The role of wetlands in the urban water cycle, from Amsterdam to Kisumu, towards a green circular economy

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INTRODUCTION

Most publications on wetlands are either on existing sites or on special applications of wetlands, seen from the viewpoint of a wetland specialist. Given the current emphasis on circular economies and future proofing cities, it is interesting to take the urban water cycle as a starting point: how do wetlands fit in the urban water cycle? In December 2017 I got invited by the Dutch drinking water organisation VEI (Vitens Evidens International) initiated support for KIWASCO (Kisumu Water and Sanitation Company) to convene a workshop on wetland solutions - Waterharmonica - to lower the nutrient load through treated waste water to Lake Victoria (www.rekel.nl/water/landen/kenya/Kisumu/).

This created an opportunity to compare the urban water cycle of two big cities, Amsterdam on the border of Lake Marken in The Netherlands, and Kisumu on the border of Lake Victoria in Kenya.

VALUES OF HUMAN WASTES OR WASTED WATER?

Human wastewater is by far the most important source of water pollution in residential areas. It is good to realise that historically human waste were seen as valuable, many cities had central collection places, rented out to commercial enterprises for successful reuse of human wastes. As an example, in Amsterdam the Maatschappij voor Landbouw (*Society for Agriculture*) had a license for using house hold garbage (mainly ash), human wastes and (organic wastes) from markets and industry. The need for nutrients in agriculture made it economically attractive. This lead in the second half of the 19th century to a huge controversy between *hygienists* in favour of delivery clean drinking water into houses, *politicians* (in favour of cheap discharge of polluted water), *agronomics* (promoting the use of human excrements for improvement of agriculture, even shipped by boat to remote areas) and *engineers* in favour of applying the new techniques, especially from England.

Actually in those days a large city like Amsterdam was close to being a ‘circular city’; this changed, however, due to several reasons. The human excrements became diluted, because piped drinking water became available to flush toilets, this led to a strong increase in the amount of waste water. The solution was to build sewer lines and develop sewage treatment plants. Agriculture did not need ‘human manure’ anymore because of the availability of fertilizers. It must be said, that a system of piped high-quality drinking water is attractive and has contributed strongly to human health. The ease of a water closet, a good sewer system and waste water treatment plants is evident but can only be realized at relatively high cost. The total cost per family per year in The Netherlands is over 700 Euro per year, of which around 125 for drinking water, 360 for sewers and waste water treatment, and 150 for maintaining the water system (in 2015: NN, 2018c). However in

less fortunate areas in this world is this not affordable, certainly not in Kisumu. It is not likely that a close to 100 % connection will be reached in the next decade. a total "Ecological sanitation solution" with separate treatment of human wastes will not likely happen, especially not in a big city.

A MIXED APPROACH

A mixed approach of a combined sewage system might be a good solution, as Mels et al already proposed in 2005. See figure 1.

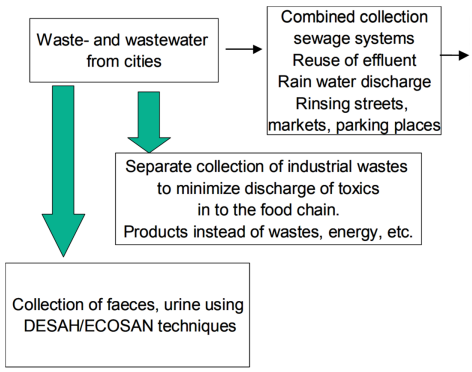

Fig. 1. Disconnecting and reuse of faeces and urine, industrial, hospital wastes etc. makes treatment and reuse of waste water much more simple (after Mels, et al, 2005).

Introduction of flow separation has a huge influence on waste water composition. Carbon (COD), most of the phosphates, most of the pathogens do come from excreta and urine, from our toilets. Above that, it is the only affordable way in the developing world to lower the discharge of medicines into the environment, as nearly all medicines in wastewater do come from excreta, and in a lesser extent from urine.

Separation of flows, as described above, needs a good organisation of the practical aspects as existed in Amsterdam around the 1900s , like the Liernur waste collection system and, like the Amsterdam Maatschappij voor Landbouw (*Society for Agriculture*) an organisation to handle the wastes and to produce fertilizers.

