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FOUNDATION
FOR APPLIED WATER RESEARCH

NEWs: THE DUTCH ROADMAP FOR THE WWTP OF 2030

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NEWS: THE DUTCH ROADMAP FOR THE WWTP OF 2030


NEWs

PREFACE

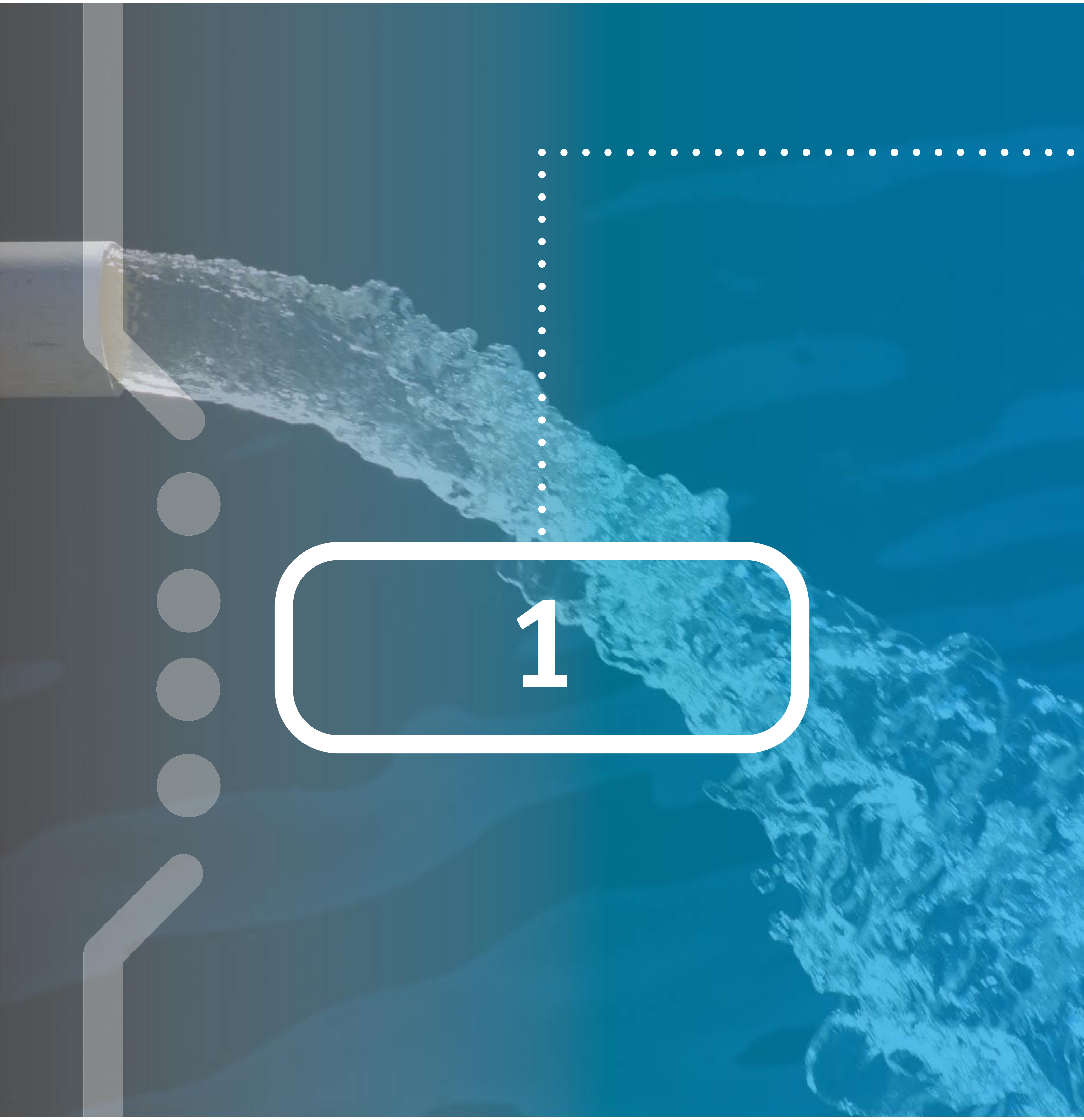
The Dutch Water sector has been a very innovative sector during the last decades. Innovations have been necessary in order to meet increasing effluent quality standards at affordable costs. This NEWs study shows possibilities for resource approach instead of a waste approach. The term NEWs implies that the new way of wastewater treatment is resource management for the three basic resources Nutrients, Energy and Water. The Dutch examples presented in this report, show that new treatment schemes based on a resource approach are already practiced.

The project was initiated by the Global Water Research Coalition (GWRC). The international network of water organisations gathered in the GWRC wanted a look at the future of our wastewater treatment facilities. Could it be useful to apply resource thinking to wastewater treatment?
Next to this, the global impact of the economic crises, the energy crises and the climate changed, caused countries to rethink their energy use and emission of green house gases. In The Netherlands, the water sector has set limits to energy use and has proposed more large projects on energy efficiency of wastewater treatment facilities.

In The Netherlands the watersector is divided in different organisations for drinking water (water supply companies), sewage systems (municipalities) and wastewater treatment (waterboards). Cooperation between these organisations is encouraged, because of cost efficiency purposes.
These three different drivers were taken as the starting point of this study. We believe that wastewater treatment will always be necessary, but the future is found in resource thinking. Good NEWs for the world: waste becomes a resource. The Dutch Water sector is setting steps towards 2030.

Amersfoort, June 2010
Director of STOWA, ir. J.M.J. Leenen

TABLE OF CONTENTS



1

INTRODUCTION

In 2008, the Global Water Research Coalition took the initiative to reflect on the future of municipal wastewater treatment, consisting of collection, transport and treatment, aiming at climate and energy neutrality. Within the context of this global research program, some countries agreed to focus on the municipal sewage treatment plant, an important element of urban wastewater management. The Netherlands are part of that group, lead by the Public Utility Board of Singapore. This report summarizes the Dutch research contribution.

The main objective of the Dutch research was, to elaborate the outlines of the municipal sewage treatment plant of 2030. First, current and future developments and trends that might have an impact on sewage treatment were summarized from literature and analyzed with an expert team (chapter 3). Next, current and potential treatment techniques were summarized (chapter 4). Subsequently, examples of future treatment plants, called the water factory, energy factory and nutrient factory, were designed by the expert team (chapter 5). Finally, a roadmap leading to an appropriate choice of technology and design was drafted.


2

THE PROJECT

2.1 METHOD

The first project activity was to analyze and summarize national and international literature on trends and developments that will or may affect the urban wastewater management in general and wastewater treatment in particular.

In the next project phase, national experts were involved. It was decided to drain their knowledge, experience and vision through two workshops. In total, 48 experts of water boards, water companies and consultants joined the expert team. The first workshop focused on trends and developments, the second on technology and the outline of the 2030 municipal wastewater treatment plant.

The final project phase focused on elaboration of the 2030 roadmap, reporting and communication.

