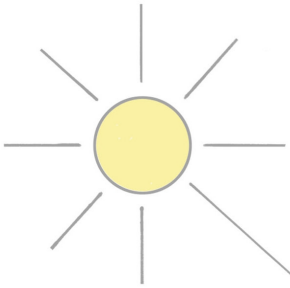
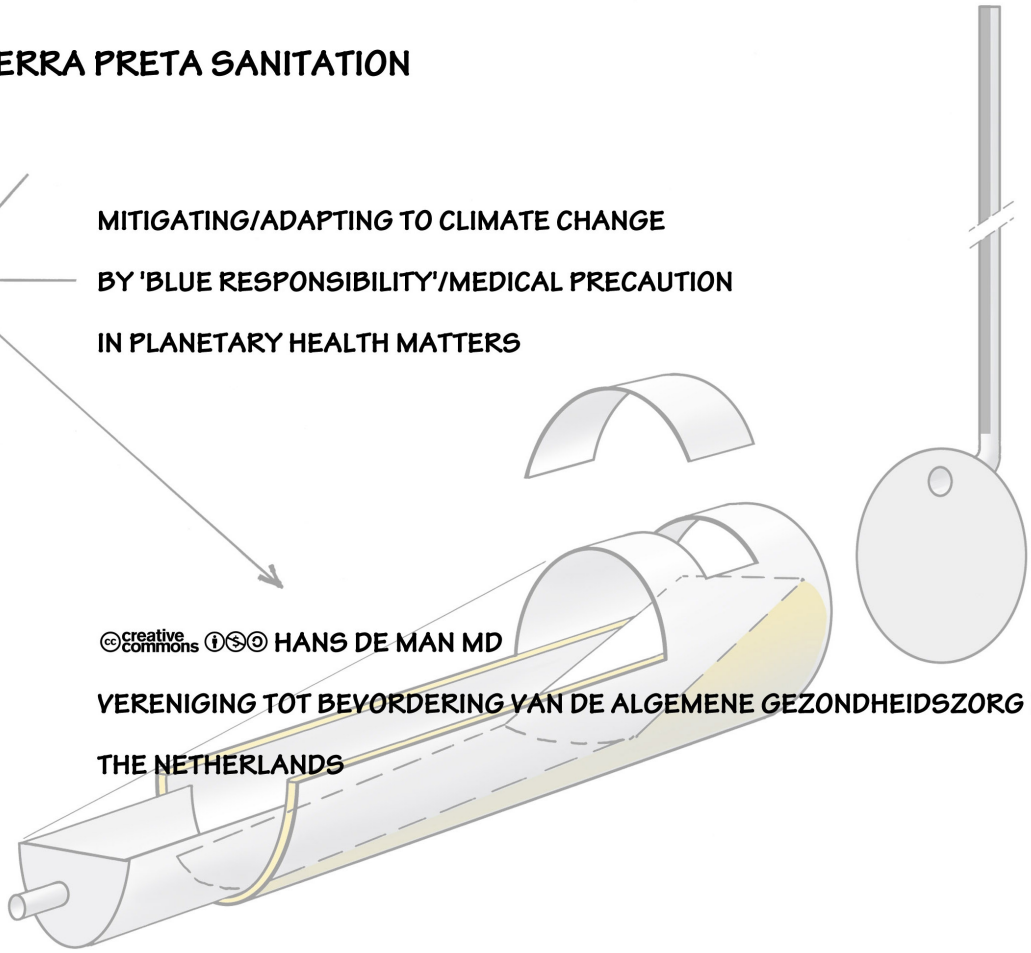
30 YEARS TERRA PRETA SANITATION



MITIGATING/ADAPTING TO CLIMATE CHANGE

BY 'BLUE RESPONSIBILITY'/MEDICAL PRECAUTION

IN PLANETARY HEALTH MATTERS



 HANS DE MAN MD

VERENIGING TOT BEVORDERING VAN DE ALGEMENE GEZONDHEIDSZORG DR. J. PENN

THE NETHERLANDS

Abstract

Mitigating/adapting to Climate Change by medical precaution/'blue responsibility' in Planetary Health Matters, that was the aim in '30 years Terra Preta sanitation'.

The start was in 1984, without biochar, but with all the other components present, closed loop on 500 m2 Earth (Self Playing Presentation, SPP 1). Sanitation was a combination of a composting toilet (Clivus Multrum with an upstairs and a downstairs stool plus a kitchen-organic chute) and a graywater-treatment (with a sieve, an aerobic-filter, a trickling-filter and a pond). Both were integrated in a sewer-less, rainwater-harvesting, low-carbon, passive-solar house with a system of balanced ventilation and heat-recovery, bypass inclusive.

From 1984-2006 simple R&D made the 'Clivus' step by step drier (SPP 2):
upstairs stool and kitchen-organic chute got closed; upstairs stool changed in an urine flush-toilet that flushed in the graywater-/rainwater-system; chute changed in a natural lure light for flies and organic ended in an earthworm box in the backyard; the downstairs stool got urine diverting (SPP 3); urine was collected down under in the 'Clivus' and added to the rainwater-system; the upstairs toilet chute became an air-outlet vent-pipe.

Two experimental models resulted in: 'separating all', so only 'faeces drying', based on the the physical principle of diffusion by thermal draught (ΔP), 'linear in time', a condition for minimizing health risks,'low/non carbon', and improving acceptance conditions with regard to odor and flies, and also to, ergonomic, economic and social-cultural aspects.

In the downstairs stool chute was constructed a cylindrical, gauzy, rotatable rack (SPP 4). Falling faeces became fragmented and spread. This surface enlargement formed also a drying condition. Temperatures fluctuated around 13º C and ΔP could (only indication) run up to about 34,6 Pa. Hand-dry-hard faeces, used as a pragmatic health-criterion, were produced in roughly estimated 4-6 month's. In a separate tube urine flew down under in the 'Clivus'. On the whole range improved acceptance conditions through the change from composting to drying.

A third experimental model (SPP 5), based on this drying/hygienic principle, became a Solar Drying Dry Toilet (SDDT), so 'non carbon'. It is a piece of sewer with a hole in the head and a half open tail. In the interior is at the sun-side an aluminum layer and at the shadow-side insulation. At the outside the SDDT is double enveloped in UV resistant folio. A solar vent-pipe with netting is based on the same sun-shadow principle. Out of use the SDDT stands in a slope towards the sun, to facilitate thermal draught. In use the SDDT is taken moving about in one's hands, put on the floor only to defaecate, so urinating happens separate, while sitting cross on the head (the solar vent-pipe is loose), and rolling slowly on the floor (paper separate) to spread falling faeces. Faeces are removed, manual contact can be avoided, in a bucket out of the tail: no pit.

