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Briefing note

Nutrients and waste water management

This briefing note on nutrients and waste water management summarises how nutrients are currently managed within waste water and proposes ideas about the future of nutrient management within waste water management.

Recovery routes for nutrients need to take account of local markets and local requirements. To establish a circular economy, it essential to create a pull in the market, through, for example, a revised Fertiliser Regulation.

There are many possibilities for the recovery and reuse of the nutrients within waste water. EU-wide End-of-Waste criteria for good quality products recovered from WWTP is essential to increase nutrient recycling from waste water.

Looking ahead, requirements on nutrients should not be set according to what is technically feasible but what is economically and environmentally sustainable as well as protecting the affordability of waste water services.

This EurEau briefing note on nutrients and waste water management serves two purposes:

1. To summarise how nutrients are currently managed within waste water i.e. the practice which has become established by waste water operators across Europe and
2. To propose ideas about the future of nutrient management within waste water management.

1. Nutrients and the cycle of life

Nutrients are essential to life. All biological processes utilise the main three nutrients; Nitrogen (**N**), Phosphorus (**P**) and Potassium (K)[1]. Nutrient cycles move nutrients from living things into water, air, soil and back into living organisms. All living organisms, including humans and our food chain, are dependent on nutrient cycles.

2. Nutrient management is a central component of waste water treatment

All living things excrete waste, including humans. Our bodily wastes (urine and faeces) include the nutrients N and P. Each year, each one of us produces approximately 4kg N and 0.5kg P[2] in the form of both urine and faeces.

Basic waste water treatment is about lowering the solids (Carbon) and oxygen demanding materials discharged by us into the environment, and protecting sensitive waters from the effects of excessive nutrients from people, all with the intention of protecting the environment. Waste water collection and treatment have become the way to do this. Consequently, it can be seen that nutrient management is a central component of all waste water treatment endeavours.

3. Excessive nutrients in the water environment

An excess of nutrients in the water environment can lead to accelerated plant growth, which then depletes the life-giving oxygen within those systems leading to both short and long term significant adverse consequences. This can happen in both fresh and marine waters and can prevent them reaching their desired target status.

Not all recipient waters have the same tolerance of nutrients. Marine waters are different from freshwaters, and standing waters (lakes) are different from running waters (rivers).

If the water environment is under stress due to excessive nutrient enrichment (i.e. eutrophication) the consequences might be accelerated plant growth, reduction in dissolved oxygen in the water, algal blooms; all of which may drastically reduce the ecological value of the water environment. In this situation, improvements are required and it becomes necessary to understand the specific nature of the problems caused by

[1] Potassium (K) is an essential nutrient for life, but is not considered to be associated with pollution or eutrophication, so is not considered further within this Briefing Note.
[2] Dr Steven A Esrey, UNICEF, October 1990, drawn from wider scientific papers.

excessive nutrients and the needs of the recipient (receiving) waters in order to bring about the recovery of ecological systems. By doing this, the right solution for the receiving waters can be identified, in terms of future nutrient concentrations.

It must be noted that treated waste water effluent is not the only source of nutrients entering the water environment. The other significant source is agriculture (arable farming for inputs of N and P fertilisers and the wastes from animal and fish farming). In addition, there are other minor sources, including untreated waste water e.g. from combined sewer overflows, industrial waste water and atmospheric deposition of nitrogen. This paper does not explore these contributing factors to nutrient management. However, this combination of inputs of nutrients is the reason why it is hard to take a "one size fits all approach" to nutrient management in the water environment.

4. Waste water treatment and the capture of nutrients

The collection and treatment of waste water allows nutrients, from people in towns and cities, to be captured and the treated water to be returned safely to the environment.

Typically, waste water is collected in sewers and conveyed to waste water treatment plants (WWTP). Mechanical screens take out solid waste (often this includes materials that are inappropriately disposed of into sewers e.g. wet wipes, cigarette butts, food packaging etc). Primary treatment settles out particulate carbon and the larger particles.

The subsequent biological treatment processes such as Activated Sludge or biological filtration significantly reduce the N in waste water (this occurs in conjunction with the removal of carbon). P is reduced in the waste water through biological removal or by chemical precipitation. Some of these treatment processes are highly energy intensive and/or rely on chemical inputs (with the extent of the demand for energy and chemicals for N removal being heavily dependent on the process conditions). The technologies selected for nutrient removal at an individual WWTP depend on the target load reduction or final concentration which the WWTP must achieve.

In the case of N captured from waste water, it is either in the biological sludge after secondary treatment or it is released into the atmosphere as nitrogen gas or nitrous oxide N_2O (thought to be a very low percentage of the total emissions to the air).