2.2 STARTING-POINTS

Reflecting on the future, easily generates panoramas that diverge from a likely reality. On the other hand, creativity should not be limited by unnecessary boundary conditions. A well balanced playing ground was defined by setting a series of general starting-points:

- Predictable changes of wastewater production and composition are taken into account;
- Wastewater treatment also comprises sludge production and treatment;
- The existence in 2030 of treatment plants build before may not be a limiting factor;
- The wastewater treatment plant is a centralized facility that offers integral treatment of wastewater; the effects of local pretreatment are not taken into account;
- The effluent quality that will be produced in 2030 is higher than today;
- It is allowed to pass the line of current legal limitations with respect to application of certain apparatus, application of residues, etcetera;
- Water boards may utilize their capacities for other purposes than the current task of protecting the aquatic environment;
- The local situation at a specific treatment location may be utilized.


3

PERSPECTIVE

3.1 DEVELOPMENTS AND TRENDS

Table 3.1 lists the major developments, derived from literature, that will or may affect municipal wastewater treatment in The Netherlands.

Table 3.1. Important developments and impact on wastewater treatment.

DEVELOPMENT	DIRECTION	IMPACT
Demographic	Population growth	Treatment capacity
	Urbanization	Treatment capacity
	Aging	Wastewater: hormones, medicines
	Shortage of technicians	Water(technology) capability
Economic	Shortage of raw materials	Capital and Operational costs
	Globalization; commercialization	Exchange; organizational change
	Declining industrial discharge	Wastewater: less degradable matter
	Increasing operational costs	Operational costs
Environmental policy	Demand of higher efficacy	Efficiency, efficacy, quality
	Effect of European legislation	Discharge standards
	Sustainability	Policies on purchase, impacts
	Strategy of containment, storage and discharge (of wastewater)	Treatment capacity
	Cooperation in water cycle	Optimization
Ecological	Climate change	Peak capacity
	Sustainability becomes natural	Reuse of resources
	Increase of treatment plant loading	Fraction non-degradable matter
Social	Individualization	Acceptance of public activities
	Demand of higher quality, luxury, comfort of life	Dilution wastewater
	(virtual) Webs	Knowledge exchange
Technological	Raw materials from wastewater	Water, N, P
	Energy from wastewater	Production, providing
	ICT development	Process management, information
	Decentralized pretreatment	Chemical use
	Increasing knowledge of hazardous compounds	Treatment performance standard
	Increase of build and paved area	Treatment capacity
	Scaling-up of treatment plants	Economics; technology
	Nano particles	?
	Application of nanotechnology	Technology
	New treatment techniques	Technology

3.2 FACTORS

In addition to the developments mentioned, certain factors may influence or even set the wastewater treatment technology to be applied in the future. The expert team was asked to generate and rank such factors in terms of priority. The results are shown in figure 3.1.

The factors effluent (quality), energy (neutrality), and nutrients (recovery) point the direction of manufacturing of products and can be materialized in terms of a water factory, an energy factory and a nutrient factory. These factories were adopted to be the leading concept at the development of the 2030 treatment plant outline.

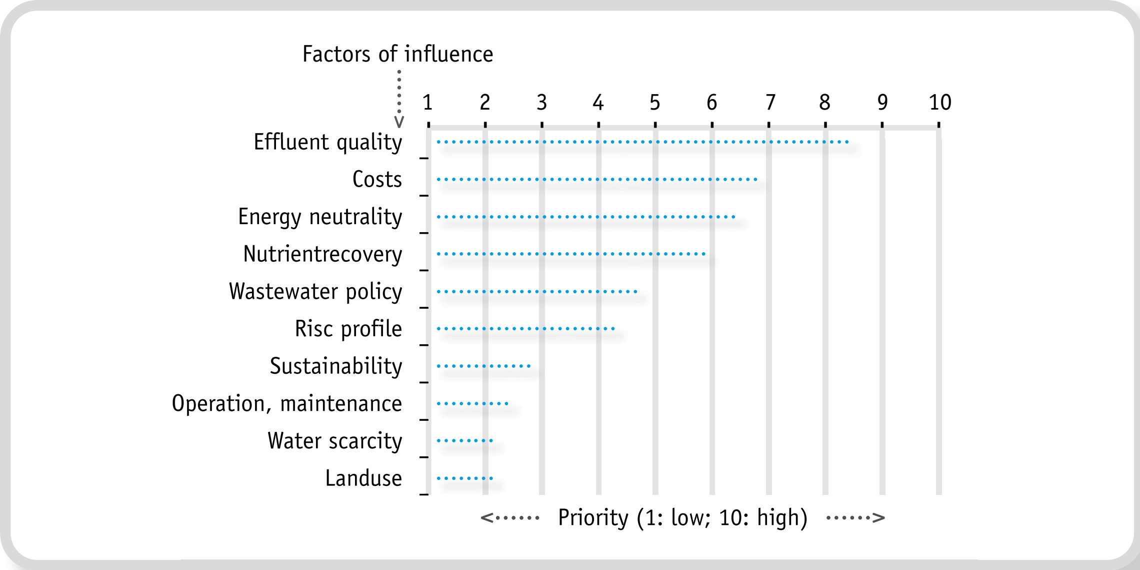


Figure 3.1. Priority of expert group for factors of influence.

3.3 IMAGES

Based on developments, trends and factors identified, the expert team was asked to reflect on the directions municipal wastewater treatment might take in the 20 years to come. The reflection had to occur within the framework of a two-dimensional space, defined by coordinates of technology and society. The meaning of the four segments, in fact scenarios, was explained on a number of aspects (figure 3.2). The experts were asked to score the probability of the scenarios to occur in 2010 and 2030. The results are shown in figure 3.3. The table clearly demonstrates a landslide to be expected.

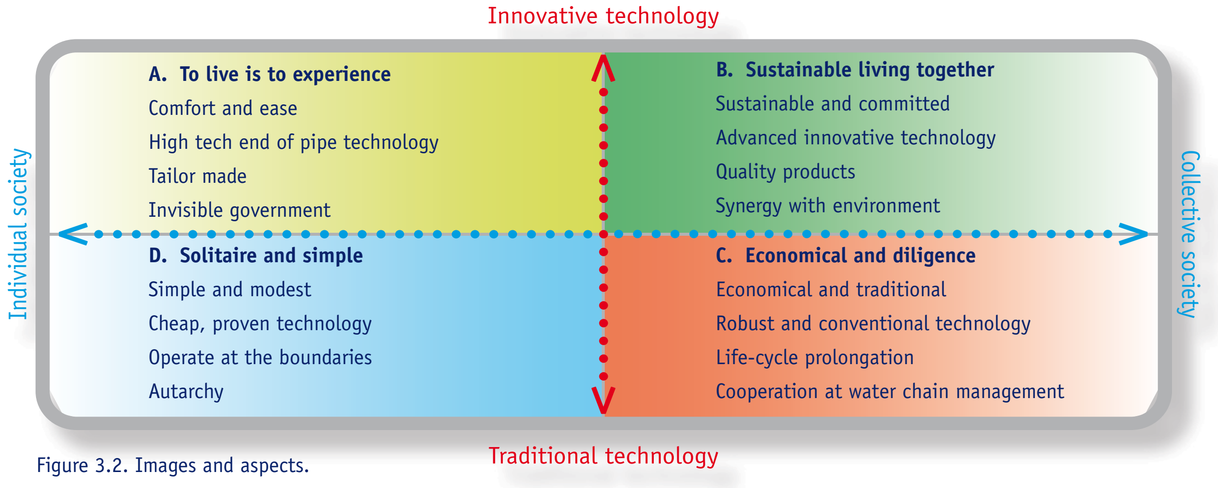


Figure 3.2. Images and aspects.

