# “White2Green”

No discharge dairy through
recovery of milk and food-chain approach

– part 1 – Inventarisation and ideas, and over one year experience

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# 1. Project definition

The Ndumberi Dairy Farmers Cooperative Society is a cooperation of farmers to process milk and produce milk products, so far only pasteurized milk and yoghurt. The dairy is situated in the centre of the village Ndumberi, close to Kiambu, north of Nairobi in Kenya.

The number of members of the cooperation is around 1200:

- 52 % of the farmers have small farms with up to 10 cows: only 14 % of the cows
- 44 % of the farms are medium to large sized with 10 – 30 cows: 42 % of the cows
- 4 % farmers do have more than 100 cows, in total 44 % of the cows

Total number of cows is just over 17,000. The milk production per cow per day is only 4 l/day on an average, the total amount of milk produced daily by the members nearly 70,000 liters per day.

The members of the cooperation do not have an obligation to delivery all milk to the dairy, only 12,000 l of milk are delivered to the dairy, less than 20 percent of the total.

It is a small, but modern dairy, well equipped with machines and tanks, with motivated personnel. Two of them are advisors for the members. As a service to the members the dairy also sells cattle feed, and related material

*The project reason was defined by the cooperation as follows:*

The waste is produced through processing of the milk by products

*The work description was:*

- Dairy water treatment solutions - Construction of a waste water treatment plant and the area required.

The client expected these results:

- *Water recycling and safe discharge to the environment;*
- *The assistance will help them not discharge the waste water to the environment.*

After a Skype talk before and discussions during the first part of my visit we translated this into this project goal:

- Minimize the discharge of waste water by:
  - *Product recovery by organised working;*
  - *Recover products as much as possible by good 'scraping an cleaning";*

  - *Keep 'waste flows separated under the principle that a 'bucket of clean water mixed with a cup of dirt ends up in just a bit more than a bucket of dirty water';*
  - *Do not only optimize by maximum production, but see wastes as products with a negative (?) value;*
  - *Try to turn these 'wastes' into products;*
  - *Milk can never be a waste as it is food;*
  - *The ultimate goal is a no discharge and wise use and application of food chains to utilise the values of milk.*

- Based on the authors experience this food chain approach is an attractive way to avoid wasting and to develop a cyclic approach.
- During the Skype conversation before my departure to Kenya I asked Francis Mihiu about the availability of land for use of gardening / agriculture to bring the wasted milk back into the circle, by a circular approach. When I arrived the cooperation had already leased 3000 $m^2$ not far from the factory and already started. We called this the '*White2Green garden*'.

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Initially this project started as a PUM-project, based on knowledge and input of the authors.

- Ndumberi Dairy Farmers cooperative society PUM Project Ltd-9467

## 2. Analysis and conclusions

Note: The project and project progress are documented in the PowerPoint report

*"No discharge dairy through recovery of milk and food-chain approach: "White2Green" – part 1 – Inventarisation*
*version 24-10-2018*

*The approach is as follows:*

- ***Step 1: Analyse the processes and operations in the factory (20 – 22 August 2018)***


*Figure 1: Analyses of processes and operation of the dairy. Every "Unit operation" is on the wall*

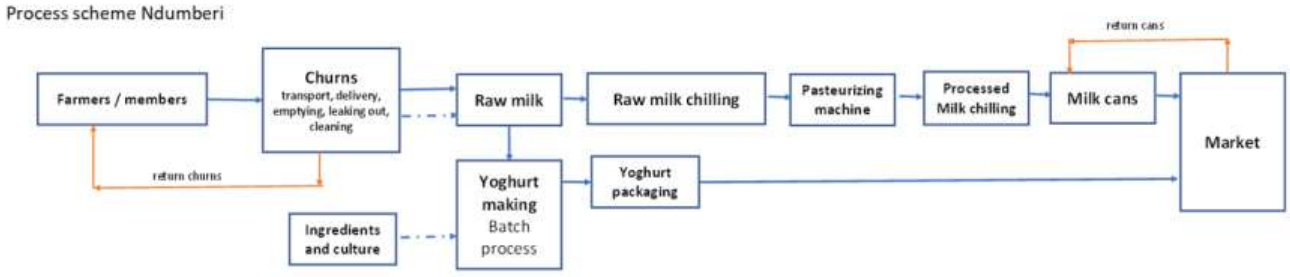


*Figure 2: The resulting process scheme*

An important part is assessing the possibilities of separation of 'waste flows', and prevent and reuse spilling.

