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SUMMARY

Water reuse is considered globally as the most critical element of sustainable water management. Addressing water scarcity, foreseen to be aggravated by climate change, necessitates maximum utilisation of non-conventional water sources to balance the increased demand. The reuse of treated wastewater and stormwater (and associated treatment-derived sludges) is driven by different motivations in the various parts of the world and, most recently, by the circular economy principles. Although reuse is accompanied by various benefits, a number of questions require urgent attention. Available treatments fail to remove completely many micropollutants and biological contaminants e.g. antibiotic resistant bacteria and/or genes (now identified under the global term of contaminants of emerging concern; CECs). Knowledge on the actual effects of reuse practice with regard to these aspects is not consolidated. WG5 aims at answering critical related questions, to provide insight on the identification and quantification of CECs in water and treatment sludge) intended for reuse, the removal performance of treatment technologies including natural-based solutions, fate and behaviour of CECs in the reuse systems and receiving environmental compartments including crops uptake and bioaccumulation in the food chain, effects of reuse practices on exposed organisms, the development of risk assessment criteria (e.g. quality standards) and methodologies to overcome current barriers and enhance further the reuse.

BACKGROUND

Water demands already exceed supplies in many regions. Currently more than 40% of the world's population – predicted to increase to 60% by 2032 – live in areas of water scarcity. The European Mediterranean countries suffer, for example, from prolonged dry periods, while the Northern European countries aim to reduce their water extraction and production footprints. On an international level, the fast development of mega-cities in high-growth areas like Asia and South America escalates urban water consumption, increasing the need for new solutions to balance the water demand. In response to the wicked challenge of water shortages, treated wastewater and stormwater runoff are widely reused and considered as a reliable alternative water source for irrigation and groundwater replenishment among other applications. Although reuse practices are accompanied by a number of benefits relating to the enhancement of water balance and soil nutrition, a number of unanswered questions are still related to this practice.

Until now, reuse was applied in EU Member States (MS) under different rules driven by different motivations but in June 2020, the EC has adopted a regulation on minimum requirements for water reuse in agricultural irrigation. During the development of the regulation, reviewers agreed that it inadequately address risks for humans and the environment associated with the micropollutants and antibiotic resistance. In 2019, a number of legislative pieces relevant for water reuse have been evaluated by the EC: Water Framework Directive, Groundwater Directive, Environmental Quality Standards Directive and Floods Directive. In conclusion, the Directives were broadly identified as fit for purpose and whilst considered to be flexible enough tackling emerging challenges not mentioned in the Directives (such as water scarcity and CECs, the key area identified as requiring further work is chemicals. Currently, the Sewage Sludge Directive adopted to encourage the safe use of sewage sludge in agriculture is also under evaluation by the commission.

CECs remaining in effluents after conventional treatment can include recalcitrant organic compounds such as endocrine disrupting compounds as the currently applied treatment processes fail to remove completely such contaminants leading to their subsequent release into the terrestrial and aquatic environment through reuse applications with potential environmental and health concerns. Besides the lack of knowledge in respect to possible accumulation of metals/elements in the soil and the subsequent uptake by plants and crops, organic micropollutants and antibiotic-resistant bacteria and genes (ARB&Gs) in treated wastewater require much attention. Current open challenges for water reuse practices include behaviour and fate of CECs, their physicochemical and biological transformation products originating during treatment, transfer to point of use, storage and application, their potential uptake by exposed organisms (e.g. worms, crops) and their accumulation though the food chain, the effects that these contaminants may induce in the environment and on humans in term of infectivity and toxicity, and the identification of means (e.g. removal technologies) and solutions (e.g. reduction at source) to overcome these problems and promote safe reuse practices further. To avoidnegative and irreversible environmental and human impacts, regulatory frameworks are required, based on validated scientific information. WG5 aims at increasing the scientific understanding on these crucial issues and to potentially boost technological developments.

PROPOSED MANDATE

The WG will focus its efforts on:

1) Identify and prioritise contaminants of emerging concern in water (and sludge) intended for reuse including transformation products, antibiotic resistance determinants, and nano-micro scale particles.

2) Assess the removal performance of treatment technologies including nature-based solutions[1].

3) Conduct studies and consolidate information on the contaminants behaviour in soil including degradation, uptake by crops and bioaccumulation through the terrestrial trophic chains.

4) Conduct studies and consolidate information on contaminants toxicity in soil including mixtures present in water (and sludge) intended for reuse.

5) Identify and respond to knowledge gaps to develop exposure scenarios and quality standards for water and sludge reuse required for their risk management.

6) Develop scientific updates and best-practice advice within a format that is useful and useable by practitioners and their dissemination to decision makers and the public.

The following sub-working groups (SWGs) will be formulated:

SWG1: Biological hazards: pathogens and mobile resistome present in reuse systems.

SWG2: Chemical hazards: micropollutants and micro-nano scale particles present in reuse systems.