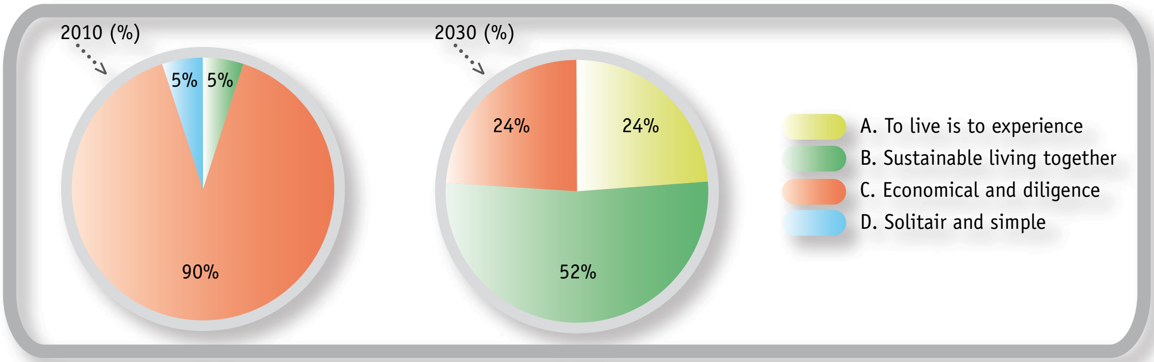


Figure 3.3. According to expert group the situation in 2010 (left) and in 2030 (right).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TREATMENT TECHNOLOGY

4.1 INTRODUCTION

Municipal wastewater treatment in The Netherlands can be schematized into six process steps (figure 4.1). For each process step different techniques are applied, available or under development. Sometimes, they are comparable in terms of treatment objective, in other cases they are applied in series for different purposes. It is to be expected that before 2030 current techniques are abandoned, available techniques become operational and new techniques are developed.

In this chapter, treatment techniques are summarized and classified according to purpose, experience, relevance to water, energy and nutrient factories, and special features.

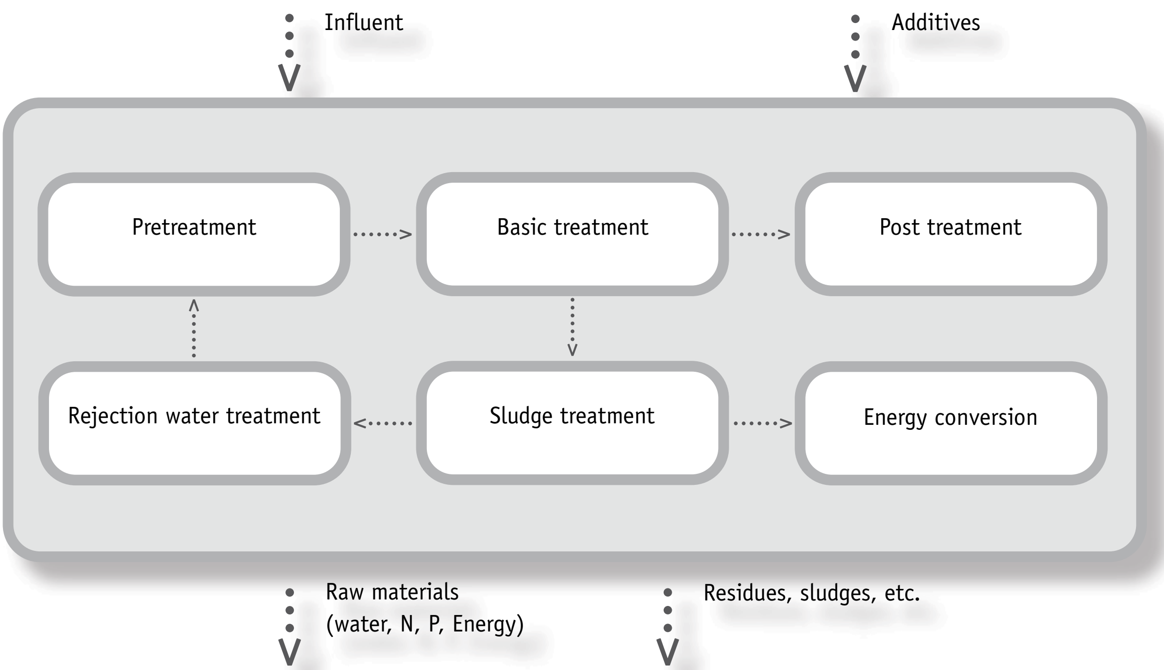


Figure 4.1. Scheme of various process steps of a wastewater treatment plant.

4.2 PRETREATMENT

The main purposes of pretreatment are, to remove coarse materials, grit and suspended matter. At removal of suspended matter also COD is removed. The techniques considered are listed in table 4.1.

Tabel 4.1. Overview of techniques for pretreatment.

SYSTEM	FEATURES
Basic	
Screen	Purpose: removal of coarse materials
Grit chamber	Purpose: grit removal
Pre-sedimentation	Purpose: removal of settleble suspended matter (COD) Special: The suspended matter removed is a residue (primary sludge). It mainly consists of organic matter and water, and is a raw material of energy (biogas) production The ratio of organic matter (COD) over N and P of the wastewater is reduced (higher removal of organic matter). This may negatively impact the subsequent biological treatment
Improved	
Coagulation + pre-sedimentation	Purpose: removal of settleble and colloidal matter (COD) and P Special: In the case of inorganic coagulants, also P is removed and can be valued positive. However, again it may have adverse effects on subsequent biological treatment (ration COD/N). Necessity for the E-factory. Use of chemicals might have a negative environmental impact
Biological adsorption (A step of AB system)	Purpose: removal of suspended and colloidal COD Special: post separation of wastewater and biomass is required
Advanced	
Membrane filtration Sand filtration Micro sieve, drum sieve	Purpose: optimized removal of suspended and colloidal matter through a combination of straining and adsorption Special: Advanced separation of contaminants/raw materials (COD removed, N and P not removed). Reduction of COD over N and P ratio. Higher removal of suspended matter and lower sludge production (lower water content)
Alternative	
Anaerobic pretreatment	Purpose: removal of COD and nutrients Special: suitable as a local pretreatment; not suitable at municipal wastewater treatment (temperature and concentrations too low)

4.3 BASIC TREATMENT

The main objectives at the basic process step are, to remove remaining COD, N and P. Most systems are composed of a bioreactor and subsequent separation of water and biomass (residue; sludge). The techniques considered are listed in table 4.2. With respect to the bioreactor, it should be mentioned that even more techniques have been developed. All of them are either aerobic or anaerobic suspended or attached growth systems.

Table 4.2. Overview of techniques.