In the case of P captured from waste water, it mainly ends up in the biological sludge or as a residual semi-solid chemical sludge or as a crystallised compound called struvite.

5. The EU legal context for nutrients and waste water

The **existing Urban Waste Water Treatment Directive (91/271/EEC)** (UWWTD) sets the legal context for nutrient management and waste water treatment at the EU level.

Essentially, the UWWTD sets targets[3] for N and P removal to limit the concentrations and/or to achieve a load removal in the final treated effluent for populations above 10,000 pe, for

[3] Urban Waste Water Treatment Directive (91/271/EEC), Annex I, Table 2.

discharges into sensitive areas.

This existing approach has been effective in creating a level-playing-field across the EU members for the collection and treatment of waste water and has resulted in the reduction of nutrients entering the water environment from towns and cities. However, there is still a compliance gap[4] to fill with respect to fully achieving the requirements of the UWWTD for nutrient management.

Nutrient control within the existing UWWTD is established around the concepts of **sensitive areas** and **less sensitive areas**. Designation of sensitive areas is set out in the UWWTD in Annex II, where standards for nutrients in final treated effluent are set for sensitive areas. Less sensitive areas may also be designated for certain marine waters, although in practice few less sensitive areas are designated.

It must be noted that the existing UWWTD sets uniform standards for nutrients. The UWWTD does not consider the degree of nutrient reduction required to protect or improve receiving water quality. Nor does the existing UWWTD co-ordinate requirements for nutrient reduction with other sources (i.e. agriculture). These two points mean that investment in nutrient removal at WWTPs across Europe may be yielding limited benefits for the water environment, or that opportunities for improvement are missed. The interaction with the Water Framework Directive, to fine tune the need for further nutrient reduction, is therefore of great importance.

6. What do waste water operators currently achieve for nutrient management?

EurEau members have exchanged operational experience on the treatment of waste waters and capture/removal of nutrients. The summary of experience is that many EurEau members are already working to deliver a combination of Water Framework Directive (WFD) and Marine Strategy Framework Directive (MSFD) objectives, alongside the UWWTD, when final treated effluent standards are set for a WWTP permit.

The objectives for establishing sensitive areas are varied and include: the protection of waters from eutrophication, protection of groundwater resources for drinking water, protection of certain marine environments e.g. Baltic Sea. Sometimes waste water operators do not know the precise reasons for designation of sensitive areas. Nutrient management may also be a requirement to achieve the Good Status objective under the WFD.

Both N and P are considered by waste water operators.

Although the UWWTD sets standards for N and P, operators work with a range of standards, taking into account local environmental conditions. Total N and Total P are not always used alone; sometimes in combination with requirements for ammonia[5] or variants of phosphorus.

[4] 10th Implementation Report on the UWWTD, September 2020.
[5] Ammonia (which in is part of the chemistry of N) is highly toxic to fish.

Data from EurEau members show that some operators are now providing treatment to tighter standards for N and P removal than currently required by the UWWTD. This may partly be to ensure targets are achieved at the WWTP, or to attain much more stringent standards set to protect the environment under other legislation.

Experience of EurEau members is that controls on P are driving the more advanced treatment requirements.

Each day, a WWTP is subject to daily variations in flows and loads, as well as other seasonal variations, such as where there is significant infiltration into the sewer system, temperature, or significant tourist populations. In addition, loads discharged to sewer by industry can vary significantly. These variations change the load of nutrients received at the WWTP on a daily basis. Considerable loads of nutrients are captured[6] at WWTP and diverted away from the water environment. All of this is achieved by using energy and a range of treatment technologies.

EurEau members note that nutrient removal at waste water treatment works is resource intensive (installation materials, energy and chemical usage). Therefore, to make best use of limited resources, further treatment enhancements must be targeted where they will bring the most benefit.

In summary, waste water operators have become highly specialised at capturing and removing nutrients from waste water. Some of the N and P is captured within the sludge generated during the treatment process. Some P might be precipitated out during treatment. N is released to the atmosphere as nitrogen gas or forms N_2O and as such, escapes to the atmosphere (fugitive emissions).

7. Beyond the scope of the existing UWWTD

EurEau notes that the existing UWWTD does not take account of the differing assimilative capacities of differing receiving waters; so on its own, the UWWTD will not deliver specific outcomes for the water environment.

Where specific environmental outcomes are wanted, then the needs of the water environment become central to the considerations. EurEau members see there is scope to align the requirements of the UWWTD more clearly with the provisions in other directives e.g. **Water Framework Directive (WFD) and Marine Strategy Framework Directive (MSFD)** when specific environmental improvements are required. We suggest that these ideas are explored as part of the up-coming Impact Assessment of the UWWTD, due by the end of 2021.

