‘We are at the very beginning of time for the human race. It is not unreasonable that we grapple with challenges. But there are tens of thousands of years in the future. Our responsibility is to do what we can, learn what we can, improve the solutions, and pass them on.’

Richard Feynman

Colofon

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RESEARCH GROUP WATER TECHNOLOGY

Aqua Fundamentalis

dr. ir. Luewton L. F. Agostinho

Inaugural speech in short version on 9 April 2014

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'All I need is a sheet of paper and something to write with. Then I can turn the world upside down.'

Friedrich Nietzsche

Prologue

Dear members of the Executive Committee, noble colleagues, professors, family, students, ladies and gentleman. It is a pleasure to speak to you today during my inauguration ceremony as a lector Water Technology at NHL University of Applied Sciences.

Teaching and science are activities that have been present in my life for more than 20 years. If accepted that such activities are responsible for a large part of one's knowledge and that a scientist, as defined by Einstein, is 'an eternally curious mind', it is possible to say that being involved in education is the most self-instructive and pleasurable activity a thirsty mind would wish for itself.

Today I have the immensurable pleasure of practising this activity one more time at an event which can be certainly placed among the most important moments of someone's academic career, an inauguration ceremony.

The ceremony will be opened by an honorable colleague, prof. dr. ir. Cees Buisman, Wetsus Scientific Director, who will share some ideas about the current and future image of water technology.

After that, dr. ir. Jan M. C. Marijnissen, formal TU Delft professor, will say a few words about electrohydrodynamic atomization, one of the best examples of (purely) physically driven systems, and how it can be related to water technology.

In sequence I will have the pleasure to share a conceptual vision of water technology, some physically driven water processes and technologies and the binomial urgent x new technology.

I hope you will find yourselves having a very instructive and interesting afternoon by the end of these talks.

After that we invite you to the formal inauguration ceremony, presented by our Executive Committee and, sequentially, to celebrate this event with some drinks.

Thank you for your kind attention.

We shall begin.

‘Water is baffling - even to scientists. From its refusal to obey the ordinary rules of liquids to its insistence on becoming lighter when it freezes, water is as curious as it is vital.’

Philip Ball

1. Background (water)

Water is practically omnipresent on our planet. It is undoubtedly the most important substance of this world, and is therefore one of the most explored[1]. Yet, it is also one of Earth’s least understood materials[2].

Many attempts have been made in order to measure or calculate the structure of water beyond the H_2O molecule. This has been proven a difficult task due to the formation of a complex, dynamic hydrogen-bond (H-bond) network, which is considered responsible for many of water’s properties[3]. It is also the reason why water should not be treated as a ‘simple liquid’[4].

1.1 Water technology

Before I start talking generally about water technology, it is maybe prudent to dedicate some sentences to the term itself and introduce the topic by sharing some intriguing thoughts with the reader.
Not very long ago the term water technology was not largely applied by the scientific community. Instead, there were simply drinking water treatment and waste water treatment

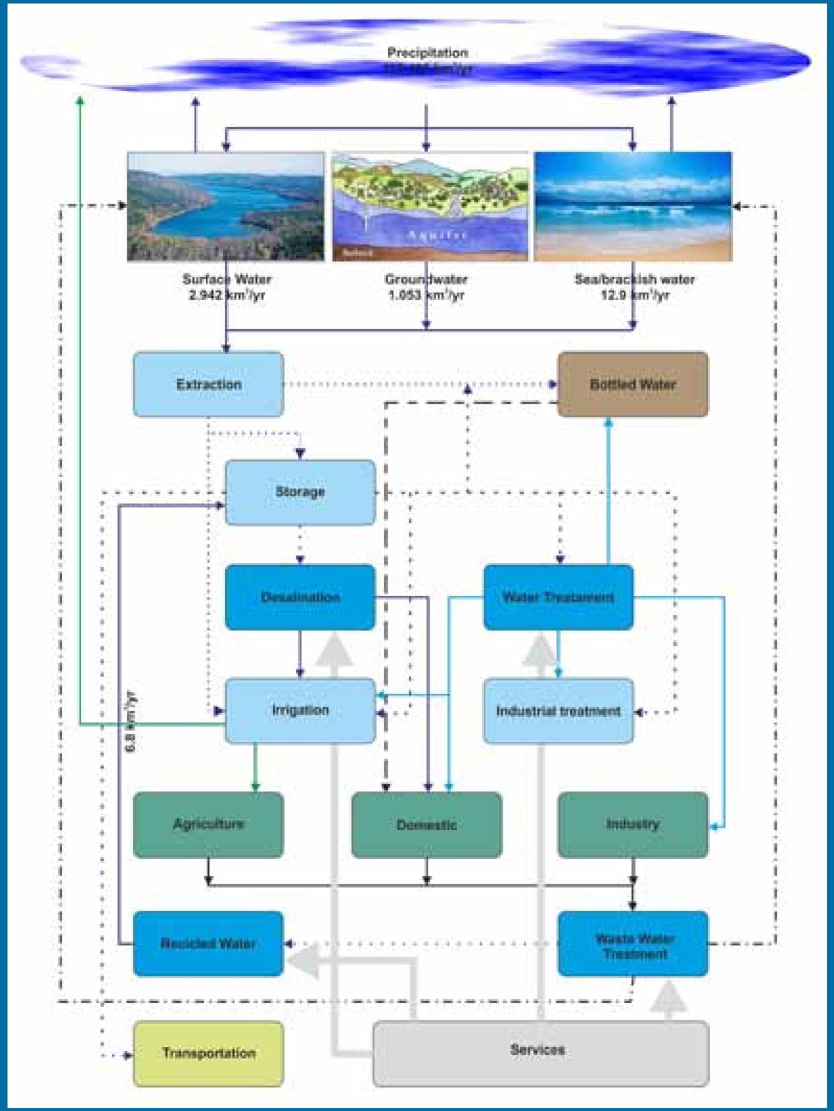


Figure 1 Technologies, services, activities and infrastructure of the Water Technology field. Personal representation of the hydrocosm image presented by Lux Research Inc.®[5].

