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Technologies for recovery and reuse of plant nutrients from human excreta and domestic wastewater: a protocol for a systematic map and living evidence platform

NOTE FOR READERS

Research and development of circular nutrient technologies has intensified over the past years, making research output in this field increasingly hard to navigate and keep track of. There is a need for a robust and comprehensive mapping and synthesis of existing relevant research and better brokering of knowledge to policy and practice.

We are a group of Swedish researchers who have set out to:

- Collate available peer-reviewed English language research on nutrient recovery and reuse into a comprehensive evidence base using systematic mapping methodology.
- Develop an online evidence platform to navigate relevant scientific papers with ease.

We have drafted this protocol to outline in detail our methodological plan for the systematic map and online evidence platform. To give you the opportunity to influence our work at an early stage, we have designed a survey (https://forms.office.com/r/L7QfNgFbbe). The survey will close on **June 15, 2021.** At this stage, we are seeking input regarding:

- What types of scientific research to include?
- What search terms to use to find relevant research?
- How to sort and categorize relevant research?

Your contribution as a potential user of the systematic map and evidence platform will help us refine the protocol, and it will influence the scope and comprehensiveness of the map and platform. Feel free to share this draft protocol within your networks but please do not cite this draft.

We thank you for your time and valuable feedback!

The End-of-wastewater team:

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Please do not cite this draft protocol but feel free to share in conjunction with the survey.

Technologies for recovery and reuse of plant nutrients from human excreta and domestic wastewater: a protocol for a systematic map and living evidence platform.

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Abstract

Background Research and development on the recovery and reuse of nutrients found in human excreta and domestic wastewater has intensified over the past years, continuously producing new knowledge and technologies. However, research impact and knowledge transfer are limited. In particular, uptake and upscaling of new and innovative solutions in practice remain a key challenge. Achieving a more circular use of nutrients thus goes beyond technological innovation and will benefit from a synthesis of existing research being readily available to various stakeholders in the field. The aim of the systematic map and online evidence platform described in this protocol is threefold. First, to collate and summarise scientific research on technologies that facilitate the recovery and reuse of plant nutrients and organic matter found in human excreta and domestic and municipal wastewater. Second, to present this evidence in a way that can be easily navigated by stakeholders. Third, to report on new relevant research evidence to stakeholders as it becomes available.

Methods Firstly, we will produce a baseline systematic map, which will consist of an extension of two previous related syntheses. In a next stage, with help of machine learning and other automation technologies, the baseline systematic map will be transformed into 'living mode' that allows for a continually updated evidence platform. The baseline systematic map searches will be performed in 4 bibliographic sources and Google Scholar. All searches will be performed in English. Coding and meta-data extraction will include bibliographic information, locations as well as the recovery and reuse pathways. The living mode will mostly rely on automation technologies in EPPI-Reviewer and the Microsoft Academic database. The new records will be automatically identified and ranked in terms of eligibility. Records above a certain 'cut-off' threshold will be manually screened for eligibility. The evidence from the baseline systematic map and living mode will be embedded in an online evidence platform that in an interactive manner allows stakeholders to visualise and explore the systematic map findings, including knowledge gaps and clusters.

Keywords: circular economy, nitrogen, nutrient recovery, phosphorus, resource recovery, sewage

1 Background

In recent years, the concepts of 'nutrient circularity', 'closing the nutrient loop', 'circular nutrient solutions', and 'circular nutrient economy' have gained traction (Koppelmäki et al., 2021; Nesme and Withers, 2016; Robles et al., 2020; van der Wiel et al., 2019). This echoes the increasing understanding that, in order to mitigate nutrient pollution in water bodies and improve global nutrient security, societies around the world have to learn how to better recover nutrients from organic residuals for reuse in agriculture (McConville et al., 2015). These organic residuals can include crop and food remains and animal and human manure.

Research and development on nutrient recovery and reuse has intensified over the past years(Harder et al., 2019; Johannesdottir et al., 2020; Rosemarin et al., 2020), but research impact and knowledge transfer to policy and practice are limited. In particular, upscaling of new and innovative solutions in practice remain a key challenge (Andersson et al., 2018, 2016). This is because issues of environmental and resource management are often related to governance (Hackmann et al., 2014) and subject to cultural, economic, institutional, and regulatory barriers (Barquet et al., 2020; McConville et al., 2017). Achieving a more circular use of nutrients thus goes beyond technological innovation and requires engagement with civil society and better translation of scientific findings into policy and practice.

