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D 4.1.8 -The Implementation of Guidelines and Standards for Ecological Sanitation Concepts in the SWITCH cities Accra, Beijing, and Lima

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SWITCH Document 4.1.8 entitled **Guidelines and Standards for Ecological Sanitation Concepts in the SWITCH cities Accra, Beijing, and Lima**

Audience This document is targeted at policy makers, the SWITCH learning alliance members and the general public.

Purpose

The purpose of this deliverable is to investigate the existing standards and guidelines related to agriculture use of water and nutrients from Ecological Sanitation systems in the three SWITCH cities Accra, Beijing and Lima.

Background

For guaranteeing a successful implementation of new sanitation systems aimed at reuse of minerals from urine and faeces adequate standards and guidelines in the wastewater sector are required and indispensable. In many countries laws and regulation were developed and altered over time to protect humans and the environment as well as to handle sanitation in an appropriate way. The implementation of new sanitation systems faces huge obstacles in some countries as the existing laws do not cover Ecosan concepts. This implies two effects: 1) constructions are not allowed as not foreseen in legislation and huge efforts have to be undertaken before permits are granted e.g. produced fertilizers cannot be used in agriculture (as it is the case in Germany, Switzerland and parts of Austria) and 2) the authorities set charges due to missing laws which are completely inadequate.

Potential Impact

In order to implement new sanitation systems the regulatory framework might have to be adapted. This deliverable provides an assessment whether that is necessary in Accra, Beijing and Lima. In addition, it provides recommendations on the safe utilization of ecosan products based on the new WHO guidelines.

Issues

With the new WHO guidelines a large step is made. Now, it lays in the responsibility of each country to discuss them and decide on their design on national and regional level related towards the environmental, sociocultural, and economic conditions of the country and adoption towards their existing legislative structure.

Moreover, certain additional aspects should be regarded which are not discussed within the guidelines. Firstly, the handling of other products deriving from Ecosan projects has to be kept in mind. As the development of technical treatment is not finished (Tettenborn, 2007), especially when it comes to urine treatment on low-tech as well as high-tech level, legal aspects have to follow up this development and define treatment parameters which guarantee appropriate standards for the Ecosan products derived and their safe handling afterwards.

Furthermore, investigations on the aspect of pharmaceuticals and personal care products within the reuse of wastewater in agriculture are just in their beginnings as already shortly outlined at the example of greywater. Until now, only a limited amount of investigations exist on the effects pharmaceuticals can cause when they remain in the nutrient cycle (Hammer and Clemens, 2007, Lienert et al. 2007). Therefore, no detailed and - even more important - final conclusions can be drawn. But people developing legislation for reuse of wastewater products should keep an eye on this item and follow the scientific discussion attentively.

Recommendations

In many countries standards and guidelines were implemented according their origin, meaning keeping the standards and limits of developed countries (Ukraine: Aqua Ukraine, 2005, China: World Water Congress 2006, Peru: Roman, 2007). But these can be never reached under the existing conditions in these countries. In many countries this problem was recognized and various programmes and projects focus on communication between stakeholders involved as in Accra promoted by IWMI and in Lima by implementation of a "round table". The new WHO guidelines for the use of wastewater, excreta and greywater are a very valid support and source of information for these initiatives especially when they are included into recommendations for guidelines and standards of these initiatives within such an framework representing various stakeholders.

Introduction

New sanitation concepts such as “Ecological sanitation” stay for a new understanding of wastewater treatment in comparison to the conventional type used in industrialised countries nowadays all over the world. Here, faeces and urine are not longer seen as pollutants but as useful resources. Summarized under the term “Ecosan” sustainable wastewater and sanitary collection systems are aimed which base on a consequent implementation of closing the loop of the nutrient cycle and offering more holistic approaches then conventional end-of-pipe-systems. Ecosan does not mean the implementation of a certain technology but stands for the way of handling wastewater streams. In the ideal case these concepts allow the complete recirculation of nutrients contained in faeces, urine and greywater towards agriculture together with an economic handling of water. This attempt shall lead to a huge minimization of environmental pollution of our water bodies. Driving forces behind are increasing water scarcity and stress, population increase, the growing recognition of its value as resource as well as the Millennium Development Goals (WHO, 2006).