processes which, among others, comprised the group of engineering activities dedicated to treat and dispose hazardous materials, i.e. also known as sanitation engineering.
However, the technological advances of the last decades extended drinking water and waste water activities beyond their initially established limits. Such fact has forced the scientific community to propose a terminology which would represent the 'water related systems/ technologies' more completely and the term "Water Technology" was then brought to the scenario. This happened most probably around the beginning of the 80's, i.e. one of the most traditional water technology journals has its first publication in 1982, and was well accepted as the term is now largely used in many sectors. The next chapters will inform the reader about some current demands of this field and describe some of its processes.

1.2 Water technology trends and activities

A more complete view on the services, activities and infrastructure involved in Water Technology is provided in figure 1.

The figure is a representation of the interrelation existent between water technology activities starting from its main sources and passing through its main processes, disposal, reuse and services. It is a relatively new representation and presents lately developed concepts and technologies like desalination and water reuse.
Its representation of the sources, e.g. ground water, surface water and sea water, is still somehow limited, as systems working with relative humidity are already a reality. Additionally, it is important to stress that it does not present the different hardware, chemicals and other surplus necessary to maintain the functioning of the activities.
A good review which presents the current situation and perspectives of the water technology field is the report presented by Lux Research Incorporation[5, 6] entitled 'The Evolution of our Hydrocosm'. There the authors present a detailed and clear vision of our world's water related services, infrastructure and technologies, which they have, very appropriately, named 'the hydrocosm'. According to them this 'hydrocosm' is currently responsible for 4.166 km³ of water flow and some $522 billion revenue. Furthermore it has a calculated compound annual growth rate (CAGR) of approximately 1.5% predicting a 5.817 km³ water flow in 2030.
Such numbers have attracted many investors and the segment is considered one of the most attractive areas of the coming years. This attractiveness has also been acknowledged by the Dutch government, which positioned Water among the top five sectors for investment and technological development. Additionally, it is also considered as a hot venture category (VC), since the investment companies have invested approximately $1.12 billion in water

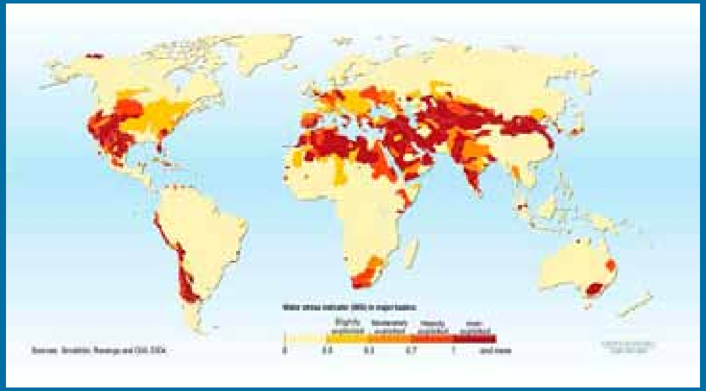


Figure 2 Global Water scarcity chart presented by the 2008 United Nation Environmental Program report.

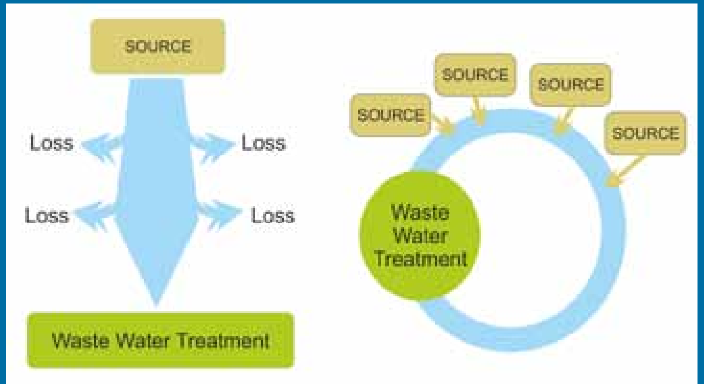


Figure 3 Schematic representation of the intrinsic aspects of 'water hunting' and 'water cultivation' mentalities.

technology related activities during the last 10 years.
Regarding possible risks and intrinsic challenges the two most mentioned aspects are its fragmented structure and its susceptibility to geographic conditions. The consequences of a fragmented structure are perceived in a multi-scenario situation varying from very simple government-owned water utilities to high-tech companies operating under zero-discharge cycles, low energy demand and nutrient recovery. The susceptibility to geographical aspects means that water treatment and processes are intrinsically related to climate, hydrology and demography.
Combined, these two aspects cause engineering companies to design systems which are almost tailor-made for each situation. Such aspects also pose a relatively big challenge on the development of a more general diagnose of the field.