One of the key obstacles for taking a full advantage of the nutrient and carbon recovery and reuse potential is that existing knowledge is scattered across different sources and is rapidly growing. Therefore, it is difficult for actors even within the same sector or country to navigate existing knowledge, let alone to keep track of new findings. Moreover, as data from different sources is likely to be reported in different formats and according to different conceptual models, significant effort is required before the knowledge can be used to inform decisions. A trusted open-access database that compiles and consolidates best available scientific evidence in a systematic and easily accessible manner is needed to support decisions related to safely and adequately recirculating nutrients and carbon in cities and rural areas.

1.1 Previous evidence syntheses

There are numerous reviews that summarise a subset of the literature on recycling nutrients from human excreta and domestic wastewater to agriculture. Typically, these reviews have focused on a specific: nutrient, e.g. phosphorus (Egle et al., 2015); recovery technology, e.g. struvite precipitation (Rahman et al., 2014); input stream, e.g. digestate (Vaneeckhaute et al., 2017); or combination thereof, e.g. struvite precipitation from digestate (Lorick et al., 2020; Macura et al., 2019a).

Other reviews were more comprehensive in scope. For instance, Harder and colleagues (2019) reviewed the option space for recycling nutrients contained in human excreta and domestic wastewater to agriculture in terms of pathways, processes, and products more broadly (hereafter referred to as 'SANAGRI' review). Two recent systematic maps collated research on ecotechnologies for recovery and reuse of carbon and nutrients from domestic wastewater (Johannesdottir et al., 2020) and agricultural waste streams (Macura et al., 2019b), but were limited to literature published between 2013 and 2017 (hereafter referred to as 'BONUS RETURN' reviews). The overlap between the SANAGRI and BONUS RETURN reviews was surprisingly low and there seems to be a substantial number of relevant studies yet to be collated.

2 Objectives of the review

The aim of the systematic map and living evidence platform is to: (1) update and extend the SANAGRI and BONUS RETURN reviews on technologies that facilitate the recovery of plant nutrients from human excreta and domestic wastewater for reuse in agriculture; (2) set up an online evidence platform that enables stakeholders to navigate existing evidence and that reports on new relevant research as it becomes available; (3) explore procedures to effectively and continuously update the evidence base in the future and optimise search strings for this subject.

The primary question for this systematic map and evidence platform is:

What evidence exists on technologies for the recovery of plant nutrients from human excreta and domestic wastewater for reuse in agriculture?

This question can be broken down into following elements:

- *Population(s):* Systems that manage human excreta (i.e., urine and faeces), streams containing human excreta (e.g., yellowwater, brownwater, blackwater, domestic and municipal wastewater), or residues and products that are derived from these streams (e.g., digestate, faecal or sewage sludge, treated effluent).
- *Intervention(s):* Practices and technologies undertaken for the purpose of recovering plant nutrients, including organic matter.
- *Outcome(s):* Recovered product containing plant nutrients (with or without organic matter) suitable for reuse in agriculture, or to produce fertilizers.

The key outputs of this work will be as follows:

1. A detailed searchable database of relevant studies, including:
    a. A description of recovery pathways (*sensu* Harder et al., 2019). A recovery pathway describes what is being reused or recovered, from what, and how. A pathway is characterized by the following descriptors: at least one source stream (e.g., municipal wastewater) and access stream (e.g., sewage sludge ash), a sequence of processes (e.g., leaching followed by precipitation), and at least one recovery product (e.g., struvite).
    b. Other relevant metadata such as bibliographic information, study type, scale, and location.
2. An evidence platform comprised of:
    a. A user-friendly interface to search for relevant evidence, organised by topic, pathway, study type, recycled product, etc.
    b. An ‘evidence atlas’, that is, an interactive geographical map visualising the location of author affiliations (and study locations, if resources allow).
    c. A series of ‘heat maps’ that cross-tabulate two descriptors (e.g., process versus product, or process versus source stream). These heat maps will be used to systematically identify knowledge clusters (i.e., subtopics that are well-represented by research studies) and knowledge gaps (i.e., subtopics that are un- or under-represented by research studies).
3. A suite of living mode procedures to keep the database up to date, including machine learning support to search and screen new research as it becomes available.