SYSTEM	FEATURES
Conventional: Suspended growth	
Activated sludge Activated sludge + chemical P-precipitation Activated sludge treatment + biological P-removal	Purpose: removal of COD, N (nitrification, denitrification), P Special: the reliability of these systems may hamper development of a new generation of treatment plants; external biomass-water separation (secondary sedimentation); return and excess biomass. Basic treatment option in all scenarios
Attached growth	
Trickling filter + Sedimentation	Purpose: removal of COD, transformation of N (nitrification) Special: extended removal of COD and P at pretreatment required; external biomass-water separation (secondary sedimentation); excess biomass
Submerged systems (e.g. Biostyrtion)	Purpose: removal of COD, transformation or removal of N (nitrification, denitrification) Special (Biostyr): attached growth at a synthetic carrier material; upflow treatment; packed fluidized bed retained by a screen; aerobic or anoxic and aerobic reactor; backwashing; external clarification of backwash water; hardly any experience in The Netherlands
Airlift fluidized systems (e.g. Circox)	Purpose: removal of COD, transformation of N (nitrification), removal of P Special (Circox): attached growth at a carrier material; internal plate separator for clarification of effluent; limited excess biomass production; limited space consumption; hardly any experience in The Netherlands
Moving-bed biofilm systems (MBBR; e.g. Kaldness)	Purpose: removal of COD, N (nitrification, denitrification), P Special (Kaldness): no P-removal; attached growth on a synthetic carrier material; aerobic and anaerobic reactors; air mixing and mechanical mixing; internal clarification (screen); no return biomass required; applicable as full treatment or pretreatment; hardly any experience in The Netherlands
Alternative systems	
Aerobic suspended bed reactor (Nereda)	Experience: promising system: first full scale reactor will start up in 2011
Cold Anammox reactor	Purpose: removal of N through anaerobic oxidation of ammonia by nitrite Special: less space consumption, reduced CO_2-emission, reduced power consumption, no external C-source required, minimal surplus sludge; until now only theoretical
Membrane bioreactor (MBR)	Purpose: removal of COD and N Special: high costs and energy consumption
Alternatives for sedimentation	
Upflow sludge blanket filtration	Special: compact system
Lamella filtration (e.g. Actiflo)	Special: widely applied abroad but not in The Netherlands; compact system

4.4 POST TREATMENT

The objectives at the post treatment process step differ. Post treatment has to fill the gap that may remain between the treatment results achieved through pretreatment and basic treatment and discharge guidelines. The objective at post treatment can also be set by the effluent quality required for water reuse purposes. Table 4.3 lists the techniques considered.

Tabel 4.3. Overview of techniques for post treatment.

SYSTEM	FEATURES
Removal of particulate matter	
Rapid sand filtration	Purpose: depending on design and operation - Removal of suspended matter and N (biological) - Removal of suspended matter and P (floc filtration) - Combined removal Special: high energy consumption
Micro sieve, rotary drum sieve Fabric sieve Fuzzy filter	Purpose: removal of suspended matter and included N and P Special: micro sieve and drum sieve are attractive because of low energy consumption; in The Netherlands only minor experience on full scale
Removal of colloidal and dissolved matter and microorganisms	
Membrane techniques	
Microfiltration Ultra filtration Nanofiltration Reverse osmosis	Purpose: removal of organic and inorganic compounds and pathogens; except microfiltration effective at disinfection Special: high treatment costs, production of a residue (brine); proven technology, mainly used for water production
Other techniques	
Activated carbon filtration	Purpose: removal of (hazardous) organic compounds
Ion exchange	Purpose: removal of inorganic compounds
Ozonisation UV disinfection Hydrogen peroxide	Purpose: removal of pathogens Special: regeneration and residue (carbon, ion); relatively high treatment costs; very limited experience on effluent treatment in The Netherlands
General effluent polishing	
Reed bed filter (constructed wetland) Algae pond	Purpose: removal of colloidal organic matter (sedimentation), N and P (plant uptake), heavy metals (adsorption), addition of oxygen Purpose: 'natural' bridging of the water quality gap between effluent and surface water (vitalization of effluent) Special: large space requirements; no removal of pathogens; possibility of harvesting plants en algae; until now no full-scale experience in The Netherlands

4.5 SLUDGE TREATMENT

Sludge is a liquid residue of wastewater treatment, containing organic matter and having high water content. Sludges are liberated at pretreatment (sediment), at basic treatment (surplus biomass) and at some post treatment techniques (e.g. clarification of backwash water of filtration).

A basic objective of sludge treatment is, to reduce the volume. This can be achieved by reducing the water and organic matter content. A higher objective is, to reduce the volume and use the organic matter of sludge for energy recovery. The techniques considered are listed in table 4.4.

Tabel 4.4. Overview of techniques for sludge treatment.

SYSTEM	FEATURES
Physical dewatering (free water)	
Gravity-belt thickener Centrifuge Belt-filter press	Purpose: reduction of water content (sludge volume) in view of successive sludge treatment
Biochemical dewatering (entrapped water)	
Enzymatic hydrolysis Thermal hydrolysis Disintegration (cavitation) Biological techniques	Purpose: reduction of water content by breaking down a complex chemical structure of macromolecules or the structure of microorganisms Special: experience in The Netherlands limited. Worldwide experience show possibilities for larger scale sludge treatment
Organic mass reduction	
Mesophylic digestion Thermophylic digestion Combined digestion	Purpose: reduction of sludge organic matter and recovery of energy and heat Special: the energy produced is mostly applied at the wastewater treatment plant and sometimes elsewhere ; the water separated from digested sludge is rich of N and P. The residue requires final treatment
Final treatment	
Composting Thermal drying Incineration Gasification and pyrolysis Wet oxidation	Purpose: reduction of mass and volume of energy recovery residue Experience: mostly direct incineration (sludge only). In some cases first composting or thermal drying and subsequently co-incineration (domestic waste, coal, cement ovens). Pyrolysis, gasification and wet oxidation are not applied

4.6 TREATMENT OF REJECTION WATER

At sludge treatment, solid matter is separated from so-called rejection water. The rejection water of digested sludge has a high N and P content. The basic objective at further treatment is, to reduce the N and P content. The higher objective is, to recover N and P. Table 4.5 lists the techniques considered.

Tabel 4.5. Overview of techniques for treatment of rejection water.

SYSTEM	FEATURES
N removal	
Sharon process De-ammonification (e.g. Anammox)	Purpose: removal of dissolved N (ammonia) from water Special: Sharon process requires an external (added) C-source, deammonification processes not; widely accepted as proven technology
N recovery	
Steam stripping Air stripping	Purpose: removal of N from water and recovery of N from stripping gas (after partial oxidation as NH_4NO_3) Special: in general N is a renewable resource. Recovery from wastewater may not be competitive to other options. Limited experience
P recovery	
Crystalactor technology Struvite reactor	Purpose: removal of P from water and recovery of P. Recovery as calciumphosphate grains (Crystal) or magnesiumammoniaphosphate (Struvite) Special: reuse may be obstructed by pollution of phosphate produced; high operation costs (Crystalactor)

4.7 ENERGY CONVERSION

At sludge digestion, gas is produced. The main objective of gas treatment is, to recover the energy contained. The techniques considered are listed in table 4.6.