Simple R&D was done inside and outside a greenhouse (SPP 6, SPP 7).Temperatures were manumonitored in tail and head. At the start of the day there were no differences. During the day they could run up to 20º C in winter and 40º C in summer, ΔP is then (only indication) about 5,19 Pa. Faeces got hand-dry-hard in 1 week-3 month's. No pit problems, so no foul odor, and no flies inside, only at the netting. And tomatoes grew on own dried faeces and were watered with nutrient-rich pond-water. This drying-principle might work all over the world with more capacity in summer and closer to the equator, and less in winter and further away. Ergonomic acceptance-conditions were based on self evident movements (co-benefits health). Economic were material costs at most 100 Euro. And social-cultural privacy/safety was important in a new idea outside privy (SPP 9). Use perspectives there are at adapting to Climate Change e.g. in floods with massive evacuations -no pit, works immediately- and at tackling open defaecation.

Fertility of the ground appears from growing and greening, tomatoes, vegetable garden etc, and overall greening, also a sign of CO2-capturing in mitigating Climate Change. A close up from South gives SPP 8: blue economy based local value, that co-benefits health. An impression from Space gives SPP 9: open loops in the street and one closed.

Business is first of all interdisciplinary. If '30 years Terra Preta sanitation' is awarded, the award is for SDDT's to verify R&D results and further R&D.

Introduction.

In 1984 -so 30 years ago- this Terra Preta sanitation started. Place of action, a sewer-less, low-carbon, house in a small street just near the town's centre. The house was designed 'integral', especially passive solar with balanced ventilation and heat recovery, one of the first of this kind in the Netherlands [17].

Terra Preta practice was, it is true, without biochar, but with all the other components present. For as a consequence of sewer-less came all urine and faeces (2-5 persons) and also all kitchen and garden biomass/organic, just as all rainwater, on 500 m2 earth surface, during indeed only 30 years and not thousands as in the Amazon region. But you have to start somewhere I hope?

Sanitation was practised with a combination of a composting toilet (Clivus Multrum) and a graywater-treatment. The 'Clivus' appeared not be the solution and became the driver to a Drier Toilet with consequences for graywater-treatment, biomass management and rainwater harvesting.

It is good to realise that this was a MD's initiative and that precaution is the cornerstone of professional medicine. If there is doubt, don't cure: in dubio abstine. And, don't do any harm: nihil nocere.

This professional doubt-precaution attitude was an important factor. Above all, doubt about Planetary Health Matters [17] by Climate Change and precaution by powerful CO2-reduction. And linked, doubt about open loop sanitation and precaution by closing, hygienic principles as a condtio sine qua non. The simple R&D approach was as well technical as behavioural, looking for a new healthy/sanitary/hygienic balance in between. Or, 'Blue Responsibility', in the motto of the award.

The MD-approach was intra- and interdisciplinary, so inter-sectoral, and appeared to be a big problem.

Intra-disciplinary was published in the Dutch Journal of Public Health referring to The Lancet e.g. [8,9,10,16] with at last a thunder-preachment 'Sustainable Development ante- and post-Rio+20' [19]. Part of the conclusion:
“(This) practice of green technology together with status quo changing behaviour, resulting in energy- and water-neutral housing, dry sanitation inclusive, stands alone. Wide gaps between Public Health (PH) science, policy and practice so result in weakening PH as a matter of general interest. That then suffers from dominant economic part-interests. Leading should become The Lancet's CO2-reduction strategies to strengthen WHO as a supporting partner of UNEP".

Inter-disciplinary ended (2009) with '25 years drier toilet' [Appendix].
Keywords:
faeces drying, linear in time, low/non-carbon, separate all, pathogen-absence
Conclusion:
“In the interior of the 'Clivus' ‘small but tangible and sustainable steps towards better sanitation were taken’. ‘Drier’ evolved to primarily ‘separating all’ respectively, kitchen-organic, urine and faeces, and toilet paper, and to ‘faeces drying’ by maximised ‘low carbon’ ventilation. Result up to the present, hand-dry-hard faeces –as maximum as possible ‘pathogen-absence chance- in roughly estimated 4-6 month’s. Connected with this indoor development were three experimental models built and tested. The last outdoor model (2008) functioned not only completely passive-solar heated and ventilated, so ‘non carbon’, but also ‘linear in time’ and produced up to the present hand-dry-hard faeces in roughly estimated 1 week- 4 month’s”.

There was urged “on verifying these results and on further R&D of this dry sanitation casuistry in the framework of a ‘new public health advocacy movement’ focused on: “Climate change is the biggest global health threat of the 21st century” [9].

First, this Dry Toilet (DT) history is picked up, references inclusive [Appendix]. It is a real 'closed loop' and 'reinventing the toilet' story, illustrated by the Self-Playing Presentation (SPP), also in the summary.

Next, the last model, a Solar Drying Dry Toilet (SDDT), is picked out for technical

description and discussion in great detail referring to the SPP.

All this forms the base for an unconventional business model.

1. Technical description

1.1. Technical history whole system (SPP 1, 2, 3, 4)

Properly speaking, history was repeating itself. For the house was built on the top of the 'Clivus' just comparable with the Middens in England before the flushing Era. The 'Clivus' (with an upstairs and a downstairs stool plus a kitchen-organic chute) and the graywater-treatment (with a sieve, an aerobic-filter, a trickling- filter and a pond) were state of the art integrated in a system of active balanced ventilation with heat recovery, bypass inclusive, and passive ventilation by thermal draught (Scheme SPP 1).

For environment superior, for agriculture interesting, was the outcome of on site research under the authority of the Dutch Ministry of Environment [8]. Of course, the loop was closed again. But, economically of no interest, came also out. That was an error. For high close-loop-investments are in R&D perspective quite normal, but in market perspective indeed not of interest. Acceptance, the same story, e.g. for the system management, normal in an R&D perspective, but not acceptable in a daily life context..

The main difficulty however formed hygienic principles, ‘because the latrines continuous process involves hazards from insufficiently composted pathogens’ [4]. This can also be concluded from one diagram for all microbiology including a safety zone [4, p.79]. The diagram also learns that maximized chances on PA absence/minimizing/health risks, are time- and temperature-dependent. In fact that meant a deep conflict between on the one hand managing well known interrelated factors that contribute to the die-off of potential pathogens as there are: nutrient scarcity, dryness, solar radiation, predation, aeration, and above all, time-linearity and temperature [4] and on the other hand managing composting factors, such as: C/N ratio, Ph and humidity [2,3]. In essence a conflict between wet and dry, between composting and drying.

