ParisTech REVIEW:

Urban wastewater: the rise of a new resource

Emmanuel Trouvé / CEO, Nerovia / July 17th, 2012

Tomorrow, urban wastewater treatment plants will be more than just decontamination factories. They will also produce a wide scope of resources, from water reused for human needs to green energy, bioplastics or even mineral components. Wastewater treatment will be a key issue in the development of a green economy: researchers will be able to combine biotechnologies, biochemistry and microbiology with chemical engineering and applied mathematics.

Nowadays, the primary function of wastewater treatment plants is to decontaminate wastewater. In other words, make it clean enough to discharge in streams or in the sea without any risk for the environment or public health. The aim is to preserve the quality of natural resources despite the increase of human activity. A wastewater treatment plant is a chemical and energy intensive unit that indirectly generates greenhouse gases and important waste, mainly sludge. This waste represents between 55% and 60% of the incoming organic matter. In most cases, it is dehydrated before being incinerated with other domestic waste, or else used in agriculture as organic soil enrichment.

Conventional research aims at minimizing the impact of decontamination processes on the environment: contain the energy consumption, greenhouse gas emissions, olfactory nuisance and the sludge waste. But we need to move even further and change the function of the wastewater treatment plants: not only decontaminate wastewater but recycle it. It is absolutely necessary when working in a sustainable growth perspective. We need faster and more efficient treatment cycles as well as renewing the management of wastewater in order to decrease the stress on natural resources. Indeed the renewal cycles of these resources aren't fast enough compared to demographic growth and the consumption and production modes of industrial societies. It's not only a matter of soft water resources – hydric stress is of course amplified by climatic change – but also the problem of fossil fuel and raw materials. Wastewater treatment must be conceived according to a logic of cycles. How can we transform what we receive into something useful? In other words: how can we recycle wastewater and its constituents as much as possible?

By 2020-2025, wastewater treatment plants will produce clean water – part of which will be directly reusable – but also bioenergy and biomaterials. This mutation is based on a change of view: rather than conceiving wastewater as contaminated water, we should think of it as water full of resources! This leads to a complete revision of the processes involved: instead of removing contaminants through multiple steps to obtain clean water, we should extract resources one after the other, starting with water, to recycle and produce clean water, energy, organic and mineral materials. The contaminants will be treated at the end of the chain, once they at very low levels of concentration.

Water Factories?

Thus, the first issue is to produce water and learn to value this production. Reusing wastewater is already a fully established reality in extreme situations – the International Space Station, the Concordia Research Station in the Antarctic or in military operation fields – and a partial reality (up to 20%) in countries under heavy hydric stress, in Australia and the Middle East for instance. With reasonable investments and existing technologies, it would be possible to reach an 80% ratio. By now it would be difficult to go beyond, mainly for economic reasons: recycling these last 20% would be more expensive than the first 80%.

During the first phase, water is extracted with very low levels of contaminants and a quality close to surface water before purification for drinking. Once the main flow is separated and cleaned, it is treated more or less intensely to produce different water qualities, according to the specific needs: cleaning of buildings, industrial use (water for heating systems, refrigeration…), irrigation. In these last cases, there will be less need for decontamination than when producing water for drinking or for electronic use.

Thanks to recycling, the same water that is extracted from the natural environment will have multiple uses. Ecologically speaking, a benefit is that groundwater is preserved and is extracted only for drinkable water production. Economically speaking, the industry can use a significantly more important volume of water.

The economic impact of this increase can be very significant: in areas under heavy hydric stress, water production for industrial use can free the production capacity of local firms. The value of this water can thus be measured according to the direct revenue increase for the industries rather the cost for the investors – a complete change of perspective in the elaboration of economic and financial models.

Decontaminated wastewater can also be useful to help accelerate the recovery of groundwater resources. This helps to maintain supplies and satisfy the need for drinkable water during droughts. This technique can also be helpful under more tempered climates to handle local peaks of demands during the summer in coastal areas, for example.

A central wastewater treatment plant appears today as the most appropriate place for water production but we shouldn't neglect the potential of decentralized systems (domestic treatment or small treatment units) that represent 20% to 30% of wastewater in Europe. In Korea and Japan for over 20 years and now also in China, devices reusing wastewater are implemented in buildings that are big enough, community housings for instance. Drinkable water is dedicated to "noble" activities – drinking, cooking, and bathing. Once used, this "grey" water can be recycled and reused for cleaning floors or in heating systems. Part of the drinkable water can be used twice before being rejected into the sewers. With this system, there is no need to double the incoming networks, apart from the incoming and outgoing water pipes. However, you do need a very strict control of the installations to avoid any error that could endanger public health.

As expected, the development of these recycling logics will raise a problem of social acceptability which should not be underestimated, although it isn't unsolvable. The recycling of wastewater into clean water could come up against the cultural reluctance of individuals, industries, collectivities as well as the whole society. For multiple reasons: fear of contamination, the myth of pure water… Obviously, economic reasons such as the increase of water bills will not be enough to overcome this reluctance. This asks for a specific effort. Sciences such as environmental sociology can be used to explain the issue of recycling and analyze the potential psycho-sociological obstacles as well as offer solutions to overcome them.

