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SWS European Chapter Meeting in Faro, Portugal: plus site visit WWTP Faro Noroeste

The Waterharmonica: (re)use of treated waste water through natural processes also in the Algarve, Portugal?

With site visit to the Faro Noroeste STP

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INTRODUCTION

During the 1st Annual Meeting of the Society of Wetland Scientists – Europe "Integrating our approaches to Wetland Science" in Bangor, Wales, UK in 2006 we presented two posters on the "Waterharmonica concept: Trophic webs from discharges: nature enhancement through the Waterharmonica concept" and "Sludge particles as food source for Daphnia". Due time the Waterharmonica became an even in national policy accepted concept in The Netherlands, with increasing global interest, especially in Spain (Sala and Kampf, 2014).

In the same period huge efforts have been made in the Algarve to construct over 800,000 population equivalent waste water treatment capacity. Most discharge, as happens elsewhere in coastal tourist areas in the Mediterranean is direct or indirect into the Atlantic ocean. This means that without water reuse yearly 50,000,000 m^3 water is directed from land into the ocean, taken out of the "fresh water cycle".

Actually, well treated waste water is not a waste anymore, the waste has largely, to a large extent been taken out of the water. The effluent turned into a very clear, but still 'dead water', clear but with loose bacteria and sludge flocs. It is good to realise that the effluent basically comes from drinking water, a very pure clean water. During the process of potable water production all forms of natural life are eliminated. Waste water treatment added only low forms of life, and energy. It is thus needed to turn this effluent into an attractive and clear water. Is it possible to apply the Waterharmonica ideas in the Algarve. Is it affordable and what are the benefits?

SUSTAINABLE WATER REUSE IN PORTUGAL

Portugal, like most of Mediterranean EU member states, regularly experience severe water supply and demand imbalances, particularly in the summer months. Half of Portugal mainland suffers of water deficit. Tourism is a very important economic activity in Portugal and is pushing water demand particularly in regions suffering of water deficit, like the Algarve. Golf courses are an important tourist factor contributing to water demand rising. A number of golf courses are installed in tourist areas and need high amount of water for irrigation. Water reuse is a very important management strategy in situations of water scarcity. Portugal badly needs to include treated wastewater as a dependable water in the nation water resources management. Safe water reuse requires guidelines. This standard presents guidelines on: water quality, irrigation practice, management of environmental impacts, protection of public and animal health and aspects of control and monitoring (fully cited from Marecos do Monte, 2014).

NATURAL PROCESSES FOR "UPGRADING" TREATED WASTEWATER

Upgrading of well treated waste water in natural constructed wetland systems is not new. We found descriptions in English like: natural systems for wastewater reclamation, enhancement marshes, wetland treatment systems, constructed treatment processes, natural reclamation systems, effluent polishing in constructed wetlands, wetland to accept tertiary treated wastewater, constructed wetlands for secondary effluent treatment and water reuse, reclaimed water potential for aquatic ecosystem restoration or recreation, free water surface wetlands for tertiary wastewater treatment, constructed surface flow wetlands treating effluent from wastewater treatment plants, "nature-based solutions for water pollution control", etc.
Plus –in other languages- as an example: Nachklärteiche, spillvattenvatmarker, efterpolering av spillvatten, moerassystemen. For the moment we call these "Waterharmonica-alikes", in the hope and expectation that the simple, fancy, short, catchy, strange name Waterharmonica will be accepted by the SWS-members, or even will become a Waterharmonica.

THE WATERHARMONICA, SINCE 2006

Calling all of the above processes "Waterharmonica" made the idea of using "constructed nature" an accepted natural constructed wetlands application for water management in The Netherlands, see www.waterharmonica.nl for backgrounds, publications and reports. The process became a part of Dutch national water policy, awarded with the Water Innovation Award 2016 in the Category *Clean Water.*

Simply called Waterharmonica in The Netherlands:

The Waterharmonica is nowadays an accepted, tailor made innovation in water management in The Netherlands.