'Maximized chances on pathogen absence' turned the scale. Stepwise (1984-2006) a developmental change took place in the interior of the 'Clivus' from creating better composting to better drying conditions (Scheme SPP 2):

. Upstairs stool and kitchen-organic chute got closed (drier, less urine and no 80 % wet from organic);
. upstairs stool changed in urine toilet that flushed in graywater-/rainwater-system;
. upstairs stool chute changed in an air-outlet and kitchen-organic chute in a light-lure fly-trap;
. kitchen-organic ended in an earthworm-box in the backyard;
. downstairs stool got urine-diverting (SPP 3);
. 'Clivus' became Drying Dry Toilet with rotatable gauzy rack (SPP 4);
. toilet paper, primarily separated;
. urine was collected down under in the 'Clivus' and mixed afterward with harvested rainwater;
. aerobic-filter changed in aerobic-gut;
. trickling filter changed in rainwater-storage for domestic purposes;
. pond got a 4 times greater capacity for storage (treated graywater, urine from upstairs urine toilet and rainwater) and for overflow in margins.

In short, this meant after a 'good bye to the flush toilet' [2] a good bye to the composting toilet, with shifts in the closed loop: kitchen-organic in an earthworm box, producing nutrients to spread and interesting proteins. And urine in graywater- and rainwater-system, so with nutrients for growing and greening and for CO2-capturing. The toilet appeared in fact a Terra Preta director.

It got time for a new DT design [14]. First, two experimental models were built [appendix].

The first model was naturally 'primarily separating’ and 70-80 % smaller than the 'Clivus'. It conditioned a not interrupted –so no double vault or pit solutions necessary- strict ‘linear in time’

running ‘faeces-drying’ process, forward moved by self-evident body movements as sitting down and standing up and reinforced by passive solar qualities. The model was tested provisionally indoor, but offered not enough perspective.

A second model followed and the step was taken from in- to outdoor. In that played a role the need for DT's at disasters (DT Congress 2006), the need for low cost ‘smart sanitation solutions’ related to the UN MDG’s [11] and a Life Cycle Analysis of ‘electric drying’, flushing and ‘dry-collecting’ [15]. Derived conclusion: passive-solar and transportation avoidance are a ‘low-carbon’ must, so decentralized solutions form the perspective [15].

This model got a semi-vertical strict ‘linear in time’ running ‘faeces-drying’ process on a simple rack construction, was heated passive-solar and ventilated with also passive-solar generated thermal draught. Inside air-temperatures raised up to 60º C, in summer resulting in hand-dry-hard faeces. Eureka! But the process-length appeared to be much to short outside the summer season, there was faeces-fly ‘inconvenience’ (entry solar pipe). ‘Odor’ (drying faeces have an own temperature dependent odor) came through, not by way of the toilet-seat but through the solar-pipe.‘Privacy’ led to the design of a small open toilet-privy and ‘gender’ to an own sitting/standing choice for men and woman. Toilet and privy needed no double vault or pit solutions.

1.2. Drying DT principles (SPP 4, 5, 6,7,8)

These models resulted in two self-drying-principle prototypes, one in the remnants of the 'Clivus' and one extended to solar in a new experimental model. That last component is described in great detail.

The focus became as in the (DT 2009) keywords: 'separating all', so only faeces for 'faeces drying', 'linear in time', a condition for minimizing health risks/maximized chances for PA absence, low/non carbon, in the context of powerful CO2 reduction and on improving acceptance conditions with regard not only to odor and flies, but also to, ergonomic, economic and social-cultural aspects. As a matter of course the loop stayed closed.

The physical principle of drying hereby is, diffusion of faecal moisture in contact with dry air. It is generated by thermal draught expressed a.o. in a formula for chimneys. Thermal draught originates from a difference in air-densities between in- and out-side a chimney/pipe. This generates a difference in pressure (ΔP), that is the driving force of thermal draught. As long as this difference in air-density is maintained, the draught continues. (ΔP, expressed in Pa, is consequent temperature related and so at the same time conditioning 'linear in time' 'die-off of potential pathogens'.) The effectiveness of diffusion is favored by surface enlargement of faeces through spreading and/or fragmenting, so avoiding pit problems. Big question is of course, is this thermal draught formula suitable here. The simple answer is quantitatively no, to much difference with a chimney, but qualitatively yes, if the answer must be yes or no thermal draught. (An actualized formula would be good business, R&D necessary)

Principle 1. Drying Dry Toilet (SPP 4).

Based on the simple rack construction from this experimental model was built in 'Clivus’s' downstairs stool-chute a cylindrical, gauzy, rotatable rack, only for falling faeces, paper primarily separated. Temperatures fluctuated around 13º C and high up to about 20º C. So ΔP could run up to 34,6 Pa, or yes, there was thermal draught. Falling faeces became fragmented and spread, instead of pit-like heaped up (SPP 4). Faeces became 'hand-dry-hard' in 4-6 month's, stored and after that used for turning into fertile ground in a small vegetable garden. Hand-dry-hard was used as an initial pragmatic criterion (R&D necessary) for 'minimizing/health risks/maximized chances on PA absence'.

Acceptance conditions improved in this change from composting to drying over the whole range. But there were also exceptions, a serious gender aspect offers urinating. Men want to stand, but are forced to sit at urine-diverting. Woman do not want to stand, for 'the Lady P', designed by a woman for woman [18] became a fiasco. Yet was the upstairs toilet only for urinating as 'Lady P' well accepted. Besides, these Drying Principles necessitate defaecating and and urinating separated.

That will not be a behavioral problem for men, but it may be for woman. Yet a tangible step forward might be implementing the following Drying Principle 2. Temperatures, ΔP, and so a wide range of acceptance conditions can possible improve. Also a good bye to urine-diverting and a welcome to strict separated defaecating and urinating? R&D naturally again, very necessary.

Principle 2. Solar Drying Dry Toilet in cm's (SDDT). Component in great detail (SPP 5, 6,7,8,)
It seems to be like a joke, for the base is a piece of sewer (SPP 5). Pragma PP double wall, Length 130, diameter 40. The head is the toilet seat with a 20-50 hole. The tail is halved lengthwise 90-40 for light-/solar-entry. The head is closed with a belonging cover, diameter 40, that fits airtight on the sewer. In the cover is fitted a PP-connection pipe diameter 12 for a solar vent-pipe.

The interior construction principle knows a shadow- and a sun-side. At the shadow-side is thermal isolation. At the sun-side lays on the top of the isolation an thin aluminum plate. In the head the plate is flat and steep in order to spread faeces (sitting, slow rolling, enlarging faeces-surface for better drying). In the tail the plate is curved along the inner side of the the sewer to conduct faeces ('linear in time'). In the tail is in the same way curved an aluminum bucket for collecting dried faeces with a hole for the vent-pipe entrance diameter 12 (manual contact can be avoided).