For guaranteeing a successful implementation of such new sanitation systems adequate standards and guidelines in the wastewater sector are required and indispensable. In many countries laws and regulation were developed and altered over time to protect humans and the environment as well as to handle sanitation in an appropriate way. Nevertheless, we face huge obstacles in some countries when trying to implement new sanitation concepts as the existing laws do not cover Ecosan concepts. This implies two effects: 1) constructions are not allowed as not foreseen in legislation and huge efforts have to be undertaken before permits are granted e.g. produced fertilizers cannot be used in agriculture (as it is the case in Germany, Switzerland and parts of Austria) and 2) the authorities set charges due to missing laws which are completely inadequate.

On the other hand, in Sweden urine fertilization is applied. Urine was proposed by the Swedish EPA to be included into their revised regulations (Schönning and Stenström, 2007). As well as “Urevit”, fertilizer based on urine and reached via electrodialysis und ozonation, is allowed as temporary fertilizer in Switzerland and EAWAG is working on its general permission as agricultural fertilizer (Boller, 2007).

Existing situation of regulation and guidelines in the cities

Due to the reasons mentioned in the introduction the legal situation which already is or will be the background for Ecosan implementations in the three SWITCH cities Accra, Beijing and Lima was investigated closer and is presented here.

Accra is a city where urban agriculture takes place as well as its irrigation with wastewater. Its population of 1.6 million includes more than 280,000 urban dwellers eating every day food grown by informal irrigation in the city or its outskirts (International Water Management Institute (IMWI), 2007). This is interesting since no specific support exists and the overall perspective of Ghanaian city authorities is that urban agriculture is a misplaced rural enterprise (Accra Multi-stakeholder team on UA). Moreover, wastewater irrigation has no institutional backing (Huibers, 2003). In legal aspects Accra Metropolitan Assembly (AMA) organises urban agriculture in form of by-laws. The by-law "Local Government Bulletin" regulates the usage of wastewater for irrigation in its passage "Growing and Safety of Crops" (AMA, 1995, Art. 190): they recommend that any use of wastewater in agriculture particularly from drainage channels of wastewater is prohibited. Nevertheless, its enforcement was not successful so far (Huibers, 2003). Wastewater of these channels is of industrial origin or coming from households, here it consist mainly greywater with smaller parts of blackwater. These channels lead directly into the rivers and lagunes. IMWI tries to develop guidelines for this wastewater regarding its quality in cooperation with the Ghanaian legal institutions (IMWI, 2006). Results are not published yet.
In general it can be summarized that also the legal situation is absolutely insecure on the farming level wastewater irrigation is already incorporated (Drechsel et al., 2007). Similar applies for Ecosan: RESPTA, a project focusing on new sanitation concepts and reuse of wastewater products funded by the German government, is running since 2002 (Centre for Agriculture in the Tropics and Subtropics, 2007).

Beijing has directives which refer to its local management of water resources and wastewater treatment such as in its drinking water and sanitation standards valid for all Chinese cities, water saving directives, regulations for water protection, management of water reservoir and channels, management of water resources, and regulations for city appearance (full name: Regulations for Beijing City Appearance and Environmental Sanitation, 2002), which result in standards for environmental sanitation in Beijing authorized by Beijing's people congress (PC). The regulations are usually developed by the respective authorities as the Beijing Environment Protection Bureau, and then adopted by the PC. The executive lies again in hands of the respective authorities. As Beijing is one of the driest cities in the world the majority of these frameworks focus on the aspects of water saving and management of water resources which are of major importance for handling the city's water demand (total water consumption in Beijing in 2000: $1.007*10^9$ m^3 (Jia et al., 2005)). Moreover, the Water Saving Office of the Beijing Water Authority set up a regulation which requires the establishment of decentralized wastewater reclamation systems since 20 years (Feng, 2006, Mels et al., 2006). The aim is a wastewater reuse of 50-60 % until 2008 and of 90 % until 2010 (Feng, 2006). Nevertheless, Mels et al. (2006) came to the same conclusion as our investigations; the legal framework is set but its effects are not obvious as an appropriate monitoring system is missing. A major reason is that economical benefits and the raise of the GDP (gross domestic product) index are used as indicator for successful governance and are of higher importance then simply abidance by the law.