1.3 Water cultivation

Implementation of new sources, real time multi-parameter monitoring, zero discharge systems, energy/water interface, emergent chemicals and nutrient recovery - these are the activities listed among the most urgent ones for guaranteeing that water related processes will comprise with modern challenges and an increasing demand.
A good and very simple theory, recently proposed to explain this trend, is the 'Water Cultivation' theory[5]. It basically says that we treat water like our ancestors treated their resources before the Neolithic period, i.e. hunting to get resources instead of investing energy to protect and increase the process efficiency.

The authors mention that the current approach shows we behave as modern 'water hunters' and fundament their theory on the following facts:

- Poor exploitation of possible sources: 98% of all the water we use nowadays comes from two single sources, groundwater and surface water. When compared to energy extraction systems, which have more than 20 different sources, water activities are far behind. We only exploit 2% of the total sources.
- Water is inexhaustible: Low prices and distribution losses as high as 70% show we treat water as an infinity source.
- Inefficient systems: Low recovery ratios and high discharge levels show we are mostly working with linear systems.

If seen in that way, as happened to our nomad ancestors, it can be expected that the high stresses caused by such unstructured activities would eventually create high scarcity zones

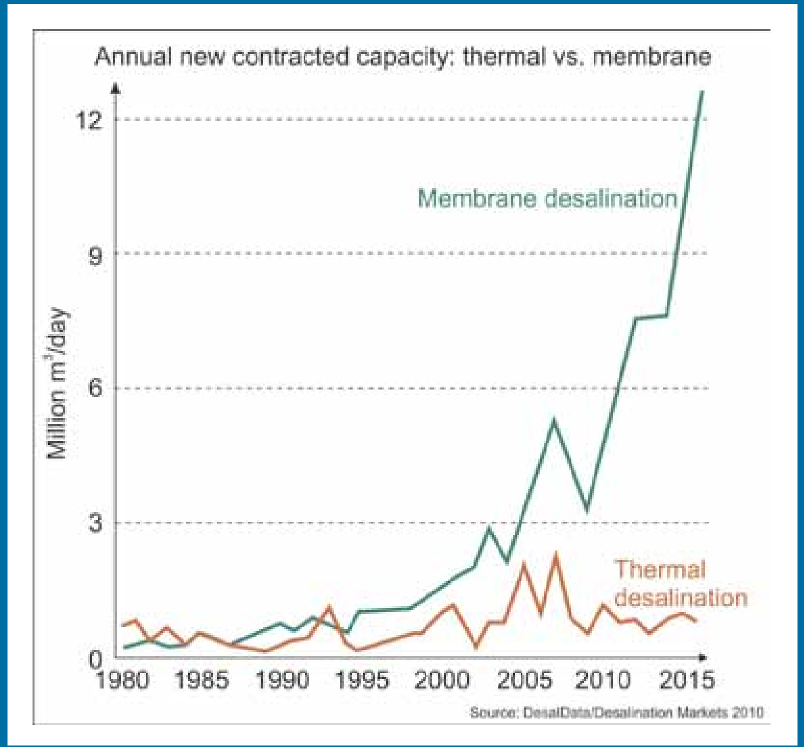


Figure 4 Cumulative capacity of desalination systems (source Desaldata 2010).

and (hopefully) enforce a change in mentality. Figure 2 shows that such stress is already a reality in many different regions of the globe.

Even though the current situation supports the 'water hunter' mentality concept, some modern systems also reflect a 'water cultivation' behavior. For example, regarding new sources, lately some reports have shown that desalination has become a well-accepted and rapidly growing technology. Figure 4 shows that thermal and membrane based desalination systems combined are currently responsible for approximately 44 millions of m^3 of desalinated water per day. Additionally, systems like rain collectors and atmospheric humidity condensers, i.e. producing fresh water by condensing air relative humidity, are also commercially available.

Regarding efficiency, the new trends point to real time detection of particles, substances and microorganisms as well as on decreasing losses caused (by instance) due to illegal connections. Also better monitoring can help improving the efficiency of modern (and old) systems. Current developments in that aspect are: acoustic sensors to detect bio-fouling in membrane based systems, ultrasound probes used to map and diagnose sand filter media and real time opto-acoustic sensors used to quantify and qualify bacteria and other microorganisms.

Regarding water reuse and recovery of compounds, the discussions are based on developing systems to recover metals (from mining effluents) and nitrogen and phosphorus (from industrial and domestic waste water). Some examples are bio-electrochemical systems (Microbial Fuels Cells or MFC) which are proven to be a feasible concept to recover copper from mining effluents, and biological recovery of phosphorus from effluents.

Another (more topic oriented) analysis of the field was recently presented by the Dutch Water Technology Innovation Board (see figure 5).

The group stated the importance of seeing the water technology market inside and outside Europe given the enormous differences in demands. Additionally, they mentioned as the most promising technologies driving future developments: desalination, censoring, decentralized systems, granular sludge and algae based systems (see figure 5).

Products in the field of watertechnology

Figure 5 Dutch Water Technology strategic road map presented at Aquatech 2012 by the Dutch Water Technology innovation board.

'Thankfully for us, water seems unaware of the laws of physics.'