The exterior is double enveloped, so again isolated, in UV resistant plastic folio, easy fixed at the head around the sewer on the edges (so 2x) and at the tail (1x) around the entry vent-pipe. At the tail the envelop is easy removable for emptying the bucket.

On the exterior can be put on the hole an also double UV-plastic layered flap 60/30, formed with a filled (old) inner cycle tube, that closes off the toilet seat airtight. The entry vent-pipe and the vent-outlet of the solar vent-pipe are closed off with a netting for fly prevention. The black painted solar vent-pipe is based on the same isolation principle. There are two types, a flexible and a rigid PP-one.

Empty weight is 6 kg and full weight about 10-15 kg.

The toilet was continuously used by one person as follows.

Not in use, the toilet is put Southwards in a slope to facilitate thermal draught for drying by light/solar (SPP 6).

Using happens on place. In the turn of a hand is removed the end of the flexible solar pipe, that remains hanging. With a small assist the flap is shifted gliding to the tail, the hole is now open. The head is lifted, tail stays on the floor, and moved about into one's hands, faeces can roll/side downwards. The toilet is then put horizontal on the floor by lifting and shifting with one hand. Sitting goes cross on the head, left handed contra right handed, because of anal cleaning ergonomics. Defaecating -only, so urinating separate- asks dynamic sitting through slowly rolling in order to spread (surface enlargement) and defaecate (seems better than static sitting or squatting). Rolling to the front gives more space for anal cleansing, also dry, so with paper or something like that, paper separate and hand washing afterward. Ready, flap back on place, toilet back in a slope and solar vent-pipe fixed again. Dried faeces are removed once in 2-3 weeks in the bucket (fixation tail removed)out of the tail, while the toilet lays on the floor, and put in the storage container (full in about 2 month's). The tomatoes are grown on these fertile dried faeces and watered with urine enriched rainwater/treated graywater out of pond/rain-tun.

The toilet can in principle be born or drawn on small wheels, just like a handbag. Born outside the green-house, it is first placed in a slope in the sun (SPP 7). The rigid solar vent-pipe is put on the head in the turn of a hand. Tomatoes and courgettes are also grown on faeces dried in this SDDT.

In short, SPP 6 and SPP 7 form a close up of a functioning SDDT with paper and dried faeces storage (right) and tomatoes growing on fertile ground (left). No flies. no foul odor and basic for transportation and recycling. Paper goes in the existing recycling system. If not self-used, faeces can be added in a comparable system, so transportation can be minimized and material losses prevented. And it all means: no pit to dig. That is of big importance in adaptation to possible Climate Change disasters, such as floods with massive evacuations. SDDT's can be put directly on

place and work immediately.

The fysical principle of drying, generated by diffusion/thermal draught was manumonitored by min/max temperatures of the two visible thermometers (SPP 6,7). Min/max temperatures were during the year most daily measured in the SDDT with sensor's on two heights, at the inlet and in the head, mainly inside the greenhouse.

Min/max temperatures showed during the year, between the tail-inlet and the head at the start of the day no real difference. That indicates hardly thermal draught, which is explicable after a dark night. ΔP is than neglect-able. Well significant differences there were during the day. They could on a sunny day run up to 20º C in winter and 40º C in summer, ΔP is then about 5,19 Pa. That only indicates: there was draught. Faeces got rough estimated hand-dry-hard in 1 week-3 months. That is inside the green-house one month shorter then reported outside [Appendix]. The explication is, that mean temperatures inside the green-house are mean 5º C higher than outside. But in full summer outside mean temperatures are in favor, so drying hand-dry-hard can occur in about one week. Also it explicates the difference between the drying effect of principle 1 and 2, temperatures in the sun are as a matter of course higher.

This makes also clear that capacity varies during the year. Inside the green-house and in summer capacity is higher. But in deep winter capacity is lower and faeces become then not hand-dry-hard, even hardly hand-dry. An additional storage based on the same drying and rack principle was therefore tried out this winter outside. But, look at a SDDT as a storage facility and take another one, is also an option. Capacity varies as a matter of fact also with individual use or shared use. And the conclusion may be drawn, that capacity the nearer to the equator will be higher. In short, all this creates flexible use-perspectives all over the world. And again, it does need further R&D e.g. concerning hand-dry-hard or hand-dry as a pragmatic health-criterion..

Acceptance conditions appeared to be as follows:

1. Odor should, to avoid overall negative associations, be distinguished in foul odor, usually a result of low oxygen or anaerobic conditions as they exist in gut and especially in pit, and in odor of aerobic conditions. Anaerobic odors include a wide range of compounds, for example the reduced sulfur compounds, volatile fatty acids, aromatic compounds, and amines. Aerobic odors of dried faeces as amber, are described as perfume odors associated with the taste of kings and emperors: the brown gold [20].

Inside the greenhouse there was no foul but such a 'perfume' odor of own dried faeces in the container and for growing tomatoes. Opening the flap for defaecating gave also no real foul odor explicable by thermal draught. Only farts/winds are in the gut an anaerobic must, and the only answer to their odor is ventilation. Outside the greenhouse there was also no perceptible foul odor. Well perceptible seems odor to be for flies at higher temperatures, so at more draught. For they appeared then at the netting of the solar vent-pipe.

For the rest, flies are not only a negative acceptance factor but also a negative health risk-factor in minimizing health-risks, for they can carry along potential pathogens at their feet. So flies at the top netting, and no flies inside the SDDT mean an important acceptance and also a health co-benefiting condition.

The explication is simple: no anaerobic conditions because of a pit.

2. Ergonomic acceptance can be distinguished in acceptance of SDDT management and acceptance of SDDT use.

SDDT management showed, although R&D, an enormous improvement compared with the management of the 'Clivus' and so it reaches acceptability in a daily life context.

From the description can be gathered that ergonomics are comfortable and not at all new slavery labor, in management with the turn of a hand, in dynamic sitting, at anal cleansing, emptying the bucket, etc. But, anal cleansing can not with water and paper-separating asks attention

and a new action. Further, they are self evident movements, somewhat comparable with the physical activity of cycling and hang out of the washing. That self-evident physical activity is important in the framework of public health. Non Communicable Diseases form a major burden of disease because of a lack on attractive physical activity. So SDDT-handling may be co-benefiting public health. And, do these local activities not create also local value?

3. Economic acceptance stands or falls with the costs.

Pragma PP is supplied in length's of 6 m. A length of 6 m costs nearly 180 Euro. There can be taken out 6 pieces with a length of 170, so some more capacity, for 6 SDDT's. That means that the economic base for one SDDT is 30 Euro. Taken into account the cost of materials, 100 Euro is a broad estimation of the costs. (Additional costs or benefits to be calculated in relation to capacity varying are let out of consideration.)

Last but not least, social economic differences in public health are a well known health-factor. This cheap working-tool attributes to reduce those differences and co-benefits in this way indirectly public health. And, does this also not mean local economic value creation?