Tabel 4.6. Overview of techniques for energy conversion.

SYSTEM	FEATURES
Basic	
Boiler	Purpose: combustion of digestion gas and recovery of heat for heating purposes
Cogenerator	Purpose: combustion of digestion gas for production of electricity and recovery of combustion heat for heating purposes Special: relatively low efficiency at electricity production (35%); contamination of digestion gas
Advanced	
Dual fuel Cogenerator applying ORC (organic ranking cycle) Fuel cell	Purpose: combustion of digestion gas for production of electricity and recovery of combustion heat for heating purposes Special: higher efficiency at energy production (> 40%); NOx-emission (Dual Fuel), high costs (fuel cell); all systems require a certain scale; limited experience in The Netherlands
Alternatives	
Heat pump	Purpose: use of combustion gas heat to produce work Special: reuse should be possible in the vicinity of the treatment plant, because of heat losses at transport
Geothermal heat pump	Purpose: subsurface storage and use of combustion gas heat Special: low thermal efficiency; not applied for wastewater treatment heat in The Netherlands; increasing applications at reuse of other forms of residual heat
Production of green gas	Purpose: production of natural gas from digester gas Special: maximal thermal efficiency (at direct delivery of gas); the energy required by the wastewater treatment plant has to be purchased


5

OUTLINE OF 2030 WASTEWATER TREATMENT PLANT

5.1 WATER FACTORY

If one considers a wastewater treatment plant to be a water production facility, at present the product in most Dutch cases has to meet a discharge permit aiming at maintaining a good quality of the receiving surface water. The discharge permit is based on a degree of dilution of effluent. In some exceptional cases, the product quality is set by more severe quality guidelines determined by its application. Dutch examples are application for industrial cooling and processes and agricultural irrigation. Another type of application is the use as surface water in arid areas, with limited possibilities of dilution. In The Netherlands, these applications may remain exemptions on the short term, because of the abundant natural water resources. A predictable trend at the moment is, that future European surface water quality guidelines will induce the need of further nutrient removal.

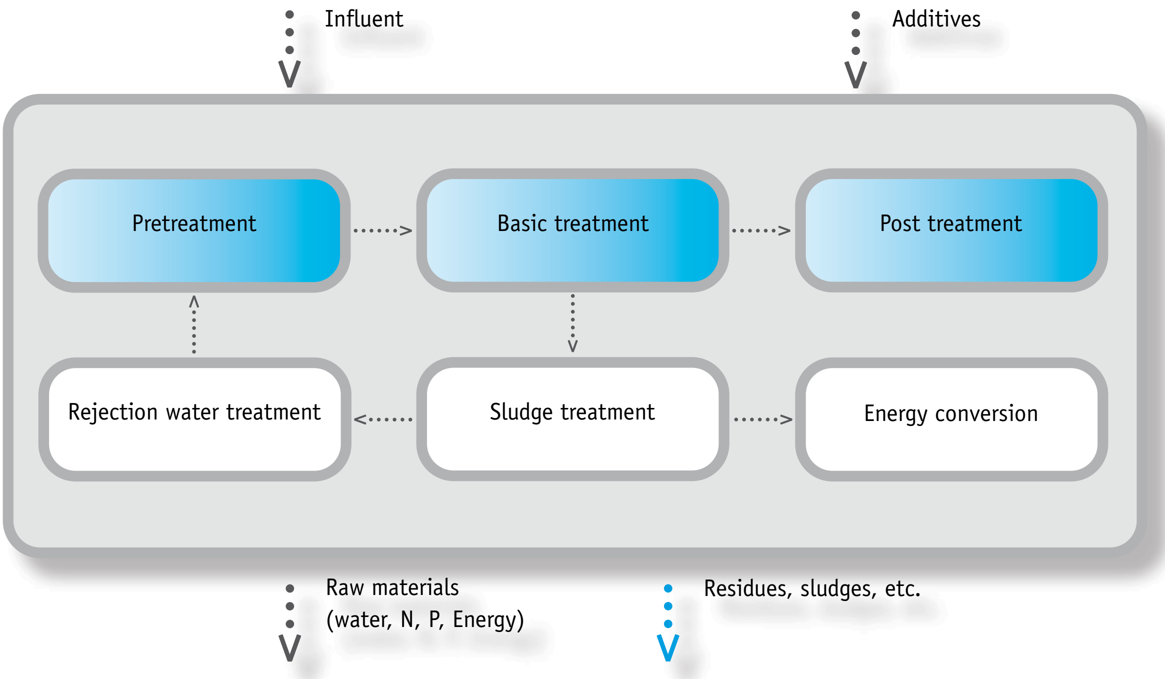


Figure 5.1. Scheme of various process steps of a wastewater treatment plant, in blue treatment scheme for a Water Factory.

5.1.1 WATER FACTORY INSPIRATION – DUTCH EXAMPLES

Terneuzen wastewater treatment plant (process water)

The Zeeuws-Vlaanderen Water Board and Evides Industrial Water have started the construction of a membrane bioreactor at the Terneuzen wastewater treatment plant. Since 2007, Evides uses effluent for the purpose of production of demineralised water. The new membrane bioreactor, having a designed capacity of 620 m^3/hour, is meant to upgrade the effluent quality, in order to produce process water (figure 5.2.).

Emmen wastewater treatment plant (boiler feed water)

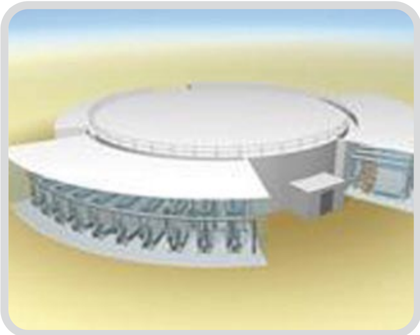
A joint venture of the Drenthe Water Company and the Velt and Vecht Water Board has embarqued on upgrading of effluent to boiler feed water for steam production. The upgrading process comprises 5 steps. These are in chronological order ultra filtration, biological activated carbon filtration, 2-phase reverse osmosis, and polishing by electro deionisation (figure 5.3).

Kaatsheuvel wastewater treatment plant (recreation water)

Since 1997, the effluent is used as recreation water, in order to avoid abstraction of scarce groundwater. The effluent is polished in a 4-compartment reed bed filter. In order to better control the nutrient content, a rapid sand filter is inserted before the reed bed filter. The filter has a capacity of about 400.000 m^3 per year (figure 5.4).

Land van Cuijk wastewater treatment plant (agricultural water)

In 1999, the Aa and Maas Water Board introduced a reed bed filter for polishing of the effluent. In dry periods, the effluent is discharged to the surface water system of a nearby agricultural area. The surface water is used for spray irrigation. In order to produce a more natural composition of the water discharged, the reed bed filter was transformed into a swamp system composed of successively a supply pond, parallel reed bed canals, a discharge canal and aquatic plant ponds (figure 5.5).



F 5.2

F 5.3

F 5.4

F 5.5

Figure 5.2. Design of Membrane Bioreactor at wwtp Terneuzen (NWP, 2009).