*Photo's 1 and 2: Avoidable spilling*

- ***Step 2a: Make a plan, based on the assessment of the milk line (*10 to 13 September 2018)**

In general the crew knew very well how to run the dairy. Only, the amount of spilling was rather big (leftovers in cans, hoses, etc.) were rather large. The total of milk losses are estimated on 250 to 500 l per day, in the milk processing alone. That is 3.5 – 7 million Kenyan Shilling per year, around 50,000 Euro per year. More important even is that less spilling of milk leads to less waste water.

Table 1 opened the eyes, it is an overview of the processes, description of the 'waste flow' and possible treatment and use. Table 2 summarizes the separate flows, the quality, estimated volume and 'where to?.

*Table 1: Inventarisation of flows and possibility of recycling – the milk line*

| nr | Processes | Milk / Soap | Churns transport and delivery | Raw milk dump tank | Raw milk Chilling tank | Pasteurizing machine | Processed Milk chilling tank | Milk cans | Separate collection | Separate treatment and the add to effluent | Use |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1a | Raw milk leaking out | Clean raw milk | + | O | O? | | | | no / yes | | To production |
| 1b | Past. milk leaking out | Pasteurized milk | | | | + | O? | + | yes | | To pig food |
| 2 | First rinse | Diluted milk | *?* | + | + | - | + | *?* | *yes* | | Use in White to Green |
| 3 | Cleaning + Rinse 1 | Some milk + soap | + | + | + | + | + | + | | *yes* | no, after treatment to effluent line |
| 5 | Rinse 2 | Still milk + soap | - | + | + | + | + | + | *no* | | Use in White to Green |
| 6 | Rinse 3 | Clean water | - | - | + | + | + | - | *yes* | | Use for cleaning tanks or surfaces, sell to neighbours fro car washing? |
| | Explanation: in black Italic already there. In red bold to be realized | | | | | | | | | | |

*Table 2: Overview of "waste streams' and possible treatment or reuse – the milk line*

| Process | Amount (l/d) | What? | Where to? | Remarks |
|---|---|---|---|---|
| Recovered milk | 20 | Raw milk | production | |
| Recovered milk | 10 | Used milk | pigfood | |
| First rinsing | 1300 | Diluted milk | pigfood, or seperate to White to green | |
| Rinse 1 | 1800 | Diluted milk + soap | seperate treatment, then to White to green | when chunk and can washing seperate only 800 l /day |
| Rinse 2 | 800 | rather clean water | to White to green | |
| Rinse 3 | 800 | more clean water | to White to green or reuse | |

Emptying, leaking out milk churns for raw milk will yield at least 20 l milk per day, can added to the raw milk flow (that is 6000 l per month, around KES 240,000 per month, or the salary of a couple of workers….). Further savings and less pollution do come from the recovered milk from the cans (pig food), and the first rinse (only milk, no soap: pig food).

It is hereby crucial to recover the milk as effective as possible, this goes rather slow and not easy because milk is a 'sticky' emulsion. Could it be possible to speed this up by breaking the milk emulsion?, as is done by butter and cheese making, if possible by organic enzymatic wastes. Some thoughts about possible use of pineapple waste, see the Annex 1. It also might save in use of soap, or use enzymatic biodegradable soaps?

The water from Rinse 1 contains soap and need to be treated separately (ow, to be determined. NB lack of space, needs to be compact).

The other flows can be used as feed for the 'White2Green garden". Apart from Rinse 3 - a rather clean water-, how to us it?

***Step 2b: Make a plan, based on the Inventarisation – yoghurt line***

The yoghurt making is a bit another issue. Though small in activity it was it really contributed to a big influence on the amount of wastes in the discharge, which could be minimised by the circular approach. Most of the remarks were on working more neatly and more organised.