4.Social-cultural acceptance knows not only as already mentioned important gender- but also privacy-aspects.

Privacy was an acceptance priority. Not for nothing the word privy expresses privacy and a water closet, expresses 'door closed', so safety. In a R&D situation is privacy and safety of course easy to realize. An open-toilet-privy is an idea for privacy outside (SPP 8). It is built from reinforced gulf-plates and easy to install, but offers only privacy, the garden provides in safety. (The SDDT is not drying -no solar vent-pipe- but fictively in use, tail extends from the new idea privy.)

A positive acceptance-factor appeared to be, that removing the airtight toilet-sitting-flap offered less drying faeces odor, because of the steady air-outlet by thermal draught. Acceptance progress by external design is in this R&D stage self-evident premature.

The major problem of open defaecation means a complete lack on privacy and safety, especially for woman. In the UN post-MDG's that will be an issue. A SDDT offers therefore so an additional perspective.

In short, all this may contribute in potential to local social-cultural value creation.

1.3. Manufacturing process.

The manufacturing of the SDDT can be done as what it means, making by hands. And in the course of time adaptations were naturally also in this way manufactured. If now an estimation should be done of the DIY manufacturing-time, it is only a couple of hours. That can be local manufacturing, yes DIY, and if no, by a local manufacturer. Another time, potential local value creation.

And manufacturing with local available materials remains an R&D question.

1.4. Terra Preta result (SPP 8, 9)

What is in those 30 years the Terra Preta result (without biochar) on that 500 m2 Earth, that is now at the end a concluding question. Growing and greening form therefore an indication in relation to ground fertility and CO2-capturing, so at mitigating Climate Change. Naturally it can not be quantified, only qualified, and that alone by a picture impression.

The first impression is on Earth from South (SPP 8 taken 29-06). It is a concluding close up from growing (tomatoes, etc.) and greening (abundant aquatic flora of the hidden pond and aerobic gut with marsh spiraea (in flower),yellow lis and cat's tale and in the overflow of the pond grape and elder. Cascading nutrients are pressed up by osmotic pressure to capture with solar-driven photosynthesis CO2 for new organic, etc., specifying blue economy characters. So together with the SDDT all this may form a close up of a blue economy that co-benefits health and creates extra local value.

The second impression of this closed loop result comes from Space www.google.maps.com (SPP 9). If scrolled from Space to the Netherlands, all towns and villages are open looped, sewer

connected, as Heiloo does with an own purification plant. But there is one big exception, Rechte Hondsbosschelaan 8: loop closed. The impression of growing and greening gives so an impression of loop open versus loop closed in the street.

2. Business Model

2.1. Description

Intra- and interdisciplinarity formed the passed years as mentioned a big problem in this Terra Preta story. But there is hope.

Intradisciplinary The Lancet is playing in the meanwhile a leading role [9,16] and has recently set to work a Commission on Planetary Health [17].

Interdisciplinary there is a lot of activity. The first international Terra Preta conference in Hamburg is a nice example. And the award-organizing committee is coming also to business. For, is stimulating 'collaboration between the participants' not just interdisciplinary business creation? We as participants can now know one another's competition-titles, websites and email-addresses, so we can inform us, even-more interdisciplinarity? And then there was Gabrielle Mainguy (implementation of innovative Terra Preta facilities in a new city quarter) who asked us as participants 31-5 by email a 'kleinen Tipp' for a Business Model instead 'von einem CANVAS Vorlage'. 'Wir sind keine Wirtschaftsingenieure' she apologized. Also interdisciplinarity from the side of a neglected sector, the art-sector?

Consequently this is in fact the underlying interdisciplinary Business Model.

In science, or here in adapted science, first results must be verified. Now, there are more results available to verify and many questions for further R&D than in 2009.

So Isabella Mainguy's 'Wirtschaftsingenieure' should wait with 'einem CANVAS Vorlage' for a while. That does not mean that there cannot be preparation. For the perspective is, that there might be business to do with something that costs, all in, at most 100 Euro with a base of 30 Euro. (Likewise external design should wait on the right moment.)

But also for interdisciplinary business, there is no time to waste. For the planet-situation is critical and asks for action.

Therefore is in this underlying interdisciplinary Business Model the pragmatic proposal: if '30 years Terra Preta sanitation' is awarded, the award is for manufacturing SDDT's, to verify R&D results and do further R&D towards a Sustainable Terra Preta Sanitation System, aiming at mitigating/adapting to Climate Change.

2.2. Sustainability and local value creation

The references form a review of all the actors that played a part. Special attention deserves [18]. For the 'integral' designed house became in the course of time in fact energy-and water-neutral and got so a kind of zero emission laboratory, on the background of the professorship 'Environmental Technical Design' at Delft Technical Universty. All this may mean sustainability at mitigating/adapting to Climate Change.

Potential local value creation can be concluded from pictures and description. Growing and greening from SPP 6 t/m 9 and description of acceptance conditions regarding a/o ergonomic, economic, and social-cultural aspects, that also co-benefit health.

3. Addional questions

3.1. Implemented, conceptual or prototype

Clear may be that parts, especially from the graywater-treatment, were or became small-scale and upscaled implemented solutions. The drying principles are, maybe needless to say, not conceptual, not implemented, but physical prototypes and were for the first time reported at the DT 2009

congress [Appendix].

3.2. Existing solutions and specific enhancement

Consequently, as far as this contribution is built up on already existing solutions, description and references refer to everybody who played a part in this development. Specific own enhancement form publications [1,6,8,10,14,19] and Drying Principles.

3.3. Type CC Licence

The type Creative Common License of choice is, as shown on the Title page: attribution, non commercial, share alike or CC-BY-NC-SA.

References.