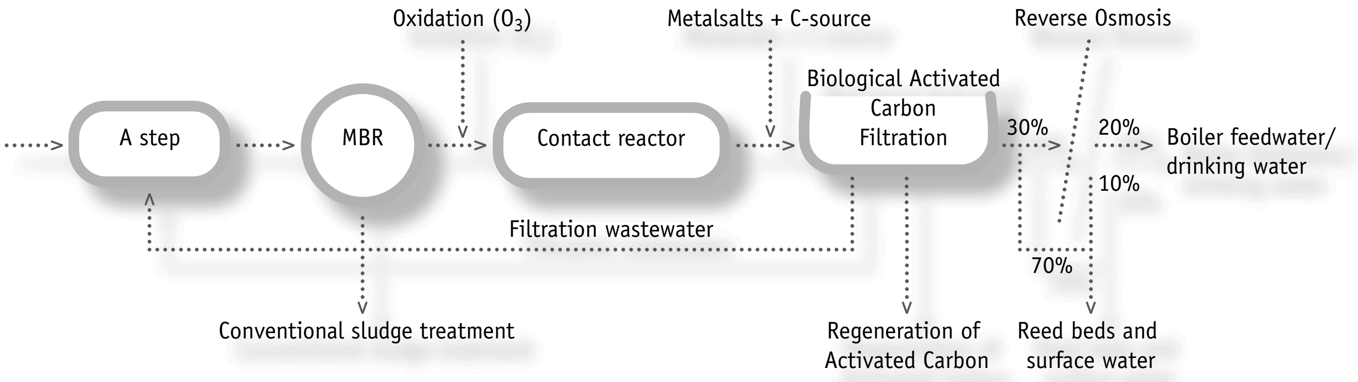
Figure 5.3. Building of facility for ultrapure water at wwtp Emmen (Kampen Industrial Care, 2009).

Figure 5.4. Reed bed at wwtp Kaatsheuvel (Brabants Dagblad, 2007).

Figure 5.5. Reed beds at wwtp Land van Cuijk (STOWA, 2004).

5.1.2 EXPERIENCE IN THE NETHERLANDS

In order to inspire, an example configuration of a 2030 water factory was developed by the expert team (figure 5.6). The terms of reference were to manufacture 2 products, boiler feed and surface water.



Figuur 5.6. Water factory scheme by expert group.

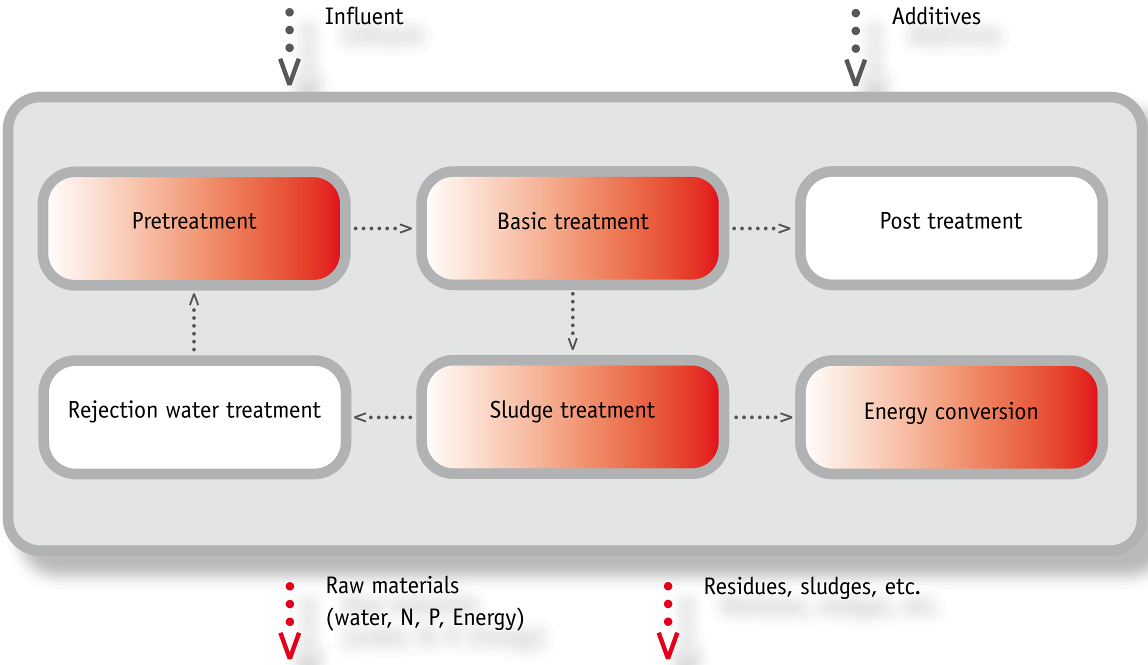
A favourable condition at application of this configuration is, that wastewater is collected by a separated sewerage system. This guarantees the most constant supply and quality of the raw material (the wastewater) and therefore offers the best treatment conditions. Also a grit chamber can be avoided.

Some important characteristics of the configuration are:
- Physical removal of COD
- Biological removal of N
- Biological and chemical/physical removal of P
- Biological processes based on activated sludge and attached growth (membrane, activated carbon)

In should be noted, that treatment of residues was not elaborated but will, to some extent, also be part of the water factory.

5.2 ENERGY FACTORY

Traditionally, energy production was not the main issue at wastewater treatment. However, energy is becoming a spearhead, considering that 14 (out of 26) water boards in The Netherlands started to cooperate in developing the future energy factory.



Figuur 5.7. Scheme of various process steps of a wastewater treatment plant, in red treatment scheme for a Energy Factory

5.2. ENERGY FACTORY INSPIRATION – DUTCH EXAMPLES

Apeldoorn wastewater treatment plant

One of the major steps taken to make the wastewater treatment plant energy neutral, was to supply residual heat for heating of 2500 newly build houses in the vicinity of the plant. For this purpose, a cooperation was started of the Veluwe Water Board, the municipality of Apeldoorn and Essent Power Supply. As a side effect, a 50% to 65% reduction of the carbon dioxide footprint of the housing area is achieved. Another step was the introduction of a co-digester and subsequent de-ammonification reactor (DEMON). The co-digester not only treats sludge but also external wastes (figure 5.8).

Garmerwolde wastewater treatment plant

Also at this plant steps were aiming at energy neutrality. An A step was inserted in the wastewater treatment process and the process further comprises 2 digesters in series. The digester not only treats locally produced sludge but also sludges of other plants. From the biogas, electricity is produced, covering about 60-70% of the internal demand. Residual heat is used for heating of the digesters. At treatment of digester rejection water the energy efficient SHARON process was chosen (figure 5.9).

F 5.8

F 5.9

F 5.10

F 5.11

F 5.12

Figure 5.8. Co-digestion, de-ammonification (DEMON) and digestion at wwtp Apeldoorn (Waterschap Veluwe, 2009).

Figure 5.9. Wwtp Garmerwolde (Waterschap Noorderzijlvest, 2006).

Figure 5.10. Wwtp Amsterdam-West (Waternet, 2010).

Figure 5.11. Biogas as car fuel at wwtp Beverwijk (HHNK, 2009).

Figure 5.12. Treatment of sludge from wwtp Ede and wwtp Apeldoorn (GMB, 2010).