*Photo's 3 - 5: yoghurt making and packing*

*Remarks on yoghurt making:*

- Make more space: remove the non-used packaging machine (already done)

- Weigh ingredients:  Run list with ingredients, signed
- Time keeping: Electronic clock, run list with times

- Recovery of milk and yoghurt: many actions, to be identified
  f.e.
  - Remove ALL yoghurt from vessel before cleaning, use scrapers
  - High  pressure cleaners to minimize water use
  - Recover milk from the chunks and vessels used for mixing ingredients and containers for tastes

And:

- Be careful, making yoghurt is a growing bacteria at “optimum temperatures”.
- Avoid contamination, work clean, use the sanitizer
- Remove the un-used packaging machine

- Electricity is in bad shape

*Experiences of Ruud Kampf:*

*A good basis for deeper thoughts is the excellent publication 'De biologische reiniging van het afvalwater van zuivelfabrieken (Biological treatment of waste water from diaries), Boekhout and Ott de Vries, J.J., published in 1915 by Rijkslandbouwproefstation in Hoorn.*
*"Over the years in the field of dairy preparation a radical change took place. Where people processed the milk on the dairy, people more and more do this cooperative or sell the milk to third parties for same goal. The causes that lead to this can be done here remain unspoken, but the result is that the dairy preparation gradually moved to the dairies and these increase annually in number. This not only has advantages but also disadvantages. One of the drawbacks which the factory dairy production is connected, is the removal waste water without causing problems for the surroundings. Formerly when the company exercised exclusively was on the scattered farms, this was of subordinate importance; the amount of scrub and scrubbing water was usually not so big that it could be discharged in ditch or canal, without, nuisance to the neighbours.*
*The dairies were not a change for the better. Where thousands of litres of milk are processes at a central point, it is obvious the large quantities of resulting waste water, poured into a relatively small surface, cause nuisance in the immediate vicinity. Which wastewater still contains a lot of nitrogen-containing organic matter soluble and suspended condition, substances that cause various odor-spreading degradation products.*
*In the beginning few complaints were heard; as however, the number of dairies increased and especially when these more in the built-up area of the municipalities, people started to become aware of the untenable condition that was thereby created. It therefore needs not to be surprised, that in the Health Committee, seated in Hoorn, complaints were brought in about two dairies located in the built-up area of one of the municipalities ……"*
*So far discussions from 1905 – 1906 in this very readable publication, in Dutch..*
*For me this was an extra motivation to think about the choices there have been made for engineering solutions for dairies. Could it be that the solution for dairy wastes is in the old agricultural solutions? I already did an experiment around 20 years ago. A nearby Dutch farmer discharged his stable water on a ditch, close to the discharge point the ditch was polluted, after 200 – 300 meter the ditch was clear. He asked me for suggestions. I suggested to make an engineered ditch parallel to the existing ditch. Make different zones (a pump pit, a settling zone, reed and submerged water plants). To remove phosphorus a little bit of iron sulphate was added. I never published this, but it stayed in my mind, and it was one of the basic aspects of development of the Waterharmonica concept (www.waterharmonica.nl). See also the report Waterharmonica in the developing world (https://www.stowa.nl/publicaties/waterharmonica-developing-world).*

***Step 3: The White2Green garden, an alternative for classical waste water treatment?***

The board of the dairy approved our ideas to use gardening / agriculture to bring the wasted milk back into the circle, by a circular approach. The cooperation had already leased 3000 $m^2$ not far from the factory and already started. We called this the '*White2Green garden*' (Figure 3).