Hence, the legal aspects for reuse are set for conventional wastewater systems. Although in some parts of China the authorities have a major interest in implementation of Ecosan systems (Ecosanres, 2007) but its commitment in laws is still missing. Although, Beijing set new requirements for newly developed communities: If the construction side is larger than 30,000 m^2, on-site wastewater reuse facilities are requested (Chu et al. 2004). This might lead on a longer range to more decentralized systems where Ecosan could be at least one option. Additionally, the reuse in agriculture for Beijing is of minor importance, mostly flushing toilets and landscape irrigation are practiced (Mels et al., 2006). In future, here has to be differentiated between Beijing as a city and Beijing the region supplying this city with food. For the rural region fertilizer will gain more and more importance due to the increasing population of Beijing and the resulting intensification of agriculture.

Lima does not have its specific regulations as Beijing. But in 2005 a new law for environmental protection was set up for whole Peru which is also influencing the water and wastewater management of its capital. This “General Environmental Law” states that the government is in charge of controlling the wastewater standards. A main aspect is the promotion of reuse without affecting human health, the environment as well as any activities dealing with treated wastewater (Law 28611, Art. 120). Additionally, the “General Water Law” defines its reuse with the respective conditions more in detail (Decreto Supremo 41-70, Art. 182 and Art. 183) but refers only to the conventional wastewater treatment types such as primary and secondary treatment. Interesting is that between the fields irrigated with treated wastewater and human settlements has to remain a distance of 100 m (Decreto Supremo 41-70, Art. 199 modified for Decreto Supremo 029-83) while the “General Law of Sanitation Service” explicitly allows the irrigation of parks and gardens with treated wastewater (Decreto Supremo 023-2005, Art. 187). Nevertheless, city planers do not consider urban agriculture as viable urban activity (Amani, 2004). It is not regarded in planning what leads to illegal structures.

Overall, it can be concluded that no detailed guidelines regarding the management and treatment of wastewater for agriculture and further Ecosan products are present in Lima. The existing laws are only implemented partially as the major obstacle is the missing regulation (de Silva, 2007) and nomination of specific authority for supervision of them.

International guidelines – new WHO guidelines Vol. 4

The descriptions of the cities’ situation show the differences between them regarding their national law. Nevertheless, it can be concluded that none of them has a law which regulates the implementation of wastewater and wastewater products in (urban) agriculture in detail. Hence, international guidelines were consulted for the operation of Ecosan products within these cities/countries. Fortunately, the World Health Organisation published new guidelines for the safe use of wastewater, excreta and greywater (WHO, 2006). Here, Volume 4 is exclusively directed towards excreta and greywater use in agriculture.

The new guidelines involve the assessment of health risks prior to developing health-based targets included into the guidelines (Schönning and Stenström, 2007). Such targets define a protection level relevant to each hazard and base on a tolerable additional disease burden caused by the reuse of wastewater and its products. This burden is expressed in disability-adjusted life years (DALY). The value is set at $\leq 10^{-6}$ DALY loss per person per year what corresponds to 32 sec of illness per year. Hence, no guideline values are given as in the version of 1986 beside those for helminth eggs.

The main Ecosan products as urine (yellowwater, diluted and undilited by flush water), faeces (brownwater) and faecal sludge (from anaerobic treatment of excreta (blackwater) which contains faeces and urine) as well as greywater (coming from discharge of sinks, showers, bathing, washing) are discussed in these guidelines, recommendations for their storage, treatment and reuse are specified. In the following paragraphs recommendations for each product are summarized and discussed.

Urine. The major risk for urine lays in faecal cross-contamination in the source-separating toilets themselves. Hence, storage is required. Only in individual family system where the risk of spreading microorganisms is minimized, direct application is recommended. A storage period of 6 months at 20°C is compulsory to reduce the risk as far as possible; then the yellowwater can be used for any crop (see Table 1). Additionally, an interval of at least one month should lie between the last fertilization and harvest. When the monitoring shows that frequent cross-contamination with faeces occurs, additional steps to protect environment and people should be taken as e.g. extension of storage time. During application, which should occur close to the ground and include an immediate incorporation of the urine into the soil, a direct contact between people and urine has to be avoided by wearing gloves, rubber boots, overalls etc.