One of the issues raised is logistics of separate collections, especially cost. The volume of faeces and urine is not more than 2.5 l per person per day, or say 10 l per day for a family of four (see for an overview Niwagaba, 2009). Actually the recent developments in separate waste collection in The Netherlands show that the private waste companies are very able in organising a quite varied waste system. It is for families in semi-urban areas, towns quite accepted to have four 200 l containers (blue = paper, green = compostable material, orange = plastic, black is other wastes. Collection is one to two times per container per month, largely done in The Netherlands by private enterprises. In cities and urban zones where there is less space separate waste collection is in underground containers (GPGroot, 2018). Besides that all communities in The Netherlands do have waste

collection centres where the inhabitants bring special waste like old household appliances, metals, stones, wood, etc..

The recent shift to “Circular thinking” is striking, it became a part of long-term government wide planning in The Netherlands (NN, 2018a). Naturally Amsterdam took up the national plans: Çircular Amsterdam ((NN, 2018a) as a part of the Smart City initiatives. Waternet, the water company in the region of Amsterdam was already dedicated to the entire water cycle, with a large scale demonstration of urban source recycling in a part of Amsterdam, Buiksloterham (Gladek, et al, 2015). More info on the so-called ‘New sanitation’ in The Netherlands on http://nieuwesanitatie.stowa.nl.

KISUMU

The recent input of VEI (Vitens Evidens International) improved the operational quality of KIWASCO. The drinking water production is on the increase to the goal of 35,000 m^3/day, quite reasonable for 500,000 people, around 70 l per head per day. The operational management of the two waste water treatment plants had been optimized. The two plants do function better than could be expected. The Kisat plant is a 70 year old conventional plant with trickling filters, with not more than a reasonable effluent quality. The Nyalende oxidation ponds have recently been upgraded, effluent quality is much better than the Kisat plant. Overall, both plants are well operated and maintained by a young and dedicated staff. It took a while, however, before I found out that the total flow for both plants is not more than 12,000 m^3/day. That is 23,000 m^3/day less than the delivery of drinking water, only 30 % is connected to the sewer system. It is not likely that a close to 100 % connection will be reached in the next decade.

WHAT DOES THAT MEAN FOR KISUMU?

It is obvious that the city of Kisumu could make use of these recent ideas and actually make a leap towards a modern circular city, in the way The Netherlands are heading.

Kisumu is one of the few Eastern African cities with a sewerage system (Letema, 2012), the other two large cities in Kenya are Nairobi, Mombasa and Nakuru. However, in all cases only a fraction of the waste water is treated.

As Kisumu is bordering Lake Victoria, water is leading, the centre. This is illustrated in a practical, simplified scheme for one of the possibilities to draw an urban water cycle with focus on the ‘urban water cycle’: figure 2. A circle does not have an end or a beginning, it is also good to realise that all these boxes in figure 2 are interconnected. The deteriorating quality of Lake Victoria has a huge influence on the drinking water production, also because of algae blooms and water hyacinth plagues. Bringing piped drinking water to houses lead to more waste water. This is actually a benefit, as the effluent of a good sewage treatment is usually very clear. It is still a “dead water” though, only organisms originates from “polluted water like organisms”. A next step in the circle before entering Lake Victoria again is a Waterharmonica, to give the treated ‘city water’ a soft landing in nature. (Kampf et al, 2017, www.waterharmonica.nl)? This Urban Water Cycle way of thinking, with integrated ‘New-sanitation’ could be a good idea for Kisumu. It needs a human waste collection system to lower the input of carbon, nitrogen and phosphorus in the urban water cycle. The existing sewer system can still be used for houses, offices with ‘old-fashioned’ flush-toilets, ‘gray water’ from washing machines, showers etc.