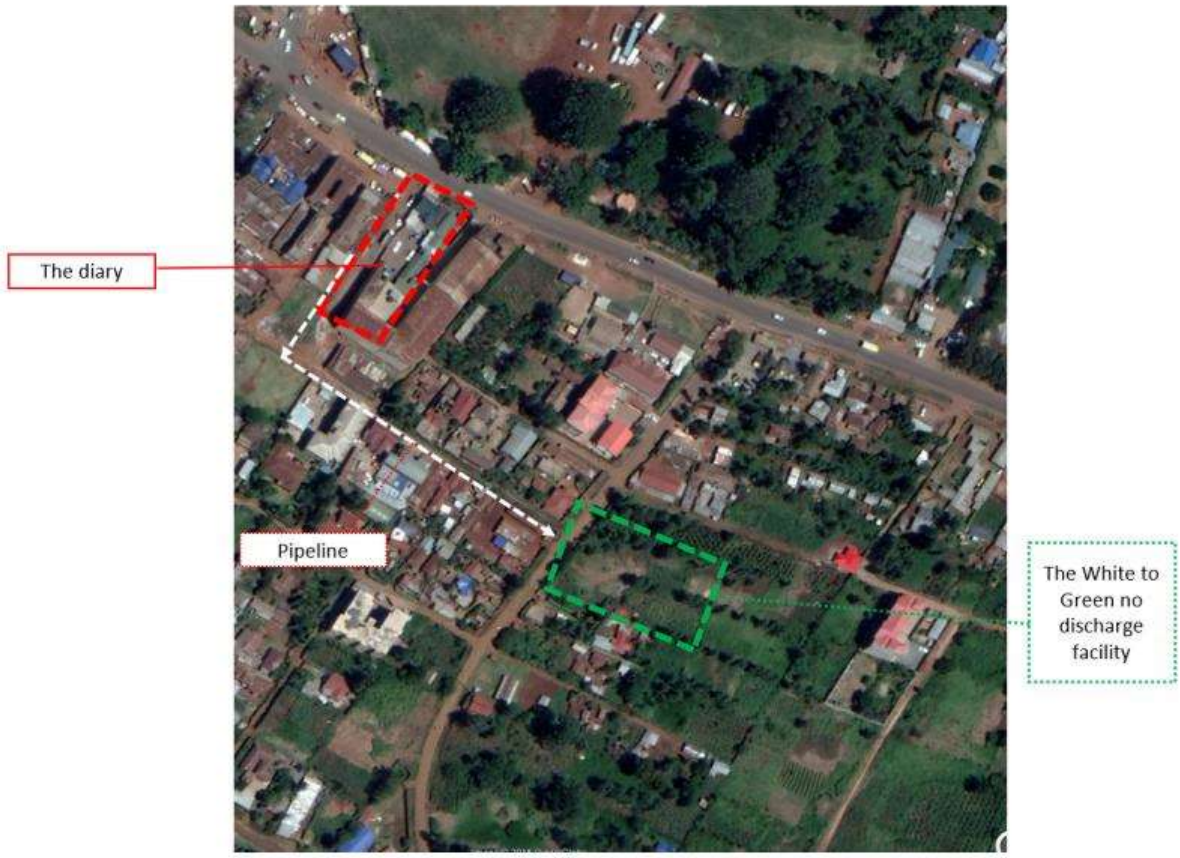


*Figure 3: Ndumberi dairy farmers cooperative and the land reserved for the White2Green garden*

The waste water from the factory is transported by underground pipelines. Photos 6 and 7: Situation 18 August 2018.



*Photo's 6 and 7: The leased garden on 18 August 2018*

Some basic idea's to make the White2Green a success summarized:

- Process integrated measures;
- Separation of flows;
- Cleaner working;
- Every spillage will be avoided;

Thus:

- As much milk and yoghurt will be recovered in the diary;
- Storage of recovered food for pig food, etc.;
- Soap water is treated separately, it was decided to transport this relative stream by truck for further treatment;

This means a very effective work organisation and process /quality control, which will not only lead to less wastes in the water but also bring money:

- Less spilling, recovery of milk: will save money: 3M KES per year? 30,000 Euro per year, or more?
- No expensive waste water treatment will be needed.

For a preliminary predesign the following separate waste flows have been derived:

*Table 3 : Separated 'waste' flows*

| Process | Amount (l/d) | What? | Where to? | Remarks |
|---|---|---|---|---|
| Recovered milk | 20 | Raw milk | production | |
| Recovered milk | 10 | Used milk | pigfood | |
| First rinsing | 1300 | Diluted milk | pigfood, or seperate to White to green | |
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And the following sketch design:

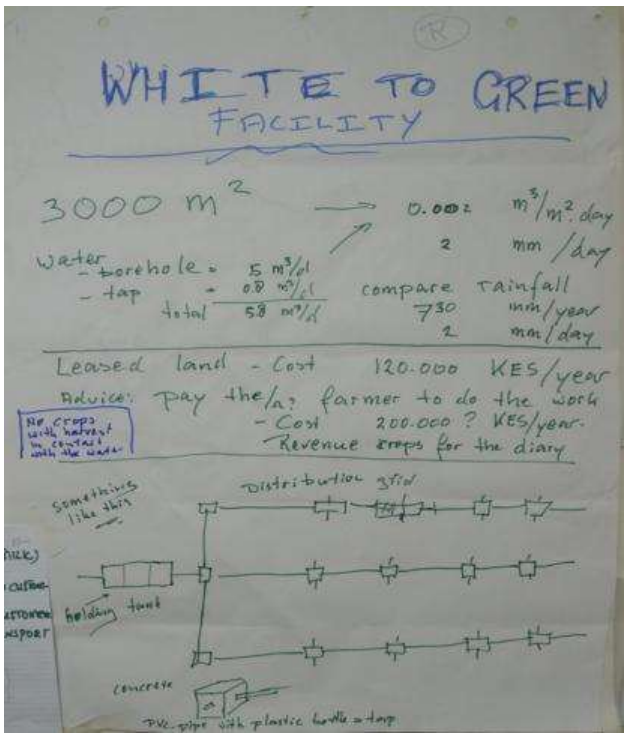


*Figure 3: Sketch design of the Ndumberi White2Green garden*

The assumptions for the predesign were as follows.

- The total flow will be not more than 6 $m^3$/day (borehole water use is 5 m3/day, drinking water 0.8 $m^3$/day). This means a load of around 0.2 m3/1000 $m^3$.dag, or a layer of 2 - mm/day. That is equal to the average rainfall in Ndumberi (730 mm/year, or 2 mm/day).
- The cost of land lease is around 15,000 KES/month, or 180,000 KES/year. It could be wise to hire the farmer to do the work on the plot. Cost could be around the same amount, resulting in yearly cost of 360,000 KES/year (around 3000 Euro per year).
- Problem is that the farmer only wants to do a 5 year lease. He is willing to sell for 20 MKES, around 170,000 Euro. A not reasonable amount.


*Photo's 8 and 9: First experiences White2Green*
*photo's taken by Francis Mihiu, Ndumberi Dairy, 19-10-2018*

It was great to see direct results of the project!

A warning is needed:

- It is receiving the  full, though already slightly reduced, load of 'waste water of the dairy';
- ***<u>The soap water needs to be treated separately, as it will overload the White2Green garden</u>***
- The water can contain pretty high levels of Coli bacteria;

*-> please analyse Coli bacteria, test the grown crops! If above standards do not let it go into the market*

- For the time being be careful with  careful with growing food, like cabbage and spinach in direct contact with the dairy water;
- Please follow up the advice to try to hire the farmer involved to have more influence on the crops to grow.

Above all, the White2Green garden needs to be designed in a proper way. It is not just a garden but an 'ecotechnological machine', it is a part of the dairy.

White2Green

*The concept is combination of old fashioned circular working compared with a no waste approach:*

- *Milk can not be a waste*
- *Milk can be wasted*

*White2Green is two parts:*

- *Prevent waste of milk by leaking out milk form the churns, pipe lines and equipment, store and reuse. Try to keep the waste water as clean as possible. Identify the most dirty flows, like soap water from first rinsing and treat separately;*
- *Then the resulting flow of water is not a waste anymore but can used in the White2Green garden.*

## 3. Recommendations on follow-up

A recommendation directly followed was installing a water meter for the borehole water.

Before the final discussions on 13th of September 2018 I had asked Francis Mihiu to come with short term solutions for the dairy, he came with:

- *Decongest the yoghurt production section to create more space by relocating the idle or broken machineries;*
- *Repaint the outer walls , production section and yoghurt shop;*
- *Design and establish a milk leak out area to save milk and also minimize the milk content in waste water (do not forget the grease trap in the waste water line);*
- *Labelling the flex pipes to specific product to avoid contamination;*
- *Develop a flow chart diagram on the process and procedures to be done on the production of both yoghurt and pasteurized milk. (During milk processing and cleaning);*
- *Always monitor the daily water usage as a cost cutting measure and avoid overburdening the White2Green garden;*
- *Analyse health related parameters in the White2Green garden (pathogens);*
- *Computer training for the process operators (both the milk line and the yoghurt making) and the Extension officer (agricultural information and education): Excell and PowerPoint skills*

A list of ideas for a the follow up are as follows:

- Organisation and quality control aimed on discussed above;
- Streamline the churn washing: move the store, and make a new and better washing place. Keep the churns and cans apart;
- Design of separate treatment the soapy / milky water from cleaning and Rinse 1;
- How to manage White2Green garden including how best we can treat the water?;
- Choice of the agriculture /plants to be established;
- How to make it attractive/training garden to other dairies or stakeholders with similar challenges;
- Long term solution on reuse of water to support one of the big four agenda( National govt) on food security.