Table 1: Reduction of microorganisms in urine related to storage time and temperature according to the new WHO guidelines Vol. 4

Storage temperature (℃)	Storage time	Possible pathogens in the urine mixture after storage
4	≥1 month	Viruses, pathogens
4	≥6 months	Viruses
20	≥1 month	Viruses
20	≥6 months	Probably none

Important to note is, that the reduction of microorganisms in urine is done on base of a urine-water-mix where dilution does not exceed a nitrogen content of at least 1g/l and allows a min. pH of 8.8. Latest research showed that the dilution rate is crucial for receiving a sanitized liquid as transformation of ammonia into NH_3 (in combination with temperature and pH) is the key factor basing on ammonia for hygienisation (Nordin, 2007). Nordin (2007) showed that approximately concentrations ≥40mM NH_3 (correlates to e.g. 2.1g NH_3-N/l at 24℃ and pH 8.9) are sufficient for inactivating *Salmonella* spp., *Enterococcus* spp., two bacteriophages (*S*. Typhimurium phage 28B and an f-specific RNA phage MS2), and a coliphage ΦX174 as well as ascaris eggs from 60mM NH_3. All microorganisms potentially occur in urine. While at lower NH_3 rates, dilution of urine with water was ≥ 1:3, little inactivation of bacteriophage 28B and ascaris eggs were observed. Similar results were received when storing yellowwater at lower temperatures of 14℃ even at 94mM NH_3 (Nordin, 2007) and came to the result that urine stored at temperatures below 20℃ should not be used for fertilisation of crops intended for human consumption.

This leads to the conclusion that WHO guidelines are correct but the given nitrogen content of 1g/l (at pH 8.8) needs to be set in context to temperature and the related free ammonia (NH_3) content. As well as the dilution rate should be specified more into detail. Especially for countries with moderate climate information given so far is insufficient and might lead to wrong conclusions.

Faeces, faecal sludge, and excreta (containing faeces and urine) have to be treated before used as fertilizer as they contain the major pathogen load. A validation of the treatment methods is highly recommended as well as precaution measures related to the contact with the material during the treatment, its direct application into the soil and keeping a time period between the last application and harvest. As treatment methods are discussed for primary treatment: alkaline treatment and storage; for secondary treatment: composting, incineration, and (sun) drying.

Table 2: Treatment options for faecal matter according to the new WHO guidelines Vol. 4

Treatment	**Criteria**
Alkaline treatment	pH>9 during >6 months
Composting	Temperature >50℃ for >1 week
Incineration	Fully incinerated (10% carbon in ash)

A distinction is made between large-scale (e.g. at the municipal level) and small systems (e.g. on a household level). With an increase in size also possible combinations for treatment rise. The guidelines recommend a primary on-site treatment for small scale systems and additional secondary off-site treatment in large-scale systems. An additional off-site treatment is not required when a pathogen reduction of 6 log units is achieved. The recommendation for a primary treatment on household level goes along with the implementation of further health protection measures which should be considered in such cases as excreta storage without additions of new fresh material, direct application into soil, time between last application and harvest, and measures after harvest as washing, disinfection, peeling and cooking always dependent on type of crop.

Additionally, new research shows that these measures might not be sufficient in all cases. Vinnerås (2007) found that composting at 50°C does not achieve the recommended sanitized status. Other factors not finally evaluated interact and enable survival as well as inactivation. Moreover, in outer parts which do not reach the desired temperature the microclimate might even favour pathogen growth. According to Vinnerås (2007) simple turning of the pile is not a sufficient measure. A well-insulated reactor or/ plus temperatures above 60°C are required to reach a good hygienisation status. Only for certain specific conditions of faecal matter (high initial pH 8.5-9.7; moisture content between 43-66%; initial ash content up to 77%) *E. coli* and total coliforms decreased below detection limit after composting at temperatures above 50°C for at least six days (Niwagaba, 2007).

Furthermore, Vinnerås (2007) discovered that addition of urea is the most promising treatment for sanitising faecal matter. This treatment is not mentioned at all in the new WHO guidelines. Only ash and lime are mentioned in context with alkaline treatment (Table 2). Addition of urea (1%) to faecal matter at 34°C reduces (viral) pathogens above 6 $\log_{10}$ within 2 months time (Nordin, 2007). Within 6 months time the faecal matter can be stated as hygienically safe.