In addition, the existing UWWTD is only concerned with setting standards for release of nutrients into the water environment, whilst also encouraging the recycling of sludge arising from waste water treatment. The UWWTD specifically does not consider emissions

[6] As an example it is estimated that for the Flanders region of Belgium annual removal of N is 23,000 tonnes and P is 3,200 tonnes.

to air[7], nor set out the recovery and reuse of nutrients. In this respect, the UWWTD does not fully represent the natural nutrient cycles.

Looking to the future, EurEau suggests a broader approach to nutrient management.

Nutrients are essential for life and the management of nutrients is and should remain at the heart of waste water treatment. The waste water sector a control mechanism for managing N and P from people and protecting the water environment from eutrophication. Huge investments have already been made to achieve the current controls of N and P, although EurEau does acknowledge that there is a compliance gap that needs to be closed.

Building on the successes of the UWWTD which protects the water environment, EurEau favours a broader approach to managing N and P in the waste water cycle, which takes into account the destination of nutrients to land, water and air, as well as taking account of the input loads that are received at the WWTP. EurEau suggests that this approach is required to ensure nutrients are managed in co-ordination with Climate Change targets and the Circular Economy.

Protection of the water environment from excess loads of nutrients may require more stringent approaches, but this should be targeted to where it is needed, due to the costs and resources required for nutrient management.

EurEau members see there is scope to align with the provisions for sensitive areas and less sensitive areas with other directives e.g. WFD, MSFD which put the needs of the receiving waters at the centre. Additionally, the Nitrates Directive may play a role. We suggest that this is explored as part of the up-coming Impact Assessment of the UWWTD.

EurEau notes that there is a large variety of language and terminology in relation to nutrient management in the water environment, for example, percentage (%) load removal and concentrations (mg/l). There are outcome-based solutions and load removal solutions. We note that clarity is needed about the objective for nutrient management so that the correct targets are selected.

The recovery and reuse of nutrients is now foreseen within the Circular Economy and EurEau welcomes this. New partnerships and business models are likely to be required to ensure nutrients can be part of the Circular Economy and their recovery is not part of the Polluter Pays Principle.

Carbon and nutrients are currently, mainly, recovered from waste water by applying biosolids in agriculture (50% sewage sludge production in Europe) or in recultivation or land reclamation (12%). **Given this situation, the Sewage Sludge Directive should be seen as part of the broader approach to nutrient management, as this approach ensures that nutrients are returned to agricultural land.**

Regarding specific P-recovery technologies already applied in some places, the recovery

[7] Whilst the UWWTD does not make requirements, some countries are progressing with their proposals, for example: a National Climate Plan was prepared in 2020 in Denmark. The plan covers a reduction of N_20-emissions for UWWTPs over 30,000 PE (Introduction of emission standards is not yet decided).

rates vary widely, from around 15-40% for struvite recovered from sludge waters or digested sludge from plants with enhanced biological phosphorus removal, to 80-90% sewage sludge incineration ash from P-removal plants. EurEau sees that new markets for recovered N and P should be encouraged as investment in technologies for recovery of resources are important.

EurEau members acknowledge that depending on the agricultural needs and the quality of the sludge, it is not always possible or acceptable to apply sludge to land for nutrient recovery. Incineration of WWTP sludge is preferred in some countries, but incineration has to consider investment costs and greenhouse gas emissions. Where incineration is favoured, P can be recovered from the ashes.

Recovery routes for nutrients need to take account of local markets and local requirements. To establish a circular economy, it essential to create a pull in the market. This could be achieved, for example, by introducing an EU Fertiliser Regulation where it is compulsory to blend a certain ratio of recovered P and N in all mineral fertiliser in the EU – a system very much a like the compulsory 5% ratio of ethanol blended in petrol sold in the EU.

There are many possibilities for the recovery and reuse of the nutrients within waste water. Where materials are deemed to be waste, the establishment of EU wide End-of-Waste criteria for good quality products recovered from WWTP is essential to increase nutrient recycling from waste water.

Looking ahead, requirements on nutrients should not be set according to what is technically feasible but what is economically and environmentally sustainable as well as protecting the affordability of waste water services.

About EurEau

EurEau is the voice of Europe's water sector. We represent drinking water and waste water operators from 29 countries in Europe, from both the private and the public sectors.

Our members are 34 national associations of water services. At EurEau, we bring national water professionals together to agree European water sector positions regarding the management of water quality, resource efficiency and access to water for Europe's citizens and businesses. The EurEau secretariat is based in Brussels.

EurEau

With a direct employment of around 476,000 people, the European water sector makes a significant contribution to the European economy.