Bill Bryson

2. Water (and) physics

Through the eyes of a physicist, the water molecule, as any other one, can be simply considered as an structure formed by fundamental interactions (electromagnetic forces) between elementary particles. In very simple terms, it could be considered a dynamic structure mostly supported by Coulomb's forces between positive and negative particles.

It contains only two different atoms, hydrogen and oxygen, with hydrogen being the simplest atoms present in the periodic table. Yet, it cannot be compared to any other liquid. For example, if you knew nothing about water and, based on your assumptions on the behavior of compounds most chemically akin to it – hydrogen selenide or hydrogen sulphide, notably – you would expect it to boil at minus 93 degrees Celcius (1 atm) and to be a gas at room temperature (1 atm)[4].

The bipolar structure of its molecule would imply that it can be easily organized when subjected to an electric field attributing a certain potential to its surface, i.e. polarization. However, it is known by experiment that after polarization, water droplets sometimes move contrary to what is expected in the presence of such fields[7]. Additionally, the phenomenon called 'floating water bridge', i.e. a liquid water bridge formed between two glass beakers

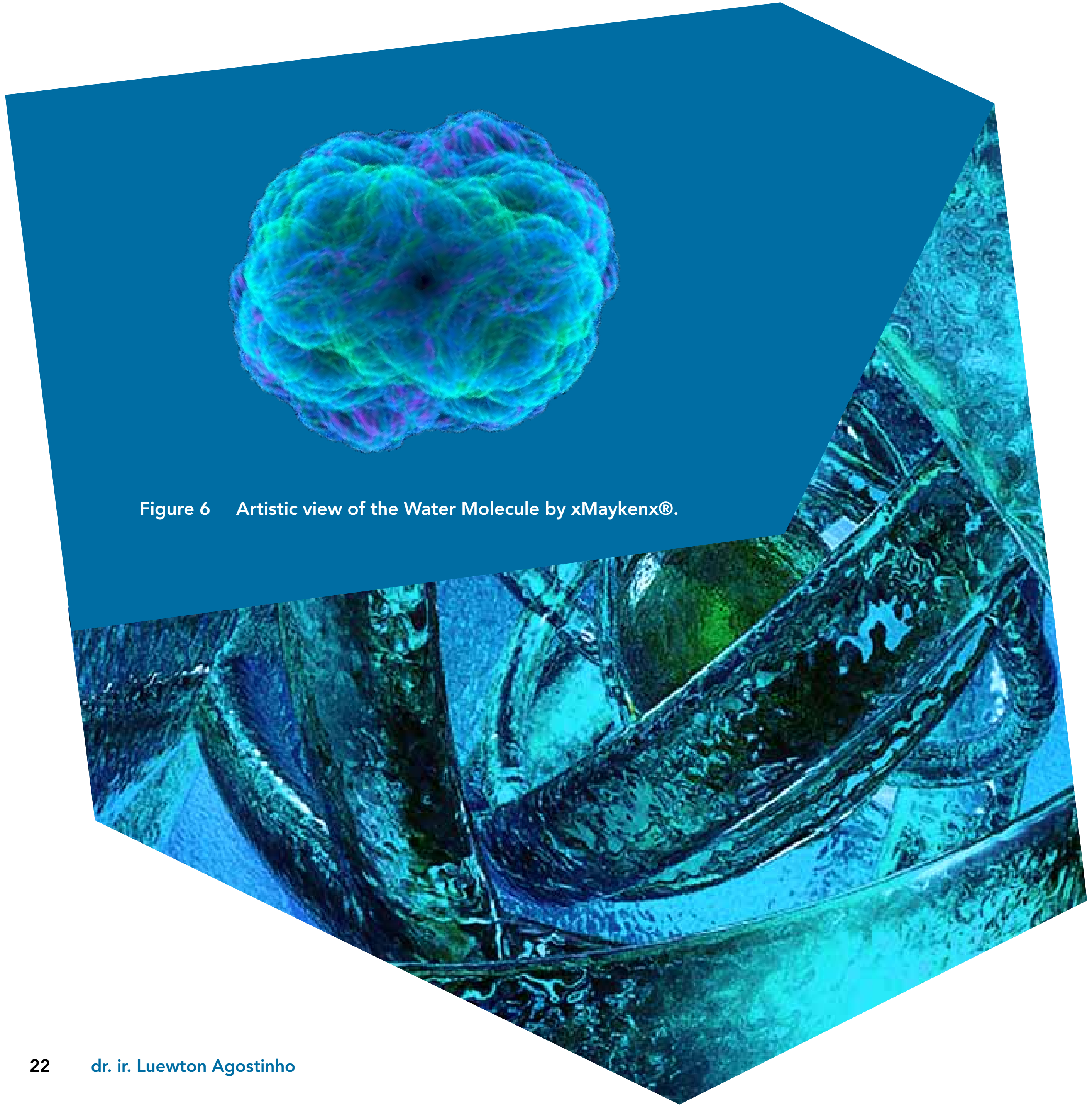


Figure 6 Artistic view of the Water Molecule by xMaykenx®.

filled with deionized water when a high potential difference is applied, is still not completely understood on the molecular level[8].
Regarding its thermodynamic properties, water, as all other liquids, is expected to contract when cooled down by about 10 per cent of its initial volume. It actually does, until around the temperature of four degrees Celcius, when it, extremely improbably, starts to expand. Even though such behavior is considered one of its famous 'anomalies', without it ice blocks would sink, instead of float, which would probably cause lakes and oceans to freeze from bottom to top ceasing all kind of life inside them.
The hydrogen atoms have a strong link to their oxygen host. However, its bipolar format allows water to constantly interact with surrounding molecules, briefly pairing and subsequentially moving on. When exposed to a gas, i.e. liquid-air interface, the most external molecules will experience a resultant force pointing inwards (created by the interaction with other water molecules) which form the so called surface tension, i.e. at 20 degree Celsius equals ~0,72 $N{\cdot}m^{-1}$, a sort of membrane formed on the water-air interface which supports insects and skipping stones, allow water molecules to flow upwards when siphoned and shapes spherical droplets when a certain volume is dispersed in air.