The Waterharmonica-alikes can be found all over the world.

Please come to the poster/interactive digital knowledge exchange session to bring in your own experiences and ideas.

Fig. 1. *Waterharmonica's in The Netherlands* (www.climatescan.nl)

Up to now fifteen full scale Waterharmonica's for ecological upgrading are in operation with capacities of 1,000 – 40,000 m^3 treated waste water per day, with five more under design in The Netherlands. The first ones were aiming on producing nutrient removal, buffering water and supply water for agriculture. Most of the recent Waterharmonica's are focusing on creating natural values, fish spawning areas and migration opportunities and on natural processes for water reuse as recreational waters. See figures 1 and 2.

Fig. 2. Variation of Waterharmonica's in The Netherlands

WHY A WATERHARMONICA?

Waterharmonica's are tailor-made systems of (Daphnia) ponds, wetlands, wet meadows, shallow or deeper reed beds, fish spawning areas, fish ponds, wet forest, etc. to convert (well) treated waste water into a living, ecological sound surface water. Possible benefits are water storage, blue/green buffers, nature values, recreation, ecosystem services and a source of water and life.

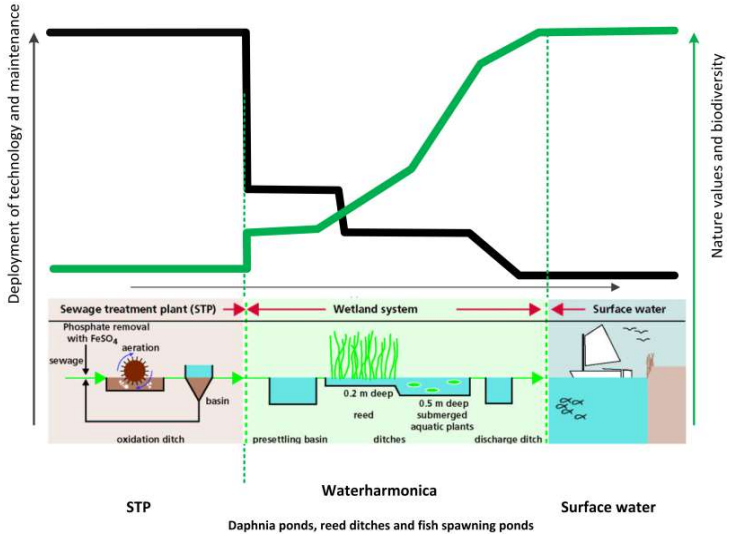

Fig. 3 The Waterharmonica: a natural link between WWTP and the environment

In figure 3 the Waterharmonica is depicted as a link between the technical part of the Water cycle (the Water chain) and the surface water, the Water system. The black line gives the 'deployment of technology and maintenance' (cost). The green line 'nature values and biodiversity', or even better biological richness ("biorichness, a wealth of natural life can with even limited biodiversity can be very attractive to, though less appreciated in scientific

ecology). A Waterharmonica provides a 'soft landing" of the effluent in the environment. In some cases the green line at the end of the Waterharmonica will rise higher than the surroundings, this is the case in f.e. the Waterharmonica's Grou and Empuriabrava.

When planning a Waterharmonica a checklist contains bullets like: is enough space available at and around the WWTP?; meeting the existing discharge requirements: can a Waterharmonica prevent the possible exceedance of N and P standards and/or suspended solids?; requirements based on the EU-WFD objectives, both water quality and layout, part of the ecological corridor; required biological disinfection to meet bathing water requirements, both for 'official bathing water according to EU-WFD regulations' and water where 'people swim'; storage and buffering of water; nature objectives; recreational use; reuse; based on the reuse as city, nature, agricultural or industrial water; government levy for the discharge of effluent, etc..