1. Man de, JCJ. Where is build the real (autonomous) house of the future, in Rosmalen, Castricum or Heiloo? Lecture, study-day autonomous systems. Study-group City design and environment Technical University Delft and International Solar Energy Society. Castricum 1989 (in Dutch);
2. Hupping Stoner, C. Goodbye to the Flush Toilet. Water-saving Alternatives to Cesspools, Septic tanks and sewers. Rodale Press, Inc. 1977;
3. Lorenz- Ladener, C. Composting Toilets. Ways to useful faeces-decare. Okobuch Verlag Staufen bei Freiburg 1992. (in German);
4. Feachem, RG et al. Sanitation and Disease. Health Aspects of Excreta and Wastewatermanagement. World Bank Studies in Water Supply and Sanitation 3 John Wiley & Sons 1983;
5. Waste (red.). At the end of pipe? Insights, visions and ideas on a shift in the sanitation paradigm, formulated during expert meetings held in the Netherlands January- March 2005. Waste 2005;
6. Man de, JCJ. Combination greywater-treatment composting toilet superior for environment. H2O (22)1989:18, p.558-61. (in Dutch);
7. Dutch National Polder Board. Nieuwe Sanitatie. Website www.stowa.nl (in Dutch);
8. Man de, JCJ. Sustainable development and the meaning for environment, health and health services. Dutch Journal for health sciences TSG 1996;74:357-61 (in Dutch);
9. The Lancet and University College London Institute for Global Health Commission. Managing the health effects of climate change. www.thelancet.com Vol 373 May 16, 2009;
10. Man de, JCJ. Hygienic revival: vision or fiction? Dutch Journal for health sciences TSG 1998;76:105-7;
11. Waste (red.). Smart Sanitation Solutions. Examples of innovative, low cost technologies for toilets, collection, transportation, treatment and use of sanitation products. Netherlands Water Partnership 2006;
12 Rautanen, SL and Viskari SL. In search of drivers for dry sanitation. Land Use and Water Resources Research 6 (2006), p.41-49;
13 Loth, M. Lady P. Finishing study-report Technical University Delft Sub faculty Industrial Design in cooperation with Royal Sfinx Gustavsberg 1988 (in Dutch);
14 Man de, JCJ. Dry Toilet. Project plan for an E(cological) E(conomical) T(echnological) invention project. Vereniging Penn 2003 (in Dutch);
15 Bruin de, B. Environmental load of three alternative sanitation-possibilities compared with the flush toilet. Waste July 2006. (in Dutch);
16 Editorial Lancet. Keeping sanitation in the international spotlight. Lancet (371) 2008: March 29, p.1045;
17 Horton, R et al. From Public Health to Planetary Health: a manifesto. Lancet (383) 2014: March p.847
18 Kristinsson, JJ. Integrated Sustainable Design. 2012 ISBN 978-90-5269-407-8 2012;
19 Man de, JCJ. Sustainable Development ante and post Rio+20. Dutch Journal of Public Health

2012;90:210-12
20 Dekkers, M. Relieve nature (abbrev., still in Dutch) ISBN 978 90 450 2648 0.
www.atlascontact,nl

Appendix.

Penn Vereniging tot bevordering van de Algemene Gezondheidszorg Dr. J. Penn advocates a new Public Health in the perspective of Sustainability. Secretaryship Rechte Hondsbosschelaan 8, 1851 HM Heiloo, The Netherlands, Tel. ++31 72 5336693, e-mail hademan@hetnet.nl

Paper 3rd International Dry Toilet Conference August 2009 Tampere University of Technology Finland

Title: 25 years Drier Sanitation
Author: Hans de Man MD**,** secretary

Contact name: Hans de Man

Postal address: Rechte Hondsbosschelaan 8, 1851 HM Heiloo, The Netherlands
Telephone: ++31 72 5336693, E-mail: hademan@hetnet.nl

Abstract

'Drier Sanitation' is the best qualification for this Dry Toilet (DT) development. It started 1984 'in the real life context'. Place of action, a sewerless, 'low-carbon', solar house, just near the centre of a small town. 'Sewerless' contained a combination of a composting toilet (Clivus Multrum) and a graywater-treatment. In the interior of the Clivus 'small but tangible and sustainable steps towards better sanitation (DT 2006) were 'taken'. 'Drier' evolved to primarily 'separating all' respectively, garbage, urine and faeces, and toilet paper, and to 'faeces drying' by maximised 'low carbon' ventilation. Result up to the present, hand-dry-hard faeces –as maximum as possible 'pathogen-absence' chance- in roughly estimated 4-6 month's.

Connected with this indoor development were three experimental models build and tested. The last outdoor model (2008) functioned not only completely passive solar heated and ventilated, so 'non carbon', but also 'linear in time' and produced up to the present hand-dry-hard-faeces in roughly estimated 1 week- 4 month's.

Urged is on verifying these results and on further R&D of this dry sanitation casuistry in the framework of a 'new public health advocacy movement' focused on: "Climate change is the biggest global health threat of the 21st century".

Keywords: faeces drying, linear in time, low/non-carbon, pathogen-absence, separate all

Introduction

'Drier' is the best qualification for this Dry Sanitation (DS) focused Dry Toilet (DT) R&D. It started 1984 'in the real life context'. Place of action, a sewerless, low-carbon, solar house, just near the centre of a small town [1].

'Sewerless' contained a combination of a composting toilet (Clivus Multrum, representatives at DT 2003) and a greywater-treatment. The Clivus (with an upstairs and a downstairs stool plus a garbage chute) and the greywater-treatment (with a sieve, an aerobic filter, a trickling filter and a pond) were integrated in a system of balanced ventilation with heat recovery, one of the main characteristics of at present by the EU promoted passive-solar houses.

It was a 'good bye to the flush toilet' [2]. For in the retrospective of 'how we got where we

are' [2,3] and taken into account a for centuries broad felt irrationality [2,3,4,5] the perspective was then [2,3]: without flushing, but with separating 'grey' and 'black' and with composting 'black'. In fact this meant, compared with 'flush away and forget it' [2], a first big step to a 'drier' toilet.

On site research took place during two years under the authority of the Dutch Ministry of Environment [6]. General conclusion: for health insufficient, for environment superior, for agriculture interesting and economically of no interest, so overall more R&D necessary. (For health insufficient was 'because the latrines continuous process involves hazards from insufficiently composted pathogens' [4].) In Holland then a development arose in three directions: a dry-collecting one connected to foundation 'De Twaalf Ambachten' (representatives at DT 2003), a dry-vacuum one connected to Wageningen University and Lettinga Foundation (representatives at DT 2006) and this dry-composting direction. (At present several no-mix, urine-collecting and dry-vacuum projects are as 'New Sanitation' coordinated by the Dutch National Polder Board [7].)

In the course of time a developmental change followed in the interior of the Clivus: from creating better composting conditions to better drying conditions. Maximized chances on 'pathogen absence' (PA) formed in this an old public health goal as a conditio sine qua non. That meant in practice managing well known interrelated factors that contribute to the die-off of potential pathogens such as: nutrient scarcity, dryness, solar radiation, predation, aeration, and above all, time and temperature [4]. And, in competition with specific composting factors, such as C/N ratio, Ph and humidity [2,3], specific pathogen die-off factors -especially 'linear in time faeces drying'- remained in this managing process.

This old public health goal became at the same time part of the question of sustainability above all as an answer to climate change [8,9]. And this means a 'call for a new public health advocacy movement', for 'climate change is the biggest global health threat of the 21st century' [9,10]. In other words, no PA without Eco-Logy (EL), as it seems to be implicit in ecosanitation (ES) or in an abbreviation-comparison: ES = PA+EL. (It would be better if 'eco' in 'ecosanitation, should be no longer conceived as only EL but as double 'eco': 'eco', in EL and 'eco' in Eco-Nomy (EN) .)