Physically driven systems

Even though the multi-diversity of current water treatment systems is such that purely physical, chemical or biological systems practically do not exist, it is still possible to classify them in such way if considered their driving aspect. For example,the lately developed Membrane Bioreactors (MBR) use membranes (a physical separation mechanism) to remove some compounds from the liquid phase. However, if classified by its fundamental principle, it is considered a biological system.

Taken the above mentioned into consideration, physically driven systems would be those which have a physical mechanism as their main process. Some examples are thermal desalination, ultrafiltration, ozonation, reverse osmosis and sand filtration.

Other examples are systems which are not completely inside the water treatment scope but still use physical tools to monitor, diagnose and/or improve the performance of existing systems. Some examples are optical, acoustic and electromagnetic sensors, atomization techniques, solar collectors and phase selective membranes.

The next sections briefly describe some of these systems and their intrinsic characteristics.

Desalination

Still considered as a nontraditional process, desalination was already mentioned by Aristotle (384-322) in his book Metrology [9, 10] as follows:

"…Salt water when it turns into vapour becomes sweet, and the vapour does not form salt water when it condenses again. This I know by experiment…"

Yet, until the Renaissance, there were no functional methods about desalination processes published or patented [10]. The first book mentioning desalination in detail is probably Magiae Naturallis (1558) written by Giovanni Batista Della Porta (1535-1615)[11]. In the first edition of his book he mentions three desalination systems [11]. The second edition, issued in 1589, contains a complete chapter dedicated to distillation in which Della Porta mentions seven different desalination methods [12] and presents different sketches. An example is shown in figure 7.

Figure 7 – Della Porta distillation apparatus published in Maggiae Naturallis (1558).

The understanding of the process developed and the first American patent claiming solar distillation was granted to Wheeler and Evans in 1870 [13].
Two years later, in 1872, the first large scale solar distillation plant was built in Las Salinas, Chile by the Swedish engineer Carlos Wilson, with a production capacity of 22.3 m^3 of fresh water per day [14]. After that, a further boost occurred during the Second World War, to provide fresh water to the troops in North Africa, Pacific Ocean Islands and other isolated places [10, 15].
After this, the investments on the technology progressively increased, causing the United States to approve the implementation of an Office of Saline Water (OSW) [10] which supported the installation of different thermal desalination plants in the country [16-19]. This triggered the implementation of other thermal desalination plants in different parts of the world, e.g. Caribbean Islands [20], Coober-Pedy, Australia [21] and USSR [22, 23].
Thermal desalination dominated the market until the introduction of polyamide membranes in the 1980s [24]. Up to this time the application of membrane systems to desalinate water was possible but very inefficient and restricted to low salinity water sources, e.g. brackish. The newly developed membranes enabled the process to take place at lower pressure and could reduce seawater salinity to potable standards in a single-pass process [24]; Seawater Reverse Osmosis (SWRO) was then introduced to the market.
The subsequent advances in material science made membrane technologies more competitive and an interesting option for desalination. Nowadays the process accounts for more than 50% of the global desalination capacity [25]. Thermal desalination is, however, still a better option when thermal energy is available, e.g. next to power plants and oil refineries, due to its robustness and large production rates. Additionally, a more modern trend are the hybrid processes, i.e. thermal-membrane based desalination, like the recently developed Membrane Distillation systems [26-30].
The global desalination capacity in 2006 was estimated to be 44.1 million m^3 per day (IDA 2008) with an average growth of 12% per year over the past five years. The projected capacity for 2010 was 64 million m^3 per day and 98 million m^3 per day for 2015 [31]. As the global capacity increases, concerns are addressed about environmental impacts, energy demand, usage of chemical agents and possible treatment for the brine stream.

Sand Filtration

Sand filtration has been one of the cornerstones of water treatment and it is still a generally accepted technology. These systems date back from 1804, when they were initially used in Scotland for municipal treatment. By that time the existence of pathogenic bacteria was unknown, so the filter was simply used as a mechanical media to remove solids. Lately, the same filters were also introduced as part of (industrial) processes and waste water treatment.

Figure 8 Sand filtration units built inside the Water Application Center (VHL) for arsenic removal experiments.

Some examples of big cities where sand filters are being (of have been recently) constructed are London, Amsterdam, Antwerp, Paris, Springfield (Mass, US) and many other cities in Sweden, São Paulo and Japan.