## *Breaking emulsion of milk in churns, cans and tanks by breaking the milk emulsion*

After many activities in the dairy a thin layer of milk left on churns, tanks, also after leaking out. This milk emulsion is not easy to remove, therefore the cleaning is done by rather aggressive soaps. The use of soap and the amount of milk left overs could be reduced when it would be possible to break the milk emulsion with an organic degradable agent.

According to a simple recipe enzymes from pineapple juice (made from wastes) plus lime could be useable: www.scientificamerican.com/article/a-milk-curdling-activity/.

The destabilisation of the emulsions caused by the enzyme bromelain. Bromelain is an enzyme extract derived from the stems of pineapples, although it exists in all parts of the fresh plant and fruit (en.wikipedia.org/wiki/Bromelain) . 'The extract has a history of folk medicine use. As a culinary ingredient, it may be used as a meat tenderizer. The term "bromelain" may refer to either of two protease enzymes extracted from the plants of the family Bromeliaceae, or it may refer to a combination of those enzymes along with other compounds produced in an extract'.

A group of students from Windesheim University in Zwolle, The Netherlands followed the recipe:

**White2Green**
*Project presentation*
*9 January 2020*

*Ulis Talacua*
*Bjorn Dijkveld Stol*
*Tim van de Wetering*


This test of proof showed at least that the idea is worth to try. At least, there was less milk sticking to the glass. It could be a good use of pineapple wastes.

## 4. Over one year of experience of White2Green

In over one year a lot of progress has been made, a lot happened, this chapter gives a short overview. Firstly, instead building a new factory on an other spot it has been decided to extend the dairy on the existing spot, to make place, offices and stores will relocated.

In the meantime the White2Green has been operating for a year. The White2Green garden appears to be successful!!! See Photo's 10 through *13.*

*Photo's 10, 11, 12 and 13: The garden of the White2Green, situation September 2019, a year after the start*

The inflow to the garden

The not-yet optimized inflow

The banana are doing well

The health aspects are not fully clear yet, see the text

Initially the flow to the White2Green garden has been interrupted and bypassed during heavy rains. It seems that this is not a good solution, as the flow is relative low compared to rainfall: the specific load is around 2 mm per day, much lower than the 20 – 100 mm of rain in the wet seasons.

The over one year operation showed that the White2Green approach, including the process integrated saving methods in the dairy are promising, there was a good learning curve, a lot of work has to be done though.

## 5. Project plan, in short, and to be discussed

The activities can be divided in two Chapters:

- Change the dairy from *Linear operation* to a *Circular operation*, and recover products and minimise wastes my better organising (incl. quality control), working more neatly and spill less and separate and treat and use flows separately.
    - - short term;
    - - long(er) term.
- Develop the "White2Green garden" to a way of combined gardening and aquaculture. The Ndumberi Cooperative Dairy can function as a demonstration and show case. We propose to base this and do this in close cooperation with the Mtopanga Training and Demonstration Farm, Baobab Trust in Mombasa. I do have very good experience with dr. Haller during my projects in the Shimo la Tewa prison and the Borstal Institute. Their farmers education plans are outstanding.

## *Finally, comments from the Ndumberi Dairy Farmers Cooperative Society, Ndumberi, Kenya Francis Mihiu from Kenya:*

*Firstly, I will thank Mr. Ruud for the support so far we have achieve with the project of White2Green. Initially before the projects we were in logger head with the Ministry of health , NEMA and also community at large over the disposal of the waste water.*

*The technology learnt from Mr. Ruud was how to reduce and reuse the water from the factory to support the environment in production of more green vegetation. As we know Kenya is among the countries with shortage of water in most part of the countries and the little we have should be used and reused without waste.*

*With the concept and additional land from the neighbours after the demonstration of the White2Green, it have attracted many other people even without leasing their land. The challenge we have is the amount out water that we can discharge bearing in mind the cost of the water bills vis a vis the benefit. Our theory is to reduce the water and only use reasonable water for the facilities and reuse the water to other purposes.*

*In collaboration with other players the White2Green garden can be fully completed by first, treatment of the water to ensure it is safe for the flora and also recycling the same water to other uses within the factory. It can also be a game changer to majority of the factories in Kenya and other developing countries as a better home grown solution, also a learning centre for academic .*

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*Stowa 2013_08:* Waterharmonicas in the Netherlands (1996-2012). Natural constructed wetlands between well-treated waste water and usable surface water


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