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3 Methods

The systematic mapping process will follow the Collaboration for Environmental Evidence guidelines and standards for evidence synthesis in environmental management (Collaboration for Environmental Evidence, 2018) and it conforms to ROSES reporting standards (Haddaway et al., 2018). Guidance for the production and publication of Cochrane living systematic reviews (Brooker et al., 2019) was also used to inform the process. The process will be comprised of several stages. In the first stage, we will produce a baseline systematic map, which will consist of an extension of our previous work (Harder et al., 2019; Johannesdottir et al., 2020; Macura et al., 2019b). In a second stage, with help of machine learning and other automation technologies for searching, screening and coding, the baseline review will be transformed into living mode to allow for a continually updated systematic map that incorporates relevant new evidence as it becomes available. Finally, the evidence from the baseline systematic map and living mode will be embedded in an online evidence platform that allows stakeholder to explore the systematic map findings in an interactive manner. The systematic mapping process and the development of the evidence platform are illustrated in Figure 1 and outlined in the remainder of the protocol.

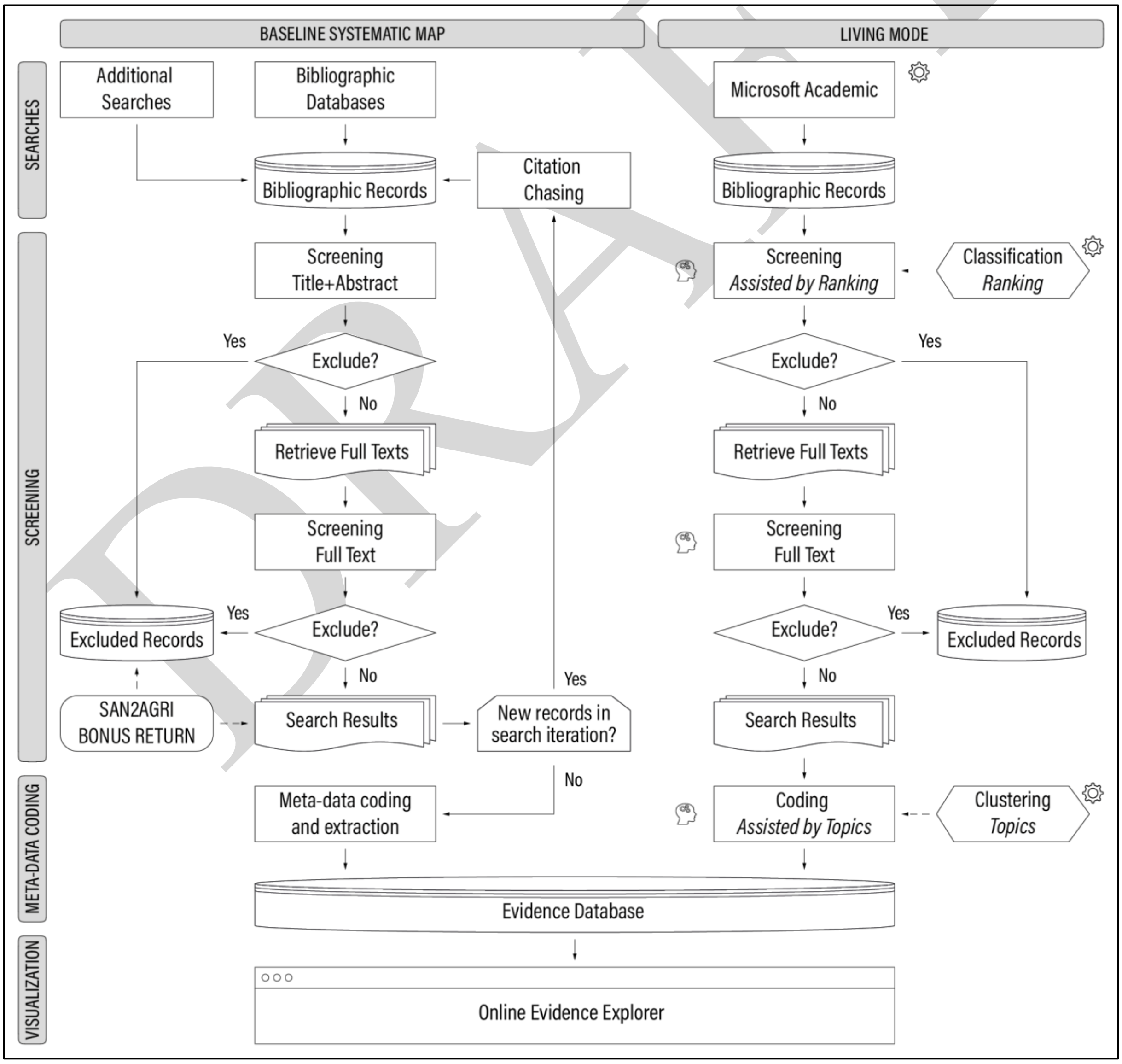

Figure 1. Flow diagram for the development of the systematic map and evidence platform.