Some current challenges and necessary research topics related to this technology are:

- High footprint: Sand filters, especially slow sand filters, use relatively large areas when compared to membrane systems. Automatic washing cycle systems, like the Astrasand system®, could be a good solution to overcome this problem.
- Removal of emerging chemicals: It is proven that such filters cannot remove most of the emergent chemicals. More research on possible hybrid systems or pre or post-treatment steps is still necessary.
- Monitoring tools: Channeling and other media modification problems are common issues which drastically compromise the efficiency of such filters. However, current diagnose tools are simply based on effluent quality and hydraulic head. More invasive and real time techniques which can help the identification of such problems are necessary.

Atomization, electrohydrodynamic atomization and droplets

Atomization is defined as the disintegration of a liquid into small droplets [32-36]. The resulted suspension of fine droplets and/or solid particles (dispersed phase) in a surrounding gas (continuous phase) is termed spray or aerosol [32-36]. In water technology many processes use atomization as one of the active mechanisms, e.g. multi effect distillation, adsorption columns, cooling towers, coagulation/flocculation processes and injection systems.

The formation of liquid droplets has intrigued scientists for many centuries. Reports on this phenomenon can already be found in 15th century literature: The Codex Leicester by Leonardo da Vinci [37]. In this book Leonardo da Vinci noted correctly that the detachment of a droplet falling from a tap is governed by the condition that gravity eventually overcomes the cohesive forces (surface tension) [34, 37]. Yet, the critical role of surface tension in the breakup of a liquid jet was only recognized many years later by Plateau, in 1849. He mentioned that a cylindrical jet, when affected by surface tension forces, is unstable regarding surface perturbations whose wave length are bigger than the jet's circumference. Some years later Rayleigh addressed the same problem dynamically and showed that the breakup of an inviscid liquid jet is controlled by the fastest growing wavelength [38]. According to him, the wavelength of this wave (λ^{opt}) can be calculated as

$$\lambda_{opt} = 2\sqrt{2}\cdot\pi\cdot r_j \qquad (2.1)$$

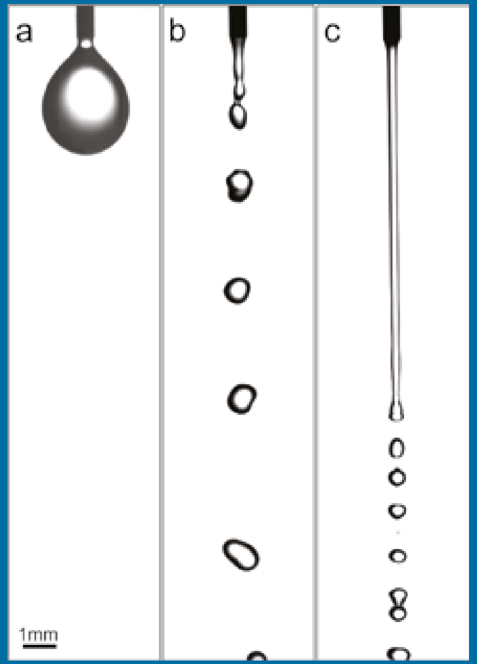


Figure 9 Droplet formation mechanisms in the dripping regime (a), dripping faucet regime (b) and in the jetting regime (c).

and it governs the droplet size as

$$\frac{4}{3}\pi r_d^3 = \lambda_{opt}\cdot\pi r_j^2 , \tag{2.2}$$

with rd being the droplet radius and rj the jet radius [33, 34, 36, 39]. When comparing the two equations, Rayleigh came to his famous relation r_d=1.89-r_j and defined that the size of a droplet formed from the breakup of a liquid jet, for a given liquid, depends only on the system dimensions [38].

Rayleigh's study comprises a specific case in liquid atomization known as droplet formation mechanism in the jetting regime. If the liquid is slowly pumped through the nozzle, it forms a pendant droplet which grows in a quasi-static balance between gravitational and surface tension forces finally detaching from the liquid meniscus [40, 41]. The droplet formation mechanism in this case is known as dripping regime. The transition between dripping and jetting is also reported and it is known as the dripping faucet regime [40-42]. Figure 9 shows images of the three mentioned regimes for the same nozzle geometry.

For flow rates above the required to form the jetting regime, the relative velocity between the liquid and the surrounding air can not be neglected. Aerodynamic effects accelerate the breakup process and a shortening of the length from the nozzle exit to the droplet pinch-off is observed [39]. This regime is known as the wind-induced regime.
Quantitatively, the transition between the regimes depends basically on the kinetic energy of the liquid. But it is also influenced by the nozzle geometry and the liquid properties, e.g. viscosity, density and surface tension. Hoeve et al [39] mentioned that the lower critical velocity for jet formation in capillary flows can be expressed in terms of the liquid Weber number *(We)*,

$$We = \frac{\rho_l r v^2}{\gamma} > 4 , \tag{2.3}$$

where P^l is the liquid density, r is the nozzle internal radius, υ is the liquid velocity and γ is the liquid surface tension. The transition between jetting and wind-induced regime happens when the inertia force of the surrounding air reaches a significant fraction of the surface tension force, so that the gas Weber number in equals

$$We_g = We \cdot \frac{\rho_g}{\rho_l} > 0.2 \,, \tag{2.4}$$

where P^g is the density of the gas. These values are however only applicable for nozzles with small inner diameters, e.g. capillary nozzles. For large values the presented limits are different. A diagram showing the limits mentioned for water with different nozzle diameters is presented by the same authors [39].