The discussion shows that sanitation of faecal matter is a complex topic and especially such complex processes as composting are hard to handle for normal users of such facilities. Therefore, it is important to inform potential users and workers above appropriate protection wear and to provide training courses as well as to guarantee an appropriate monitoring system.

Greywater has the largest volume of the wastewater streams which comes from the households and contains only a low nutrient and pathogen content due to its origin. As a pre-treatment is recommended an ordinary solid/liquid separation by a settling tank followed by simple treatment techniques such as soil infiltration, gravel filters, constructed wetlands or ponds. More complex methods are activated sludge, rotating biological contactors or membrane filtration. The effluent can be used for irrigation of crops, as well as for groundwater recharge, industrial/urban reuse or discharge into surrounding water resources. If properly designed and managed no problems should occur when it comes to irrigation.

Subsurface application, greywater is directly led to the root zone of plants, is free of restrictions as long as no interferences with groundwater occur. Also, such systems should be applied downhill of wells etc. and are dependent on soil type. Impermeable soils, shallow rocks or areas with very shallow water tables are inappropriate for appliance of such systems. Pond systems are another option. Here, the main focus lies on the aspect of a potential creation of a habitat favourable for breeding of vector insects of diseases as e.g. favourable for mosquitoes which can spread malaria.

Vol. 4 is not discussing a lot the risks caused by pathogens contained in greywater. They mainly reach it via cross-contamination from feaces as well. The largest risk is seen in rotaviruses (Ottosson, 2003). Additionally, they are not mentioning other substances as drugs, pesticides, fragrances and flame-retardants contained in greywater (Eriksson et al., 2003) and their hazardousness. Furthermore, their potential removal by the processes outlined is not stated and additional processes are not discussed. Last but not least the WHO guidelines do not state anything regarding e.g. the reuse of low polluted greywater and the reuse option in agriculture afterwards. Although, this is not the main aim of this WHO volume, a short categorization of these additional wastewater mixed should be mentioned and classified according to the processes outlined. E.g. greywater used of toilet flushing as to treated as excreta or greywater used for car washing is heavily polluted and subsurface application as stated in the guidelines is not a satisfying solution.

Further development for Ecosan guidelines

With the new WHO guidelines a large step is made. Now, it lays in the responsibility of each country to discuss them and decide on their design on national and regional level related towards the environmental, sociocultural, and economic conditions of the country and adoption towards their existing legislative structure.

Moreover, certain additional aspects should be regarded which are not discussed within the guidelines. Firstly, the handling of other products deriving from Ecosan projects has to be kept in mind. As the development of technical treatment is not finished (Tettenborn, 2007), especially when it comes to urine treatment on low-tech as well as high-tech level, legal aspects have to follow up this development and define treatment parameters which guarantee appropriate standards for the Ecosan products derived and their safe handling afterwards.

Furthermore, investigations on the aspect of pharmaceuticals and personal care products within the reuse of wastewater in agriculture are just in their beginnings as already shortly outlined at the example of greywater. Until now, only a limited amount of investigations exist on the effects pharmaceuticals can cause when they remain in the nutrient cycle (Hammer and Clemens, 2007, Lienert et al. 2007). Therefore, no detailed and - even more important - final conclusions can be drawn. But people developing legislation for reuse of wastewater products should keep an eye on this item and follow the scientific discussion attentively.

Last but not least another important issue should be kept in mind: Who should be addressed by the developed guidelines? E.g. private users of urine in backyards need a complete different approach as professional farmers which specific crop rotation schemes. Hence, the appropriate development while keeping in mind the receiver is indispensable for designing successful guidelines. A problem that's consequences can already be observed nowadays. In many countries standards and guidelines were implemented according their origin, meaning keeping the standards and limits of developed countries (Ukraine: Aqua Ukraine, 2005, China: World Water Congress 2006, Peru: Roman, 2007). But these can be never reached under the existing conditions in these countries.

In many countries this problem was recognized and various programmes and projects focus on communication between stakeholders involved as in Accra promoted by IWMI and in Lima by implementation of a “round table”. The new WHO guidelines for the use of wastewater, excreta and greywater are a very valid support and source of information for these initiatives especially when they are included into recommendations for guidelines and standards of these initiatives within such an framework representing various stakeholders.

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