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3.1 Codesign process and stakeholder engagement

A codesign process with continuous stakeholder input will be used throughout the development of the systematic map and evidence platform to assure relevance of the review findings for stakeholders, legitimacy of the review process, and better evidence uptake into policy and practice (Land et al., 2017). Involved stakeholders are being identified using the team's knowledge and contacts, snowballing, systematic searching and open online comment periods. Although we will be initially engaging mostly with Swedish researchers and practitioners, our ultimate aim is to work with stakeholders internationally and with practitioners in Sweden.

We have designed multiple points of entry for stakeholder engagement, see Figure 2.

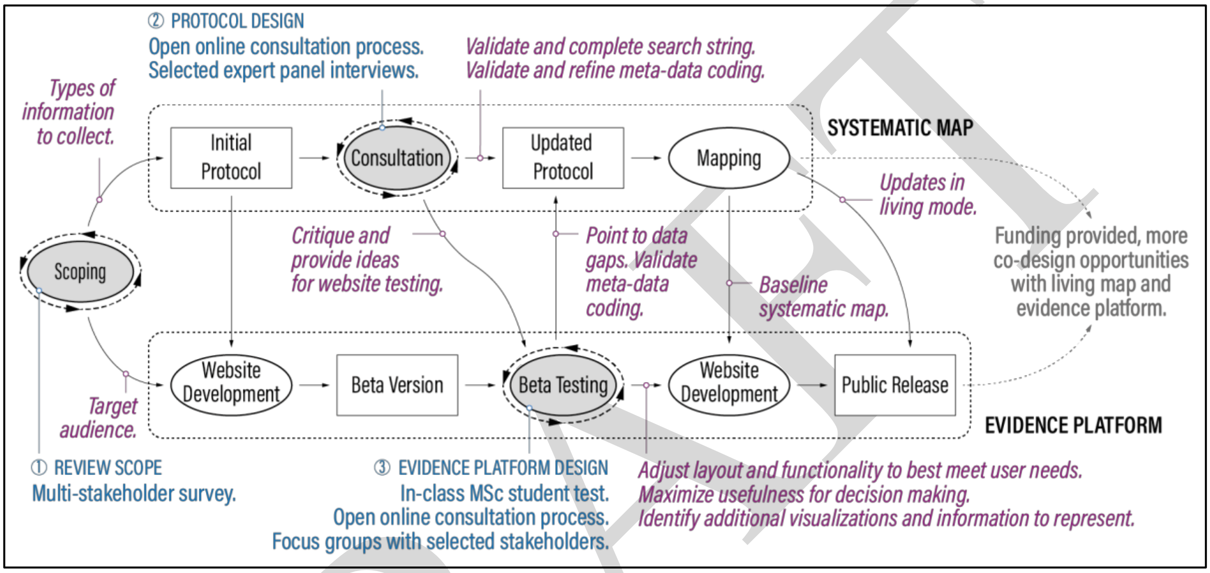

Figure 2. Overview of the codesign process supporting the development of the protocol, systematic map, and evidence platform. The upper part of the figure describes the codesign of the systematic mapping, the lower part of the evidence platform. Ovals represent processes and squares are resulting products. Text in blue denotes types of interaction with stakeholders, and text in magenta describes types of expected input from stakeholders.

① *Review scope.* In order to understand interest for this map and evidence platform, the research team administered a survey during June and July 2020 to the Swedish Nutrient Platform (SNP) network and Swedish experts known to the team. Survey questions were initially piloted at an SNP workshop and narrowed in scope before circulation of a wider survey within our stakeholder network. Respondents were asked to evaluate the relevance and usefulness of three potential functions of an evidence platform:

- A description of technological solutions or practices for nutrient reuse and recovery with details about relevant pathways;
- Technical details and performance of these technological solutions;
- Information about relevant actors, including networks, researchers and developers in this field.