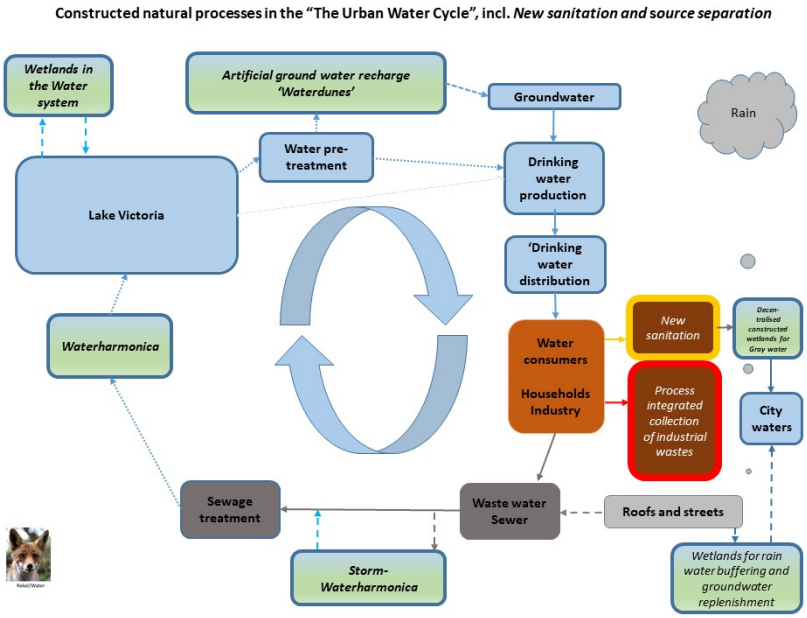

Fig. 2. Constructed natural processes in the "The Urban Water Cycle", incl. New sanitation and source separation.

The volume of 'human wastes" in a city like Kisumu is surprisingly low: roughly 2-5 l per person per day. This contains most of the nutrients excreted by humans (60 – 80 % of nitrogen, half of phosphorus, all pathogens, and nearly all pharmaceuticals). The around 400,000 people not connected to the Kisumu sewer systems produce between 720 and 2100 m^3 black wastes per day. Depending on the organisation 10 – 40 trucks will be able to transport 120 – 350 truckloads per day. When this system is picked up cleverly then it is even possible to tackle a big part of the pharmaceutical pollution, by separate collection of wastes from hospitals. When these loads would be transported to new digesters and "fertilizer production by drying, composting, etc." it would not only produce fertilizer but also a considerable amount of "green gas", also to be used for the trucks. It could be worth expanding on the incentivisation involving and developing private enterprises as household waste management by including a basic business model: Producers of human waste get money per tank, or per day, a privatised company produces and sells fertiliser cheaply, farmers can buy it and increase their income?

WHAT DOES THAT MEAN FOR WETLANDS?

In figure 2 several wetland applications are distinguished:

a- "Water dunes" and lakes for artificial groundwater recharge for drinking water production;

b- Wetlands for rain water buffering and water harvesting, also for and groundwater replenishment;

c- “Stormwaterharmonica’s” for storage of sewage during stormwater event to prevent discharge of diluted sewage during rainy periods;
d- Waterharmonica’s to change treated waste water into a living and usable surface water;
e- Natural and constructed wetlands along rivers and lakes.

Above that, when the carbon-load from human wastes is collected separately it becomes attractive to have constructed wetland on a decentralised scale throughout the (semi-) urban area of Kisumu. These constructed wetlands will contribute to human health and well-being, but can also contribute to urban livelihood.

IS THIS CIRCULAR WETLAND APPROACH POSSIBLE IN KISUMU?

To the opinion of the attendants of the workshop (involved were representatives of Water Resources Authority (WRA), Water Services Regulatory Board (WASREB), Lake Victoria South Water Services Board (LVSWSB), Kisumu Water and Sewerage Company (KIWASCO), National Environment Management Authority (NEMA), Lake Victoria Environment Management Project II (LVEMPII), County Government of Kisumu, Mixta farm and also the Nyanza Golf Club). Just some headlines from the workshop: Improve the WWTP Kisat with simple means. The idea of the Waterharmonica seems to feasible for Kisat and could well be combined with the Nyanza Golf club, situated between the plant and Lake Victoria and fish spawning areas, similar to Waterharmonica’s in The Netherlands (Kampf and Van den Boomen, 2013). For the Nyalende ponds the most important conclusion was see the Nyalende ponds as a part of the surroundings, see fig 3 (Kampf, 2017).