Agostinho (2013) has found experimentally that the dripping regime occurs at $We < 2.5$, the transition at $2.5 \leq We < 4$; and at $We \geq 4$ the jetting regime takes place. The wind-induced regime does not lie within the scope of their work.

The disintegration of a liquid into droplets can be achieved by many different means: aerodynamically, mechanically, ultrasonically, electrostatically, etc. For example a liquid jet or sheet can be atomized by shear stress when exposed to a high-velocity gas, using the mechanical energy provided by a vibrating or rotating device, or using an electric field[32, 33, 35, 36]. Typical applications of these processes include spray drying, spray pyrolysis, spray freeze, drug delivery, pesticide dispersion and fire suppression. Good reviews about atomization and sprays can be found in the books of Lefebvre [33], Nasser [36] and Liu[32]. Good reviews about droplet formation mechanisms and the breakup of liquid sheets and jets can be found in the book of Lin 35 and in the review written by Eggers and Villermaux [34].
Electrohydrodynamic atomization (EHDA), or shortly electrospraying, is an atomization process which implements electric stresses into the liquid breakup process. These stresses are inserted by creating a strong electric field in the breakup region. The method is known for its capability of controlling the diameter of the generated droplets which is provided by adjusting parameters like the properties of the solution, the nozzle geometry, the electric field characteristics and the flow rate. Among many other applications electrospraying is used for drug delivery [43], in greenhouses [44] and for controlled deposition [45].

In EHDA the electric field is created by establishing an electric potential difference (Φ) between the nozzle and a counter electrode placed at a certain distance from the nozzle tip. Various nozzle/counter electrode configurations can be used. The most known one is the nozzle/plate configuration in which the counter electrode is a metallic plate placed below the nozzle tip 45. Alternatively, configurations like double cylinders [46] and nozzle/ring [44] have also been successfully applied. In all the mentioned configurations the field is defined by the applied voltage, electric permittivity of the continuous phase, the chosen geometry and the interaction with other charged surfaces [47].

In most cases the liquid is pumped through the capillary at a constant rate using a precision pump, but other authors have omitted the pump and used hydrostatic pressure [45, 48].

Good examples of possible applications for electrohydrodynamic atomization in water technology are: Controlling droplet size and droplet dispersion to enhance evaporation in Multi-effect desalination systems[7], controlled dispersion of pesticides and growth regulators in crops to reduce effluent contamination, combined application with ion selective liquids for metal recovery and liquid-liquid dispersion to enhance coagulation in drinking water treatment.

‘If you can’t explain it to a six year old, you don’t understand it yourself.’

Albert Einstein

3. Research and education

Established by the Faculty of Technology (Instituut Techniek) of NHL University of Applied Sciences, the research group Water Technology is part of the Life Sciences and Technology department (LS&T). Because of the intrinsic configuration of LS&T, i.e. hosting courses in Van Hall Larenstein (VHL) and the NHL, the group has the opportunity of functioning between the two universities.

Its structure is based on the competence triangle, i.e. professional activities, education and research, and focused on stimulating each one of the topics (individually and combined) inside the university, through the development of water technology related activities.

Its (sub)area of focus is physically driven water technologies with special attention to sand filtration systems, monitoring (sensoring), disinfection, low cost technologies and desalination technologies. Additionally the integration between Electrohydrodynamic Atomization and water technologies will be explored.

Regarding professional cooperation, the NHL has an unquestionable advantage of being situated in Leeuwarden (Friesland), a city which is currently working to become the world capital of Water Technology. Such tendency is attracting companies, institutes and expertise

to this area and will be explored as an important key to position of the NHL among the most important educational/professional institutes for applied sciences.

Education is also seen as a key point for the research line of this group. The activities in this area will comprise the implementation and/or supplementation of water technology related modules, supervision of PhD and master students, organization of scientific seminars and the development of activities involving different levels, e.g. secondary school, MBO's and University.

The strategic position of the NHL, placed in the Dutch Capital of Water Technology, facilitates the development of this research group. Among many other positive characteristics, it can be also seen as an unique opportunity for professional and scientific development, a possibility to contribute to the formation of very capable young professionals and an opportunity to help the development of the field locally and internationally.

Knowledge circulation

The NHL Water Technology research group is part of the Water Alliance initiative. Its actions will therefore focus on stimulating the cooperation between private and public initiatives inside the water sector with special attention to the HBO level.
Among many possible (and current) partners it can be mentioned: the University Campus Friesland network, the Water Application Center, The Sectorplan Noord Initiative, the Centre of Expertise Water Technology and Wetsus Centre of Excellence for Sustainable Water technology. The last two institutes are of special importance due to their strong link with the HBO level (CEW) and compromise with innovation (Wetsus). A better description of these institutes and the possible links with this group is presented in the next paragraphs.

The Centre of Expertise Water Technology (CEW)

The Centre of Expertise Water Technology (CEW) is a public-private partnership. Its core business is to support and improve innovative development by offering applied research services. With a broad range of knowledge, experience and facilities CEW is able to offer services in a wide variety of technical challenges. Main regional Universities of Applied Science are among its primary partners. Its other focus point is to enable the educational system to absorb knowledge, innovation and entrepreneurship within its curriculum. This creates a healthy environment and knowledge infrastructure in which students, educational professionals and businesses benefit from each other.