Over 55% of respondents thought all three functions could be useful for their work or to their organizations in general. Moreover, when asked what types of stakeholders might benefit from such an evidence platform, the wastewater utilities, government agencies, and researchers were the top three groups of actors identified as the platform beneficiaries (although many more were mentioned). This information has been used in the design of this initial protocol.

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② *Protocol design*. Additional input on the scope of the mapping and on future engagement strategies for design of the platform will be solicited through a review of this initial protocol. During a 3-week open consultation process we will reach-out to a wide network of actors for comments. The protocol will be shared on the project website (http://www.endofwastewater.net/), via the Swedish Nutrient Platform (SNP, https://www.ri.se/sv/svenskanaringsplattformen), the European Sustainable Phosphorus Platform (ESPP, https://www.phosphorusplatform.eu/), and other similar networks that connect subject experts, decision makers and others interested actors. Stakeholders will be invited to comment on the scope, search strategy, meta-data coding structure and to suggest additional sources of relevant literature. We will collect comments via a survey form which has specific questions related to the above points but also allows for free text answers. The protocol will be updated following this process.

③ *Evidence platform design.* We will invite representatives of academia, farmers, utilities and government agencies to codesign and test the evidence platform. Stakeholder input and feedback will be used to ensure usefulness of the platform to potential users. We will combine three methods for improving the platform design: focus groups, beta-testing and open feedback. Focus groups (with 3 to 4 participants) will be organised in autumn 2021. The participants will be survey respondents (12 expressed interest) and practitioners and experts in waste management and food systems identified through the previous codesign activities. Focus groups will be asked to use the platform and give feedback on comprehensiveness, ease of use, data organization and visualization options, as well as if/how the information can help in decision making. The focus group setting allows for different types of feedback as participants can build on each other's experiences. Using the platform during a focus group will also allow the research group to observe how people navigate the platform and see if there are sticking points. Because academics were highlighted as an important potential user, we will also organise a beta testing session with MSc students as part of a class. The beta version of the platform will also be available online for open testing and commenting during a 4-week period where users will be able leave comments via a feedback form. Finally, we plan to have continued open dialogue with users after the platform is launched to continue improving it. There will be a comments and questions section on the website but pending funding and interest we also hope to continue more dynamic engagement to update the evidence platform as well as the user interface over time to further match user needs.

3.2 Search strategy

3.2.1 Searches for baseline systematic map

Here we describe search strategy for the baseline systematic map. The review will merge the datasets of the SANAGRI (Harder et al., 2019) and BONUS RETURN (Johannesdottir et al., 2020; Macura et al., 2019b) reviews and continue adding new search records from several sources as described below. Searches will not be restricted to any time period.

3.2.1.1 Bibliographic searches

We will search for evidence in the following bibliographic platforms:

1. Scopus
2. Web of Science Core Collections (consisting of the following indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, and ESCI)
3. The ProQuest Dissertation & Theses
4. Microsoft Academic

Searches will be performed using English language search terms. Subscriptions from the Swedish University of Agricultural Sciences and Stockholm University will be used.

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3.2.1.2 Search strings

The search string will be composed of four substrings described in Table 1. The string builds on the experience from previous reviews (Harder et al., 2019; Johannesdottir et al., 2020; Macura et al., 2019b) and it includes a combination of population, intervention and outcome terms. In addition, to avoid literature from pharmacology, medicine and veterinary science, we have added a set of exclusion terms. The idea is to compose the final search string as follows: **A AND B AND C AND (NOT D)**.

Table 1. Search substrings (shown as formatted for Web of Science).