Besides, no DT Technology (DTT) without Eco-Nomy (EN) acceptance, that is to say management acceptance, 'nomy' is Greek for management. No question that EN-acceptance improvement formed a permanent point of attention, not only in managing the system as such, but also in lowering fly- and odor-inconvenience and in improving gender, specific economic/low cost and privacy aspects, as it is the case in for instance 'small sanitation solutions'[11].

The R&D method for this toilet change –so from composting to drying and from old to new public health- was, as urged on at DT 2006: "taking small but tangible and sustainable steps towards better sanitation, also in the real life context" [12]. The steps are chronologically indicated quoting the keywords and the introduced PA-, EL- and EN-factors. They are now and then related to DT 2009 theme and topics.

Tangible steps.

1984 Garbage chute Clivus connected with first chamber. (supposed better 'C/N' mix);
1985 Permanent better symptomatic fruit-fly abatement with a/o lure(electric)light, lure-stuff and fly traps (more 'health' and less 'inconvenience');
1986 Upstairs stool closed and closed chute connected with ventilation system ('aeration' improvement, 'odor' reduction);
1987 Addition passive ventilation possibility by an external bypass of the heat-exchanger (passive draught by high-low temperature difference plus wind-intensity dependent draught by wind-direction independent wind-cap outside the heating-season, 'low carbon' 'aeration', consequence 'odor'-sensibility by false draught);
1989 replacement broken V shaped air-ducts by a rustproof steel-grate ('aeration' repair);
1990 turning the heap once a year on the steel-grate from first to second chamber and pushing it down a year afterwards ('aeration' improvement; 'drying'-effect appeared up the grate and wetting-

effect down, due to the urine-flush);
1996 garbage chute closed (termination internal organic waste composting, supposed causal 'fruit-fly abatement' (more 'health' and less 'inconvenience', 'separate' outdoor composting);
1999 upstairs (closed) stool changed in woman urinal for standing urinating, 'Lady P' [13] (strict urine 'separation' -less technological complexity- men could try it also, urine-flush in greywater-treatment, 'gender' aspect);
2000 'Lady P' changed in a flush toilet, only for urinating ('gender' aspect, upstairs woman didn't accept 'Lady P', men did, downstairs men mostly didn't accept sitting, urine-flush in greywater-treatment);
2001 Downstairs stool changed in a urine 'separating' stool (urine collected in Clivus's collecting chamber and combined with rainwater harvesting, continued 'drying' effect up the grate and no longer wetting down, supposed causal 'fruit-fly abatement', choice for men sitting urinating downstairs or standing urinating upstairs, 'gender' aspect);
2002 Between times result, while the exterior of the Clivus stayed the same, and while the load decreased from 5 i.e. to 2 i.e., the interior changed completely and asked 70-80 % less process-space. It got time for a new design.
2003 Start new design with a project-plan [14]. 'Dry' was defined no longer implicit as 'good bye' without flush-water, but explicit: With maximized chances for PA as 'a conditio sine qua non', with 'separating' urine and faeces, so no-mix, with minimal environmental impact (EL) and with better acceptance conditions in DT-management with regard to social, cultural, gender and economic aspects (EN);
2004 Design corresponding this definition of an experimental DT model, while the developmental change of the Clivus into 'drier' proceeded. It was primarily 'separating' (not secondarily as in the dry-collecting type of De Twaalf Ambachten) and external and internal 70-80 % smaller than the Clivus. It conditioned a not interrupted –so no double vault or pit solutions necessary- strict 'linear in time' running 'faeces-drying' and toilet paper composting process, forward moved by self-evident body movements as sitting down and standing up and reinforced by passive solar qualities. The model was tested provisionally indoor, but offered not enough perspective a/o because of its technological complexity;
2006 A second experimental model followed and the step was taken from in- to outdoor. In that played a role the need for DT at disasters (DT 2006), the need for low cost 'smart sanitation solutions' related to the UN MDG's [11] and a Life Cycle Analysis of 'electric drying', flushing and 'dry-collecting' [15]. Derived conclusion: passive-solar and transportation avoidance are a 'low-carbon' must, so decentralized solutions form the perspective [15].
'Separate all' primarily became the device for respectively garbage, urine and faeces, and toilet paper. The model, less technological complex, got a semi-vertical strict 'linear in time' running 'faeces-drying' process on a simple rack construction, was heated passive-solar and ventilated with also passive-solar generated thermal draught (idea De Twaalf Ambachten). Inside air-temperatures raised up to 60º C, in summer resulting in hand-dry-hard faeces. But the process-length appeared to be much to short outside the summer season, there was faeces-fly 'inconvenience' (entry solar pipe). 'Odor' (drying faeces have an own temperature dependent odor) came through, not by way of the toilet-seat but through the solar-pipe. 'Privacy' led to the design of a small solar-open toilet-privy and 'gender' to an own sitting/standing choice for men. Toilet and privy needed no double vault or pit solutions and conditioned so fast and easy installing (climate change disaster management [9]).
2007 Based on the simple rack construction from this experimental model was build in Clivus's downstairs-stool-chute a cylindrical, gauzy, rotatable rack. Toilet paper stayed from now on also 'separate' for also outdoor composting in a so called earth-worm box ('time linearity' and 'aeration' improvement by faeces spread instead of accumulation);
2008 up to the present. A third experimental semi-horizontal model was the next step, also outdoor, primarily 'separate all' and combining experiences with the first and the second. Thermal qualities, monitored over a year, appeared to be considerable better. Maximum inside air-temperatures raised

up from 20ºC in winter to nearly 80ºC in summer, large temperature-doubling with regard to outside temperatures occurred in half an hour full sunshine, declining during several hours. Inside temperatures in dried faeces and drying faeces ran 5-10° C lower parallel to inside air temperatures. Also ‘faeces-drying’ efficiency, with hand-dry-hard faeces as an initial pragmatic criterion for PA, improved substantially. The hand-dry-hard result came to roughly estimated a week-4 month’s and passed contra-parallel to the temperatures-path. At this ‘health and safety topic’ it is also of importance that the model manual- and fly-contact with drying faeces excluded.
‘All separated’ was external processed: garbage and toilet paper in earth-worm boxes and urine in greywater-treatment and rainwater-harvesting for biomass-production and agriculture (vegetable garden).
‘Acceptance’ progress was paid attention to at sit-comfort (based on dynamic instead of static sitting), at ‘privacy’ (the solar-open toilet-privy), at the ‘gender’ issue (man and woman could make their own choice) and at user’s ‘convenience’ (at putting toilet paper ‘separate’ and removing dry faeces and urine as a manifestation of new recycling behavior.) An ‘acceptance’-factor appeared to be that removing the airtight toilet-sitting-flap offered less drying faeces odor, because of the steady removal by ‘thermal draught’. ‘Acceptance’ progress by external design was in this R&D stage self-evident premature.
2008 up to now. In the Clivus-rack appeared ‘hand-dry-hard’ to occur at mean temperatures of 13-15º C within taking it roughly 4-6 month’s (so in principle a factor 4 more efficient compared with the original 24 month’s situation) and was the electric lure-light replaced by natural light through the closed garbage- and upstairs-stool-chute (‘low-carbon’). A big sawed hatch in the side of the Clivus meant its external end.