A quick-scan in the province of Friesland in the north of the Netherlands pointed out that most of the 28 WTP's of the water authority from the point of view of improving the effluent quality a Waterharmonica is an appropriate solution. But moreover the value is basically a combination of EU-WFD requirements, water system improvement efforts, nature and recreation values and drought mitigation. It is a good method to tackle integral water issues with a low-tech, low-energy and cost-effective approach (Sala, Serra, Huguet et al, 2004). But it also means that in Friesland (and elsewhere!) Waterharmonica's are only possible in a joint effort from many different stakeholders, like the province, municipalities, nature protection organisations as, the drinking water company, farmers and residents.

Cost for Waterharmonica's vary very much, depending on size, and especially the simplicity or recreational services, creation or biological values, etc. As a rule of thumb, total cost of making a "living water" out of well treated wastewater cost around 5 Eurocent per m^3 of treated water, with a bandwidth between 2 and 12 cents, comparable with cost of sand filtration alone.

MAPPING WATERHARMONICA'S

The map above has been made with the international open source tool Climatescan, a mapping for all kind of green initiatives (*www.climatescan.nl*): roll-out menu: *Waterharmonica: biological link to change (well) treated waste water into usable surface water.* More than 1000 green projects are listed by now, see for information and backgrounds Boogaard et al, 2017).

The basic, background information can be found on the *Google maps Waterharmonica application*: www.google.com/maps/d/edit?mid=1ldUqKDoICusiUcbJcLuJgr5zmjw . It lists not only the Dutch Waterharmonica's but also the Waterharmonica-alikes. Quite a few of these came from Fabio Masi, who kindly made a dataset of Global Wetland Technology available for us. The Google application gives the possibility to propose your Waterharmonica-alike to be a Waterharmonica. To do that, please get in touch with the first author.

WATERHARMONICA'S IN THE ALGARVE?

Since 2005 the Algarve made a huge progress in waste water treatment, eight WWTP's with a total capacity of over 800,000 population equivalent (PE) will be constructed at the end of 2017, amazing progress in a short period (table 1). The total investment will be over 70 million Euro. It is however good to realize that waste water not only has disadvantages. Once

it was drinking water, plus rain water. The volume of treated waste water will be more than 100,000 m^3/day, ready to be used again, ready for an upgrade in a Waterharmonica.

Table 1. Waste water treatment plants in the Algarve (Águas do Algarve, SA)
Data f rom www.postal.pt/2015/02/faro-olhao-portimao-ganham-novas-etars/

ETAR / WWTP	Year	Capacity PE	Investment Million Euro	Waterharmonica possible? 1	2	3	4	5
Lagos	2005	138,000	?	+ +	+	+	+	0
Companheira	2017	140,000	11.6	++	++	++	+	0
Boavista	2007	33,180	5.0	-	--	+	+	?
Vale Faro	2005	130,000	4.2	--	--	+	--	--
Vilamoura	2006	138,000	9.3	++	--	++	++	++ ?
Faro Noroeste	2009	44,350	9.7	++	++	++	++	0
Faro/Olhao	2017	140,000	14.5	++	++	++	++	0
Almargem	2007	48,200	5.5	++	+	+	+	0

Notes to the table:

1	Water Framework Directive / Wetland restauration	+ +'	very attractive
2	Fish spawning	+'	attractive
3	Natural values / landscaping / birds / recreational values	0	indifferent
4	Effluent polishing, nutrient removal, disinfection	-'	not important
5	Water buffering	--'	why?

Google mapping is used to assess feasible Waterharmonica possibilities in the Algarve. For the eight WWTP's a rough estimate has been made of the possible benefits of a Waterharmonica, for aspects like the European Water Framework Directive, wetland restoration, possible fish spawning (including fresh water / salt water gradients), natural values, landscaping, birds (bird watching), recreational values, effluent polishing, nutrient removal, disinfection and the need for temporary water buffering. As an illustration for a Waterharmonica with high natural values and a fish spawning area based on the revived treated wastewater, even close to the conference venue: WWTP Faro Noroeste, figure 4.