A. Population terms	(WASH OR sanit* OR watsan OR toilet* OR urine OR feces OR faeces OR excreta OR excrement* OR yellowwater OR "yellow water" OR brownwater OR "brown water" OR blackwater OR "black water" OR "faecal sludge" OR "fecal sludge" OR septage OR sewage OR sewerage OR wastewater OR "waste water" OR digestate* OR effluent* OR sludge OR "sewage sludge" OR biosolid*)
B. Intervention terms (process terms) (recovery terms)	(*alga* OR *compost* OR "microbial fuel cell" OR "microbial electrolysis cell" OR "membrane filtration" OR "membrane bioreactor*" OR sorbent* OR "anaerobic digestion" OR crystallization OR crystallisation OR evaporation OR gasification OR hydrothermal OR hydro-thermal OR incineration OR "Low Pressure Oxidation" OR membrane OR microwaving OR micro-waving OR "reverse osmosis" OR "forward osmosis" OR "advanced oxidation" OR ozonation OR pasteurization OR pyrolysis OR sanitisation OR smouldering OR "smoulder combustion" OR stabilisation OR stripping OR supercritical OR thermochemical OR wetland*) OR (recover* OR *circul* OR reus* OR recycl*)
C. Outcome terms	(organic* OR nutrient* OR biosolid OR nitrogen OR urea OR ammonia OR ammonium OR phosphorus OR phosphorous OR phosphate OR potassium OR potash)
D. Excluded topics	(Veterinary OR metabolomic OR nephro* OR kidney* OR pharmacology)

3.2.1.3 Citation chasing

Records that are cited by eligible records indexed in Scopus and Web of Science will be retrieved and added to the search results (i.e., backward citation chasing). Moreover, the reference lists of all relevant reviews found during the systematic mapping process will be searched for eligible studies. If possible, we will also retrieve records that cite eligible records (i.e., forward citation chasing). Citation chasing will be implemented as an iterative process. After each iteration duplicates will be removed, and the process will stop once no new records are found.

3.2.1.4 Additional searches

The BONUS RETURN reviews (Johannesdottir et al., 2020; Macura et al., 2019b) included extensive searches for grey literature, but the contribution of grey literature in English to the evidence base was minor (for example, out of 448 articles included in the evidence base of a systematic map on recycling of carbon and nutrients from domestic wastewater, only 3 relevant reports in English were found and included). This review will search Google Scholar – no specialist websites will be searched. Nevertheless, an effort is made to map case studies that include real application of reuse and recovery technologies in Sweden. Moreover, we will contact other experts and our stakeholder group for relevant research (see section 3.1) and the calls for evidence will be issued on Twitter, ResearchGate, and similar platforms.

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3.2.1.5 Testing comprehensiveness of searches

During the scoping phase, search results were screened against a benchmark list including articles of known relevance to the review to examine whether these searches are able to locate relevant evidence. In cases where relevant articles from the benchmark list were not found with the search strategy, the search strings were examined to identify why articles were missed. Search strings were then adapted where relevant. The final search string includes all articles from the benchmark list.

3.2.1.6 Assembling a library of search results

Results of the bibliographic searching will be combined, and duplicates will be removed prior to screening. A library of search results will be assembled in EPPI-Reviewer (Thomas et al., 2020).

3.2.2 Searches in living mode

We will keep our evidence base up to date with the help of the Microsoft Academic database (https://academic.microsoft.com). To test comprehensiveness of this database, we have checked if it contains records from SANAGRI (Harder et al., 2019) and the BONUS RETURN wastewater (Johannesdottir et al., 2020) reviews. Out of 2904 records in total from these studies, only 94 (3.2%) were not indexed on Microsoft Academic, which is a convincing argument to consider using this as the only search source for living mode. We will re-assess the comprehensiveness of Microsoft Academic however upon completion of the baseline systematic map.

Two approaches will be combined to conduct searches on Microsoft Academic. The first approach consists of conducting standard Boolean searches on Microsoft Academic done within EPPI-Reviewer. The second approach uses a newly developed machine learning feature in EPPI-Reviewer. EPPI-Reviewer receives a new copy of the Microsoft Academic dataset every two weeks. The team at the EPPI-Centre, in conjunction with a team from Microsoft, has developed machine learning tools that can 'learn' the scope of a given review, and automatically identify newly published and potentially relevant studies each time a new version of the Microsoft Academic dataset becomes available. Even though there is likely to be substantial overlap between the machine learning and Boolean search results, the set of records that will result from the combination of the two approaches will be free of duplicates and will be combined into a unified list. We will be testing sensitivity by comparing numbers of missed records between the two approaches.

3.3 Article screening and study eligibility criteria

3.3.1 Screening for baseline systematic map

Screening will be done at two levels: at title and abstract (screened concurrently for efficiency) and at full text. Potentially relevant abstracts will be retrieved, tracking those that cannot be located or accessed and reporting these in the final review. Retrieved records will then be screened at full text, with each record being assessed by one experienced reviewer.