Towards the Production of Raw Materials

However, producing water is only a small part of the story and certainly not the most stimulating one from an economic point of view. The issue is also to recover the solid deposits from wastewater. The challenge is to sort raw materials according to their specificities and send them to where there will most efficiently used. Beyond their organic nature, which is the only criteria recognized today, they will be separated into different categories: proteins, sugars, lipids, fibers etc. by using quick 3D fluorescent analysis techniques, for example.

There are already three different recovery fields: the energy field, the green chemical field and the mineral chemical field. Part of the high energy potential materials (such as sugars, fats, proteins) will be sent to reactors that produce bio-gas. Promising experiments have been led in Prague, Budapest or Braunschweig, suggesting that great quantities of energy can be produced from this type of organic matter. The rest could be sent to green chemistry each time direct or indirect applications can be found. Last, some components such as nitrogen, phosphorus or sulphur will be extracted and delivered to fertilizer producers or to chemistry labs. That way, part of the wastewater materials are reincorporated to the soil in a specific and controlled framework.

Some microorganisms used in biological decontamination processes are cultivated to produce polymers during the degradation of organic matter. These polymers are very similar to oil-based products from the chemical industry. The only difference is that this method produces green carbon which is then used by the bio-plastic industry to make multiple products: pens, computer mice, car bumpers… Organic products won't significantly change the biopolymer market, the same way mineral components won't revolutionize the fertilizer market. Given the very low quantities, the priority is to find sustainable outlets for wastewater products by controlling that their specificities do match with the needs of the industry. Our flows must be integrated into a more global cycle of materials.

The most challenging issue is then to conceive economic models that will let us think in terms of production and recovery of outgoing flows. This implies to label outgoing products – a work that must be accomplished with the industries and actors involved in their use. If we take the example of the phosphorus recovered from wastewater, its quality and its cost must be attractive enough for the fertilizer industry. Normative campaigns must be led. For biopolymers, they will need a clear labeling led with the plastics industry.

All of these processes will lead, as for the production of water, to completely turn upside down our economic evaluation models: costs, which are at this day the principal economic indicator in water treatment, must be evaluated according to the creation of value.

In countries such as Germany, where energy is more expensive than elsewhere, the methanization of organic matter is not only an added product of the wastewater transformation. It can also prove to be a key feature in the cost balance of the transformation process, by helping achieve energetic autonomy for wastewater treatment plants. Factories in Braunschweig and Budapest almost cover all their needs by methanizing their sludge with byproducts, such as unsold or expired products from supermarkets, to fuel the electric generators with the gas they produce.

This renewable energy production (biomass) will not disrupt the energy market, although in some cases there may be a methane surplus than could be used locally in gas networks or as fuel. Today, researchers in the energy field are trying to industrialize the methanization process, with or without the use of byproducts. The bio-gas production also generates juices with high concentrations of nitrogen. These processes were developed to work with four times less energy than conventional nitrification/denitrification processes.

How about the last residues? They will be concentrated at the end of the chain. They should be inferior to 10% or 5% of the incoming matter. Reduced to very low volumes, they will be easily taken in charge as special industrial effluents. This induces an extra advantage: a sustainable solution for emerging contaminants contained in wastewater. Concentrated at very low rates, they can be destroyed, inerted or stabilized.

Decontamination: a Field in Mutation

Big decontamination players will see their role evolve. New functions appear that will have to be assumed, either internally or by new third-party specialists. Certification, negotiation with industrial users, dialogue with regulation authorities, all sorts of high-end capabilities should find their place in this new chain of value.

The production of clean water, bio-gas, raw mineral materials and polymers will mobilize high-end technologies, which are currently in development phase. Conventional operators are involved in R&D projects, but they also keep solid relations with an ecosystem of start-ups that explore one aspect or another of cleantechs (for instance, there are four or five in the world for phosphorus). Operators share their access to the market with these start-ups against the pooling of risks.

On the whole, decontamination is on the verge of transforming into something completely different. Traditionally based on hydraulic bases, this field has incorporated chemistry and process engineering and is starting to use biotechnologies, biochemistry and microbiology. Life sciences have also been embedded into this sector during the last fifteen years. This has led us to continuously adapt in order to be able to drive the processes based on the living.

The function of wastewater treatment plants will evolve and consequently, their morphology as well as their place within the economy. Today, wastewater treatment plants are energy-intensive places that produce sludge that is extremely costly to transform. Tomorrow, they will be energy sufficient and produce commercially sustainable products, with less residues. The economic balance will have a whole new look. Not to mention the benefit of decontamination for the environment and health, an aspect that still hasn't been valued economically. Decontamination will step in the era of green economy.

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Note from the editors: Emmanuel Trouvé is still under contract with Veolia, a patron of ParisTech Review. A previous version of this article was published in Symbiose, AgroParisTech Alumni's Review.