Fig. 4. ETAR de Faro Noroeste Sewage treatment plant (N 37.018°, W -7.957°) (Google maps, 2017)

CONCLUSIONS

Natural water reuse in Waterharmonica's in Portugal, and in particular the Algarve, will be feasible and will also not be very different from the Costa Brava in Spain. The results from the Waterharmonica Empuriabrava will be useful (Mujeriego, Lagostera, Sala et al, 2011, Sala and Kampf, 2014). Most WWTP's in the Algarve are situated in quite natural settings, that means that most Waterharmonica's could be low to very low loaded, aimed on natural values. That implies hydraulic loadings less than 0.1 m/day, or 0.7 – 2.5 m^2 per population equivalent. This means sizes for the plants of around 140,000 PE between 10 and 35 ha, when all treated wastewater goes through Waterharmonica's. The smaller plants could be between 2 and 10 ha, though for instance for Faro Noroeste size could be better determined by "the chance": how much fresh / saltwater can be created for fish spawning area of attractive nature. Actually the existing ponds are already around 16 ha, only "restyling" into a Waterharmonica could be enough. The WWTP Vilamoura is situated adjacent to a Océanico golf course. A part of the effluent could be "upgraded" as in the Dutch Waterharmonica Klaterwater (leasure centre De Efteling). See for more backgrounds Kampf and Boomen, 2013.

APPENDIX: VISIT TO THE WWTP FARO NOROESTE AFTER THE CONFERENCE

After a short visit to the WWTP we started with the discharge point, see figure 5. The effluent attracted a lot of fish, well over a hundred, as far as we could tell the same species, Thinlip Mullet (*Chelon ramada).* See figure 6 and 7.

Fig. 5. The effluent discharge point of WWTP Noroeste

Fig. 6. Over a hundred fish trying to get into WWTP Faro Noroeste

Fig. 7. All fish seemed to be Thinlip Mullet *(Chelon ramada)*

A walk on the fields behind the WWTP revealed a great site for a Waterharmonica, as the structure of the previous lagoon system is still there, as also clearly can be seen on both Google maps and Bing maps (figure 4).

The old lagoon system is very good visible on the Google map from 2004, figure 8.

Fig. 8. The lagoon system in 2004 (Google Earth). Left of the black line is now occupied by the new WWTP

The total area is around 16 ha, roughly estimated. Since the new WWTP is in use the ponds are left for nature, as can be seen on the photo's in figure 9. very low loaded: 0.04 m/dag (Flow around 5000 – 6000 $m^{3/}$day). See Kampf and Boomen, 2013.

Fig. 9. An impression of the obsolete lagoon system, wating for "better days"

Our conclusion was that the old lagoon system is exceptionally suited for a Waterharmonica with high natural and recreational values, a true multi-functional with fish spawning ponds and good opportunities for seagrass. See for more inspiration the different existing Waterharmonica's like Grou and Soerendonk (fish spawning area), Kristalbad (water buffer,spacial planning, recreation) and the planned ones Groote Lucht, Vlaardingen) and on the islands Ameland and Terschelling. A good example for nature values and use of the "Waterharmonica water" in a nature reserve is the Waterharmonica Empuriabrava. See Kampf and Boomen, 2013 and www.waterharmonica.nl.

We hope this paper, and especially this appendix will make the Algarve enthusiast for one or more Waterharmonica's.

SOURCES,

Project site: www.waterharmonica.nl
Waterharmonica 1st SWS Europe in Bangor, Wales:
www.waterharmonica.nl/publikaties/2006_Bangor_Wales/bangor.htm
Waterharmonicas in the Netherlands (1996-2012):
stowa.nl/upload/publicaties/STOWA%202013%2008%20LR.pdf
Netherlands Water Innovation award 2016:
www.waterinnovatieprijs.nl/project2016/s-c-h-o-o-n/
Waterharmonica mapping:
www.google.com/maps/d/edit?mid=1ldUqKDoICusiUcbJcLuJgr5zmjw
www.climatescan.nl
Waste water treatment in the Algarve (Águas do Algarve, SA): www.aguasdoalgarve.pt

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