Prior to commencing screening, consistency checking will be performed with all reviewers on a subset of articles at both title and abstract and full text levels. A subset of approximately 10% of title and abstract records and full text records will be independently screened by all reviewers. The results of the consistency checking will then be compared among reviewers and all disagreements will be discussed in detail. Where the level of agreement among reviewers is low (below 80%), further consistency checking will be performed on an additional set of articles. This will be repeated until the consistency level reaches at least 80%.

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We will provide a list of articles excluded at title and abstract, and at full text, with reasons for exclusion in the final report. Reviewers who have also authored articles to be considered within the review will be excluded from decisions regarding inclusion of their own work.

3.3.2 Screening in living mode

For the living mode, we will explore how eligible records could be identified automatically using machine learning algorithms available in EPPI-reviewer. A training set will be compiled from records that were manually screened based on titles and abstracts by at least two reviewers. Based on the training set, the system will build bespoke classifiers which will rank records in order of their expected eligibility. This means that it will be possible to tailor a machine learning threshold below which a record is unlikely to be relevant. Records below this 'cut-off' threshold could be automatically excluded while records above the threshold would have to undergo manual screening. In case the number of new potentially relevant records exceeds the capacity for manual review, reviewing only those ranked highest will help maximise the yield of relevant records identified within available resource.

At the moment, EPPI-reviewer only has machine learning technology for classifying and screening records based on information available in title and abstracts, but not based on full texts. Therefore, full text screening (and consequently also coding) will still need to be performed manually in the living mode.

3.3.3 Eligibility criteria

The following criteria will be applied at all levels of screening and for both baseline review and living mode:

- *Eligible population(s):* Systems that manage human excreta or streams containing human excreta, notably domestic and municipal wastewater. This includes systems that manage residues and products that are derived from human excreta or wastewater, such as digestate, sewage sludge, treated effluent, etc. Both municipal and on-site systems are relevant, as well as co-treatment with other organic residuals. Systems that manage only greywater, stormwater, industrial wastewater or agricultural wastewater will not be considered.
- *Eligible Intervention(s):* Any technology or practice undertaken for the purpose of facilitating the recirculation of plant nutrients, and possibly organic matter, to agriculture. Recirculation can take place either through direct reuse after treatment of human excreta or streams containing human excreta, or through products derived from the extraction of nutrients from human excreta or streams that contain or derive from human excreta. Practices that are undertaken for the purpose of recovering carbon (for instance as methane for energy purposes or as polyhydroxyalkanoate for producing bioplastics) and water (for instance for irrigation or industrial purposes) are excluded unless the practice allows for simultaneous nutrient recovery or reuse.
- *Eligible Outcome(s):* Product that contains plant nutrients, with or without organic matter, and is suitable for reuse in agriculture, or as raw material to produce fertilizers.
- *Eligible Study type(s):* Primary research and reviews that describe nutrient recovery technologies or the reuse of recovered nutrients in agriculture. In addition to experimental studies at the lab, bench, pilot or full scale, this also includes human health risk and sustainability assessments, as well as studies on user acceptance.
- *Eligible languages*: English
- *Time frame:* No time limitations will be applied.

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3.4 Study validity assessment

The validity of studies will not be appraised as part of this systematic map, which is in accordance with accepted systematic mapping methodological guidance (James et al., 2016).

3.5 Data coding strategy

3.5.1 Data coding strategy for baseline systematic map

The meta-data to be extracted for all eligible studies relate to the recovery pathways, see Figure 1. A recovery pathway describes the combination of a primary input, treatment train, and a product. This and additional meta-data will be coded as specified in Table 2.