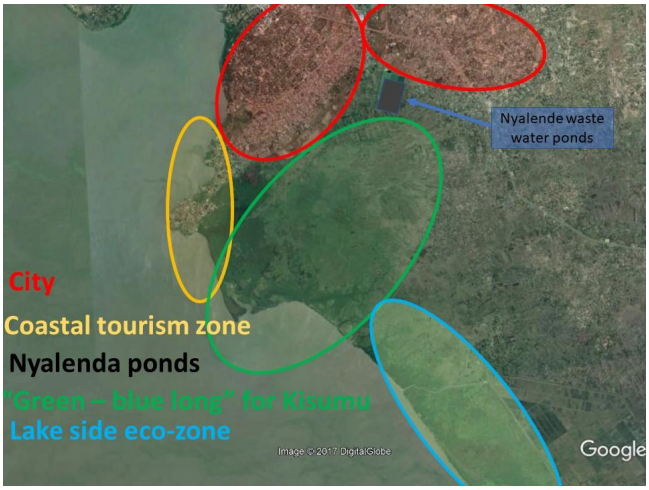

Fig. 3. The Nyalende ponds could be a part of a “green-blue lung” of Kisumu

Further recognised aspects are to optimize the ponds, by disconnecting the “human wastes”, including gas production. Thus also lowering the methane losses from the

sewage treatment ponds. An important issue is to prevent people from entering the ponds, make a good fence (safety for people and health aspects as people are taking untreated waste water for farming on, even, grabbed land), also to prevent disturbance of birds on the ponds. And include more natural constructed ponds with reed and submerged water plants to turn the water into a more natural water (Waterharmonica approach), as there is a large need for good quality water for irrigation farming and fishponds. And last not least saving wetlands for nature and eco-tourism. This fits well within the plans of the Lake Victoria Environmental Management Project (Bard, 2015).

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REFERENCES

GP Groot 2018. *(Semi-)ondergrondse containers* www.gpgroot.nl/afvalinzameling/afvalcontainers/ondergrondse-containers.

Kampf, R., 2008. *Improving agricultural practices as a way to meet the Millennium Developments Goals: a demonstration project in the Shimo la Tewa prison in Mombasa, Kenya. Conference Millennium Development Goals on Sanitation,* International Water Association IWA, Amsterdam.Kampf, R. and Boomen R.M.v.d. 2013. *Waterharmonica's in the Netherlands (1996 – 2012), natural constructed wetlands between well treated waste water and usable surface water*, 2013-08, Stowa Amersfoort.

Kampf, R., 2017. "Nature based Nitrogen and Phosphorus removal from 'Waste Water Treatment Plants effluent in developing countries, Acacia hotel, Kisumu, Kenya. www.rekel.nl/water/landen/kenya/Kisumu/ .

Kampf, R., Sala L., Claassen T. and Boogaard F. 2017. *The Waterharmonica: (re)use of treated waste water through natural processes also in the Algarve, Portugal? With si visit to the Faro Noroeste STP*, SWS European Chapter Meeting in Faro, Portugal, 4 6 May, 2017. Faro. www.waterharmonica.nl/publikaties/SWS_Faro_2017_05_poster_abstract_updated.p

Letema, S. 2012. Assessing sanitary mixtures in East African cities, Wageningen University.

Mels, A., Martijn, E.J. and Kampf, R., 2005. *Waterharmonica in the developing world*, 2005 2005, Stowa, Amersfoort.

Niwagaba, C. B. 2009. *Treatment Technologies for Human Faeces and Urine.* Uppsala, Swedish University of Agricultural Sciences.

NN, 2018a. *A Circular Economy in the Netherlands by 2050, Government of The Netherland* www.government.nl/documents/policy-notes/2016/09/14/a-circular-economy-in-the-netherlands-by-2050.

NN, 2018b. *Circular Amsterdam*, www.amsterdamsmartcity.com/circularamsterdam

NN, 2018c. *De staat van ons water*. http://www.destaatvanonswater.nl/?sc_lang=en-GB