Amsterdam-West wastewater treatment plant

This plant of 2006 is one of the biggest in The Netherlands, having a capacity of about 1 million inhabitant equivalents. The plant applies conventional sludge digestion and delivers the biogas to the nearby waste incineration plant, that also treats the digestion sludge. The waste incineration plant supplies heat to the wastewater treatment plant (figure 5.10).

Beverwijk wastewater treatment plant

Biogas at wwtp Beverwijk was used for the production of electricity and heat. The surplus biogas was burned. In 2006 a new biogas treatment facility was build, which purifies the biogas to natural gas standards. At this moment 2,000 m^3 of natural gas are produced a day (400 households) and 20 cars of the waterboard. At this moment, improvements are being made for a higher recovery of natural gas out of biogas (up to 70%). (Goverde, 2007; HHNK, 2009).

Ede and Apeldoorn wastewater treatment plants

The GMB-company treats sludge of the 2 plants of two different Water Boards, Veluwe and Vallei and Eem. The major part of the sludges is exported directly to Germany and treated in a coal drying process. Also in Germany, the minor part is upgraded to a secondary fuel (figure 5.12).

5.2.1. EXPERIENCE IN THE NETHERLANDS

In order to inspire, an example configuration of a 2030 energy factory was developed by the expert team (figure 5.13). The terms of reference were, to create a net production of energy. This requires minimization of energy consumption of the plant itself and maximization of its energy recovery. In terms of treatment options:

- Separation of COD instead of aerobic degradation (optimization of biogas production and energy consumption at aeration)
- In terms of energy consumption, economic removal of N, P and residual COD (deammonification will be an important tool)
- Maximal recovery of sludge caloric content

It should be noted, that supercritical gasification and anammox are not yet applied on a technical scale.

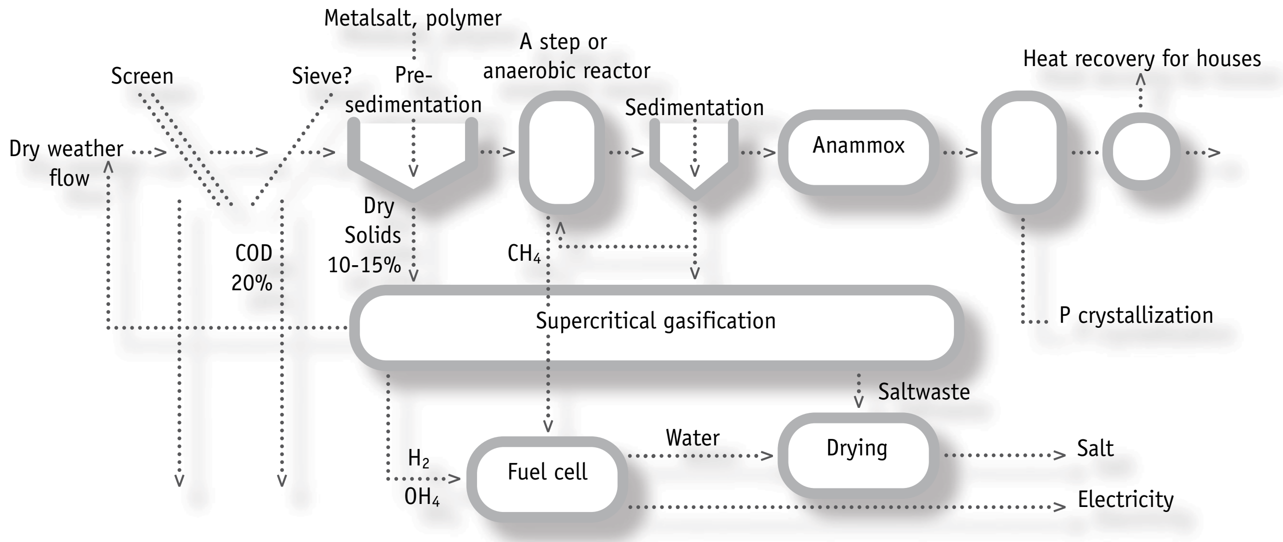
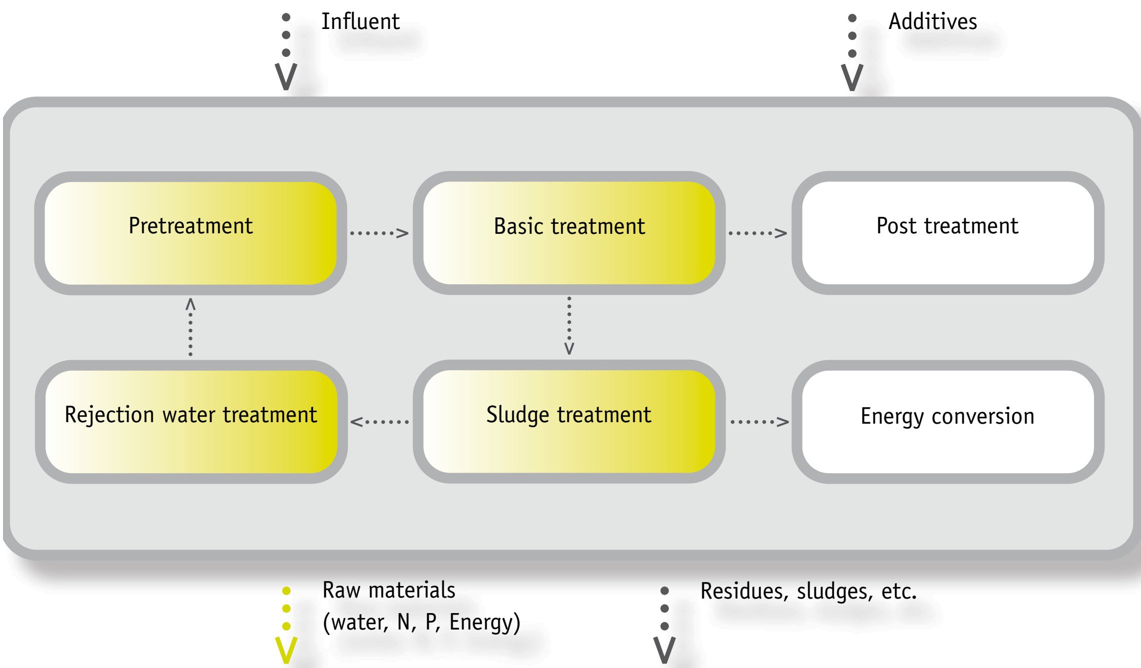


Figure 5.13. Energy factory scheme by expert group.

5.3 NUTRIENT FACTORY

The nutrients encountered in municipal wastewater so far are considered a pollutant rather than a raw material. However, the first examples of P recovery have erased.



Figuur 5.14. Scheme of various process steps of a wastewater treatment plant, in green treatment scheme for a Nutrient Factory

5.3.1 NUTRIENT FACTORY INSPIRATION – DUTCH EXAMPLES

Geestmerambacht wastewater treatment plant

Phosphate can be recovered at a wwtp as Calcium Phosphate. Since 1993 this is done at the wwtp Geestmerambacht by using a Crystalactor (granular reactor). This process used to be applied at more wwtp's, but from 2004 Geestmerambacht is the last one. Phosphate is removed from the sludge with the Phostrip process, using acetic acid resulting in Calcium Phosphate granules. This product is transported to the Phosphate industry. The process is costly because of the use of large volumes of chemicals. Also operational problems led to a decrease of Phostrip plants (STOWA, 2005c).