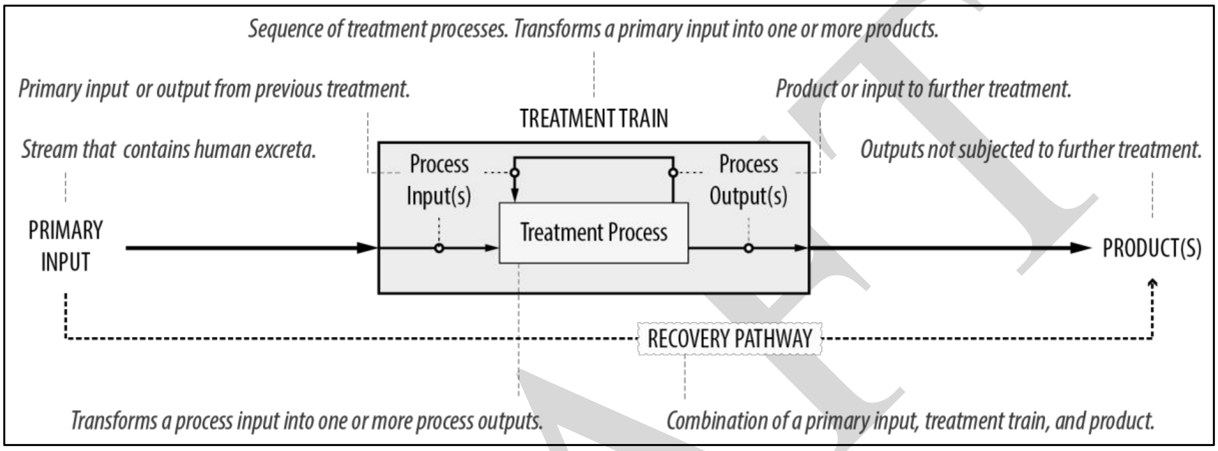

Figure 3. Definition of key terms used for meta-data coding.

Meta-data extraction and coding will be performed by multiple reviewers following consistency checking on a subset of up to 30 full texts, discussing all disagreements and clarifying coding scheme where needed. If resources allow, we may contact authors by email with requests for missing information or clarifications. Whenever information was to be retrieved in other ways than directly from the document, this will be annotated and reported in the final review.

Table 2. Overview of meta-data to be coded.

Meta-data domains	Possible values	Comment
Primary input(s)	e.g. urine, blackwater, sewage sludge ash, treated effluent.	
Process(es)	e.g. selective crystallization, hydrothermal liquefaction, sorption, membrane filtration, etc.	
Product(s)	e.g. struvite, ammonium sulfate, algal biomass, etc.	
Commercial name of process	e.g. NuReSys, DHV Crystallactor, etc.	Where applicable.
Commercial name of product	e.g. Aurin, Crystal Green, etc.	Where applicable.
Author affiliation location	Country and city, including coordinates of the city.	
Study location	Country and city, including coordinates of the city.	Where applicable.
Study scale	Lab, bench, pilot, or full scale.	Where applicable.
Study type	Recovery process, recovery product, reuse in agriculture, sustainability assessment, user acceptance.	
Research type	Primary (experimental or theoretical) or secondary (reviews and syntheses).	

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3.5.2 Data coding strategy for living mode

It is currently not possible to consistently and comprehensively code full texts using automation technologies. Therefore, at least for the moment being, any automated meta-data coding will have to rely on information present in the title, abstract, and keywords. We will also be testing clustering of records using the Microsoft Academic topics (including parent, child and related topics) that are available for each record in the database. These topics are automatically generated using topic modelling on the basis of full texts. Manual data coding will be done as shown in the section 'Data coding strategy for baseline systematic map'.

3.6 Study mapping and presentation

The evidence base identified within the map will be described primarily within a systematic map database; a searchable (relational) database with columns containing codes and meta-data related to the variables described in the meta-data extraction and coding schema, above. In addition, we will produce heat maps that cross tabulate two variables and detail the volume of evidence (number of studies) within each cell of the table. Various combinations of variables will be used for these heat maps, including pathway components and similar meta-data as per **Table 2**. The heatmaps will be used to identify knowledge clusters (well-represented subtopics that are amenable to full synthesis via systematic review) and gaps (un- or underrepresented topics). Identification will be performed by visual inspection by a methodology expert of the review team (i.e., not a subject expert to avoid preconception bias). The gaps and clusters will then be validated with stakeholders in focus group discussions.

3.6.1 Visualising the systematic map findings via an evidence platform

Evidence syntheses and knowledge brokering tools work at the boundary between science and policy and thus have to meet user needs (McNie, 2007). To increase the use and uptake of evidence, the findings of this systematic map will be visualized through an evidence platform continuously developed through a codesign process with stakeholders (see section 3.1).

3.6.2 Maintaining the living evidence platform

After the baseline review is finalised, and once the living mode is set up, the database will be automatically populated and uploaded to the evidence platform every 6 months or when there are more than 50 new records found and up until the year 2026. The process will then be revised to account for technology improvements. After every update, a short report will be produced describing records added to the database.

Declarations

Competing interests

The authors declare they have no competing interests

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