Results and discussion

This casuistry not only demonstrates a ‘goodbye to the flush toilet’, but also a good bye to the composting toilet and a hello to the DT. Absolute conditional PA, and, EL and EN improvement, were the main objectives in this DS focused DT R&D.

In the PA objective specific composting factors related to nutrition richness failed in favor of specific drying factors related to nutrient scarcity. DTT became focused on ‘faeces drying’ ‘linear in time’, by gradually ‘separating all’ nutrition factors primarily, successively ‘grey’ from ‘black’ ‘without’ flush-water but still ‘with’ composting, then by ‘separating’ garbage, next by ‘separating’ urine from faeces and finally by ‘separating’ toilet paper. ‘Faeces drying’ as such developed by improving ventilation passively with yes or no solar in heating. Indoor, without solar, ‘low carbon’, while the exterior of the Clivus stayed the same and the interior got gradually ‘drier’. Outdoor, completely solar, so ‘no carbon’ at ventilation and heating. In creating maximum PA-chances as possible the result was hand-dry-hard faeces in roughly 4-6 month’s indoor and in 1 week-4 month’s outdoor.

The EL improvement objective conditioned DT R&D by ‘all separated’ waste processing, ‘grey’ in greywater treatment, garbage and toilet paper in earth worm boxes, urine in greywater-treatment and rainwater-harvesting for safe application in biomass production and agriculture (vegetable garden). ‘Low carbon’ was a must.

The EN improvement objective meant a mentality change from ‘flush away and forget it’ to ‘separate all’ primarily and ‘accept’ what has to be further improved on all aspects.

The weakness and at the same time the strength of these ‘small but tangible and sustainable steps towards better sanitation’ is, that it is singular casuistry. Overcoming this weakness is simple: verify the results, especially PA, in comparable circumstances.

If verified, DTT R&D in semi-comparable circumstances is necessary. For the Clivus can be redesigned as DT and the final experimental model can be re-dimensioned in length and width, and so adapted to different loads on a household-scale and on degree of latitude and weather circumstances (sun- and temperature variations) allover the world. Besides it can mean in the West

a revision of in- and outdoor application, yes or no linked to passive solar house policies.

If verified, further specific DTT R&D has self-evident to follow on all objectives as such, in between and at adapting results in the real life context at all signalized aspects. (A self-evident example of adapting R&D is DT-construction of local available materials.)

This DTT R&D was also weak because of institutional failing. For there was neither governmental nor national health community support.

An explanation may be that public health was considered up to the present mainly as a matter of national interest instead of global. And also that public health as general interest suffered from the pressure of economic part-interest. The credit-crisis seems to strengthen this public health annex economic protectionism further.

On the contrary there is an alarming report from the jointly held Commission between The Lancet and University College London (UCL) Institute for Global Health. The report opens and sums up that 'Climate Change is the biggest global health threat of the 21st century', with the water and sanitation question as part of the problem [9].

The Lancet-UCL commission realizes the (DTT implicit) technology challenge and 'calls for a new public health advocacy movement'. Near it the commission criticizes the institutional failing of the health community: "Too many doctors have been silent for too long about the importance of climate change for the future of health and health services".

The appeal of the commission means an advocacy for a public health movement as there was in the 19th century. Then sanitation was put with full engagement on the agenda and became one of the key factors in doubling life expectancy. But now 'the shamefully weak presence of the health sector in advocating for improved access to water and sanitation is incomprehensible and completely short-sighted' criticized The Lancet earlier at the start of the International year of Sanitation [16].

This DS casuistry will contribute to that urgently needed 'new public health advocacy movement'.

References. If no author is indicated it's this one.

1. Where is build the real (autonomous) house of the future, in Rosmalen, Castricum or Heiloo? Lecture, study-day autonomous systems. Study-group City design and environment Technical University Delft and International Solar Energy Society. Castricum 1989 (in Dutch);
2. Hupping Stoner, C. Goodbye to the Flush Toilet. Water-saving Alternatives to Cesspools, Septic tanks and sewers. Rodale Press, Inc. 1977;
3. Lorenz- Ladener, C. Composting Toilets. Ways to useful faeces-decare. Okobuch Verlag Staufen bei Freiburg 1992. (in German);
4. Feachem, RG et al. Sanitation and Disease. Health Aspects of Excreta and Wastewatermanagement. World Bank Studies in Water Supply and Sanitation 3 John Wiley & Sons 1983;
5. Waste (red.). At the end of pipe? Insights, visions and ideas on a shift in the sanitation paradigm, formulated during expert meetings held in the Netherlands January- March 2005. Waste 2005;
6. Combination greywater-treatment composting toilet superior for environment. H2O (22) 1989:18, p.558-61. (in Dutch);
7. Dutch National Polder Board. Nieuwe Sanitatie. Website www.stowa.nl (in Dutch);
8. Sustainable development and the meaning for environment, health and health services. Dutch Journal for health sciences TSG 1996;74:357-61 (in Dutch);
9. Lancet and University College London Institute for Global Health Commission. Managing the health effects of climate change. www.thelancet.com Vol 373 May 16, 2009;
10. Hygienic revival: vision or fiction? Dutch Journal for health sciences TSG 1998;76:105-7;

11. Waste (red.). Smart Sanitation Solutions. Examples of innovative, low cost technologies for toilets, collection, transportation, treatment and use of sanitation products. Netherlands Water Partnership 2006;
12 Rautanen, SL and Viskari SL. In search of drivers for dry sanitation. Land Use and Water Resources Research 6 (2006), p.41-49;
13 Loth, M. Lady P. Finishing study-report Technical University Delft Sub faculty Industrial Design in cooperation with Royal Sfinx Gustavsberg 1988 (in Dutch);
14 Dry Toilet. Project plan for an E(cological) E(conomical) T(echnological) invention project. Vereniging Penn 2003 (in Dutch);
15 Bruin de, B. Environmental load of three alternative sanitation-possibilities compared with the flush toilet. Waste July 2006. (in Dutch);
16 Editorial Lancet. Keeping sanitation in the international spotlight. Lancet (371) 2008: March 29, p.1045.