Wastewater treatment plants of Steenderen and Olburgen

At wwtp Steenderen the wastewater of a potato industry is treated together with the municipal wastewater from wwtp Olburgen. Magnesiumoxide (MgO) is dosed in order to produce struvite. Struvite is being used as a fertilizer. Additionally, this process results in a decreased (biological) sludge production. For energy efficiency, the anammox process is implemented. Ammonia is oxidised via nitrite at oxygen limiting conditions to nitrogengas.

Sludgetreatment at SNB

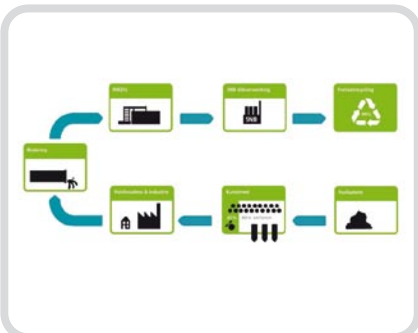
In the south of The Netherlands at SNB, sludge from municipal wwtp's is incinerated (400,000 tonnes per year). During incineration, the phosphate in concentrated in the ashes at a concentration of 80 grams per kilogram ashes. The yearly phosphate production is 3,100 tonnes, part of it is sold to the phosphate industry (Thermphos). The municipal sludges need to be low in ironsalts, especially biologically P-fixed sludge and P-fixation by alum salts is needed for phosphate recovery.

Deventer wastewater treatment plant

WWTP Deventer is built as a BCFS process, which is a process configuration with a phosphate rich sidestream. In the second anaerobic compartment, the phosphate rich wastewater is stripped using ironchloride (Dortmund reactor). The chemical precipitated sludge is led to the sludge thickeners, leaving the main biological process with chemical sludges. For phosphate recovery, the use of ironsalts must be minimised, therefore research has been done using calcium, aluminium and magnesium. Research showed that calcium is the best alternative to iron and the additional costs are lower than the additional benefits. (STOWA, 2005c).

F 5.15

F 5.16



F 5.17

F 5.18

Figure 5.15. Crystalactor at wwtp Geestmerambacht (Giesen, 2009).

Figure 5.16. Struvite production at wwtp Steenderen (TUDelft/Paques, 2009).

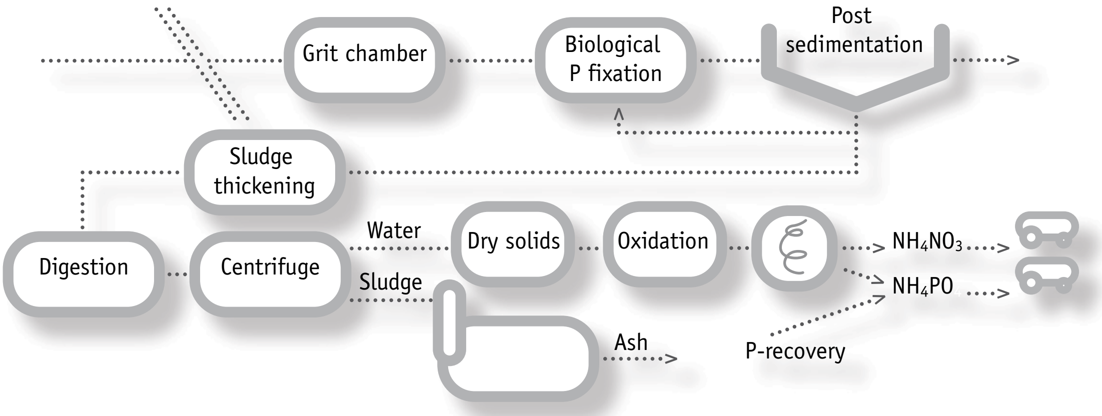
Figure 5.17. The phosphate cycle (SNB, 2009).

Figure 5.18. BCFS reactor at wwtp Deventer (Waterschap Groot Salland, 2009).

5.3.2 EXPERIENCE IN THE NETHERLANDS

In order to inspire, an example configuration of a 2030 nutrient factory was developed by the expert team (figure 5.19). The terms of reference were, to optimize the production of a raw material from sludge and reject water that can be used by the nutrient industry. This requires in terms of treatment options:

- Separation of nutrients from COD
- Concentration of nutrients



Figuur 5.19. Nutrient factory scheme by expert group.


6

ROADMAP

6.1 DESTINATION

The Dutch water boards have developed a common perspective on the future of urban wastewater management. It reads:

> There will be one institution responsible of the integral urban wastewater management.
> It will act as a directing linking pin that cooperates in several strategic alliances, to efficiently treat wastewater and transform wastes into raw materials and energy.

The profiles of future water, energy en minerals factories as the new generation of current wastewater treatment plants have been developed. A challenge still to be met is, to combine them into one coherent concept, the Nutrients+Energy+Waterfactory (NEWs).

At the materialization of the perspective and concept, local conditions are important and will cause a certain variety of appropriate alternatives.

6.2 ROUTE

The destination is defined in general terms but not as a fixed set of coordinates. In the 20 years to come, several phenomena will gradually define first the route and later the destination. These phenomena can be clustered as starting points, boundary conditions, factors of influence and factors that require attention. These phenomena have to monitored regularly, in order to stay on track.

Tabel 6.1. Important phenomena.

PHENOMENA	MONITORING
Starting-points	Will effluent be discharged into surface water or used as a water source? Will it be possible to utilize local circumstances in favour of the viability of a kind of factory?
Boundary conditions	Protection of public health by safe discharge and treatment of human wastes is a prime objective Protection of surface water quality and environment by prevention of discharge of oxygen demand and nutrients is a second important objective Setting up water, energy and nutrients factories requires a guaranteed sales of products Sales requires marketing; this is a new skill that has to be developed
Factors of influence	The choice of technology is not only determined by boundary conditions but also by effluent quality, costs, energy neutrality and nutrient recovery
Factors that require attention	Process steps should be tuned, in order to design a well balanced plant Plants should be flexible (modular), in order to accomodate developments smoothly

6.3 GPS

The ongoing development of current treatment techniques and design methods has to be monitored carefully and may have to be stimulated. The table summarizes some relevant activities.

Tabel 6.2. Future activities.

TOPIC	ACTIVITY
Technology known and proven in The Netherlands	Knowledge and experience is well documented by STOWA This database should always be consulted
Technology known in The Netherlands but only proven abroad	Participation in an international network Excursions Development of business cases Demonstration projects at a Dutch wastewater treatment plant
Technology known but not proven	Similar
Design	Development of existing models for the purpose of design of water, energy and nutrient production

Furthermore, ongoing research has to be evaluated and future research has to be directed, in order to optimize the efforts and results in the perspective of the 2030 wastewater treatment plant. It is of utmost importance, to develop a coherent research program on separate and combined production of water, energy, and nutrients.

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