cracking of the surface (confirmed by the identification of clay terms of expandable type) also specifies the classification at a level of subgroup "Vertic Xerofluvent".

The lithological substrate is made of alluvial and Holocene sediments, with the presence of pyroclastics and secondary limestones, alternated by pumice lapillus and swamp residues (Buondonno and Violante, 1987).
Therefore, the classification "Vertic Xerofluvent, mesic, mixed, calcareous".

The average structure of the Ap horizon is loamy-clay. The reaction level is neutral-sub-alkaline. The total contents of organic carbon and of nitrogen are into the limits of the sufficiency. On the contrary, the heterogeneous composition of the matrix determines a high availability of potassium, meanwhile associated to a limited mobility of the phosphorus.

The waters used for watering, got at different deepness of the aquifer, are strongly salted, with prevalence of Na+ ions. Nevertheless, because of the presence of free carbonate and of their buffer action on the reaction of alkaline hydrolysis of the sodic salts, the value of the soil pH is within the limit of the physiologic alkalinity."

MINERAL OR CHEMICAL FERTILIZERS
PRODUCT CATEGORY CLASSIFICATION: UN CPC 3461, 3462, 3463, 3464 & 3465