Wetsus Centre of Excellence for Sustainable Water Technology

Wetsus Centre of Excellence for Sustainable Water Technology is a facilitating intermediary for trend-setting know-how development. Wetsus creates a unique environment and strategic cooperation for development of profitable and sustainable state of the art water treatment technology. The inspiring and multidisciplinary collaboration between companies and research institutes from all over Europe results in innovations that contribute significantly to the solution of global water problems. Innovation, partnership, joy, cooperation and reliability are the values around which all Wetsus' activities are organized and performed.

Wetsus acts as Technological Top Institute for Water technology and is located in Leeuwarden, The Netherlands. Wetsus' scientific research program is defined by the private and public water sector and conducted by leading universities. The Centre of Expertise Water Technology is one of the main supporters of this research group.

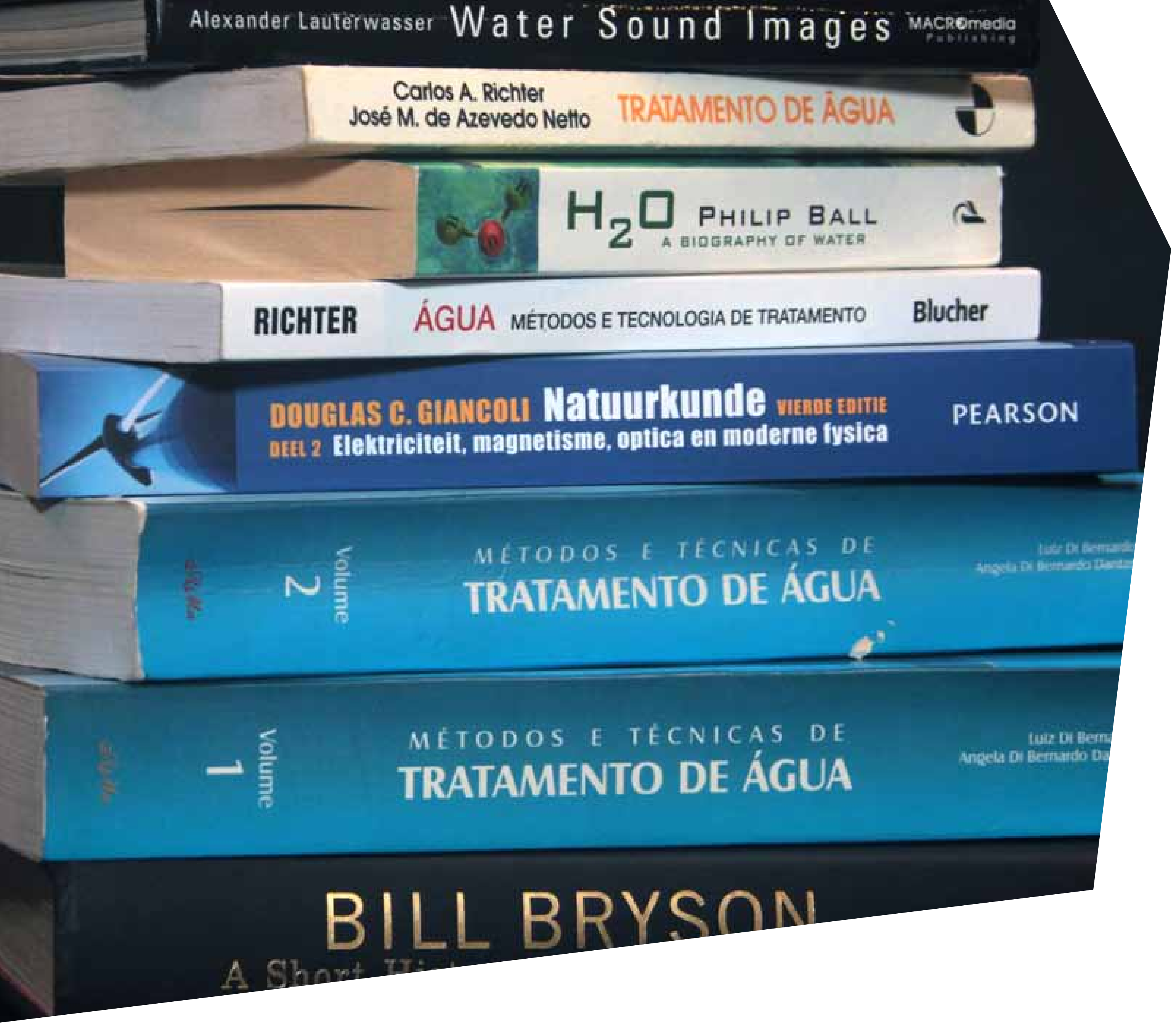
Actions regarding cooperation are focused on narrowing the distance between Wetsus and the NHL. They comprise the realization of activities to support cooperation at different academic levels, e.g. seminars, workshops, combined research programs, etc, as well as supporting the introduction of final stage technologies into the market.

Epilogue

The lectoraat is one of the most important knowledge nuclei inside the University of Applied Sciences. This position and its intrinsic echoes have to be structured and targeted in such a way that courses, students and staff can benefit scientifically and professionally from it.

There are indeed differences between the applied and the fundamental approach in science. However, there is also a big intersection zone where fundamental science and application coexist. This area is the main area of activity of the lector. He (or she) in his (her) autonomy is mainly responsible for finding this area and exploring it as intensively (and extensively) as possible.

So it has been said.



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