More details on the suggested activities of the various SWGs are provided below:

SWG1: Biological hazards: pathogens and antibiotic resistance present in reuse systems

Based on the fact that emerging pathogens and mobile genetic elements (MGEs) enabling the transfer of antibiotic resistance to bacteria are now considered as contaminants of emerging concern, information on the capacity of the currently applied wastewater treatment systems in removing them and (if not) their subsequent spread through recycling practices will be gathered and evaluated. Model sites in various countries will be examined in relation to established wastewater reuse schemes and selected pathogens (e.g. SARS-CoV-2), antibiotic resistance determinants and mobile genetic elements determined in the final effluents and receiving compartments.

SWG2: Chemical hazards: micropollutants and micro-nano scale particles present in reuse systems

Micropollutants including transformation products of parent substances, nanos and micro-scale contaminants like microplastics will be identified, prioritised and assessed in water reuse systems.

[1] "Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions." according to the EC https://ec.europa.eu/info/research-and-innovation/research-area/environment/nature-based-solutions_en

WG5 aims at establishing a strong scientific collaboration channel with the existing NORMAN network WGs:

- WG1 on “Prioritisation of emerging substances” and cross-WG Activity Non-target Screening (NTS) to assess priority CECs in reused water (and sludge).
- WG2 on “Bioassays and biomarkers in water quality monitoring” and WG3 on “Effect-direct analysis for hazardous pollutant identification” to assess how valuable insight already produced will be utilised in the activities related to the water reuse risk assessment.
- WG4 on “Nano-and micro scale particulate contaminants” to assess the fate and behaviour of particulate contaminants in WWTPs and natural systems.
- New cross-WG on CECs in the terrestrial environment: fate and behaviour of chemical pollutants in soil.

OUTCOMES OF YEAR 2020

1) Road map of activities for 2020.
2) NORMAN – SCORE joint initiative to facilitate data comparison between “SARS-CoV-2 in sewage” studies. Contribution to the NORMAN Database System.
3) NORMAN database system project: water reuse water quality database
4) Existing White Paper (Mandate) on the WG5 activities, based on decisions taken during the kick-off meeting of WG5 held virtually in September 2020.

WORKPLAN / ROADMAP FOR 2021

A draft description of the proposed activities is provided in Annex I (to be completed).

ORGANISATION

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ANNEX I
Road Map of Activities for 2021

NORMAN – SCORE joint initiative to facilitate data comparison between "SARS-CoV-2 in sewage" studies.

The NORMAN SCORE SARS-C0V-2 in sewage (SC2S) database is an open-access database, developed as a collaboration between the NORMAN and SCORE networks (https://score-cost.eu; established to harmonise methodologies for measuring human biomarkers in sewage to evaluate lifestyle, health and exposure at the community level). The database is located within the NORMAN database system at https://www.norman-network.com/nds/ as the 13th database within its linked database system series for the collection and evaluation of data / information on emerging substances in the environment. The SC2S database structure follows that of the NORMAN Antibiotic Resistance Bacteria/Genes database, enabling users to freely access data at a wastewater treatment plant level as well us upload new data via a customised data collection template (DCT; downloadable from the website) which facilitates its automatic uploading to the system. On accessing the database, users can search via country and/or wastewater treatment plant or view the entire data set (both within the database or it can be exported into MS Excel). Data displayed in the dashboard includes sampling date, gene copy (number of copies /ml and/or ng of RNA/ml), cycle threshold (Ct), wastewater treatment plant and country name, population served and the number of people reported SARS-CoV-2 positive on the day of sampling. However, the full DCT (containing all reported data on the wastewater treatment plant characteristics, sampling procedure and conditions, analytical method and quality assurance steps) can be downloaded for each dataset.

To launch the database, invitations to participate were initially shared through both the NORMAN and SCORE networks, with a request for members to disseminate further through their own networks. To harmonise activities, participants were provided with a common protocol covering sample collection, RNA extraction and analysis. The common protocol adopts the Medema et al (2020) methodology with an alternative simplified protocol for SARS-CoV-2 extraction from wastewater via *polyethylene glycol (PEG) precipitation* (recognising that many consumables/equipment currently in short supply). A further step was to establish a 'buddy system' for research groups who were able to collect wastewater samples but whose laboratories were under lock-down/not familiar with RNA analysis. Two scheduled sampling campaigns were held on June 1st 2020 and June 14th 2020. To date the SC2S database contains 30 sets of data from 21 WWTP located in five different countries. However, several contributors have been unable to submit their data as yet due to delays sourcing reagents. A research communication to raise awareness of the database and invite further submissions is under development.

NORMAN database system project: water reuse water quality database

Recent developments in the policy arena have brought the issue of CECs into sharper focus:

- The recent EU Fitness check of water legislation concluded that existing directives were broadly fit for purpose with the exception of chemicals
- The EU Water reuse regulation (2020) has been criticised by both the SCHEER and EFSA for its failure to adequately consider the risks from CECs
- The European Green Deal includes a strategy to eliminate pollution through implementation of a new chemicals strategy for sustainability for a toxic-free environment.

Within this context, the development and population of water reuse water quality database is an effective mechanism to support the collaborative development of a baseline to for example, inform future policy discussions on future research directions and the comparative importance of water reuse as a pathway to the environment. A useful initial activity is to collate and review current knowledge on the occurrence and loads of conventional pollutants CECs in treated wastewater and stormwater. Another activity is to identify and review existing quality standards and to assess their protection targets and methodologies for the future development of water reuse quality standards.