# Chapter 17

# Rapid assessment and SWOT analysis of non-technical aspects of natural wastewater treatment systems

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## 17.1 INTRODUCTION

A general overview and technical details of natural treatment systems (NTS) including constructed wetlands (CWs), waste stabilization ponds (WSPs), duckweed ponds (DPs), water hyacinth ponds and polishing ponds have been provided in Chapters 8 and 10. As outlined in Starkl *et al*. (2013), often assessment studies focus on technical aspects only, with no or little consideration of the non-technical aspects. It has been argued that the non-technical aspects do influence the long-term sustainability of technologies and therefore their critical assessment is of importance. This chapter compliments the previous information through investigations on environmental, health and safety as well as economic, social and institutional aspects of those technologies. The work presented here encompasses an initial sustainability appraisal of currently existing NTSs followed by a strength-weaknesses-opportunities-threats (SWOT) analysis.

NTS utilise natural processes such as attenuation and buffering capacity of natural soil-aquifer and plant-root systems and as such, the process of contaminant removal is not aided by the input of significant amounts of energy and/or chemicals (Sharma & Amy, 2010). NTS can be classified as soil-based and aquatic treatment systems. Examples for soil-based systems are horizontal sub-surface flow constructed wetlands (HSSF-CWs), soil aquifer treatment systems or planted filters. Aquatic systems are DPs or WSPs. They can be used as secondary or tertiary treatment systems and in combination with conventional and other NTS (hybrids) or be solely based on the influent water quality and intended reuse of the treated water. It has also been reported that a combination of different treatment technologies allows for improved water quality of the effluent (Alvarez *et al*., 2008; Mbuligwe, 2004; Kaseva, 2003).

The survey of existing NTS across India showed that the NTS for wastewater treatment are WSPs and DPs; other technologies such as modified CWs and floating wetlands have been implemented only at pilot scale so far. A detailed overview of NTS in India can be found in Chapter 8.

## 17.2 METHODOLOGY

The main intended benefit of all Saph Pani case studies is the provision of and access to safe water for human consumption or agricultural use. Thus, the rapid assessment evaluated selected case studies to see if intended benefits of the NTS (technologies) were achieved. Further, other relevant expected and unexpected benefits were also studied, for example income generation and employment for those communities that are associated with the systems and risks that could jeopardize the successful functioning of the systems. Based on the intended and unintended benefits, current risks and future risks, the case studies were classified as “success” or “failure” cases. During the rapid assessment the underlying reasons for success or failure of the cases were also studied and a SWOT analysis was carried out for a robust assessment. The methodology for the rapid assessment was based on previous studies conducted (Starkl *et al.*, 2010) and is comprised of the following four steps (Figure 17.1):

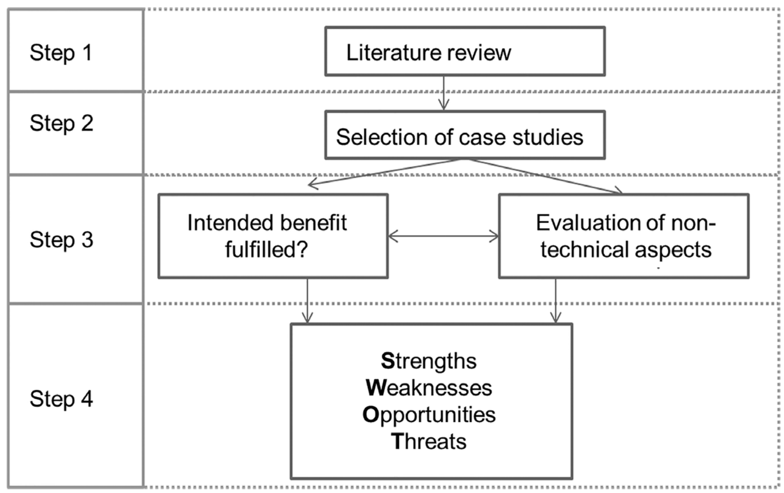


**Figure 17.1** Methodology adopted for Assessment.

### 17.2.1 Step 1: Survey and review of existing information on Indian case studies

First, a survey and a review of natural treatment technologies that exist in India were carried out based on a literature search. Existing information on non-technical (environmental, health and safety, economic, social and institutional) aspects was summarised and relevant issues and knowledge gaps were highlighted.

### 17.2.2 Step 2: Identification of suitable case studies for the rapid assessment

After the survey and review of existing case studies, suitable case studies were selected for the rapid assessment. They were selected based on certain criteria such as existing knowledge gaps, its current use, accessibility or application under real life conditions.

### 17.2.3 Step 3: Rapid assessment

The rapid assessment was primarily based on questionnaires: a general questionnaire for all case studies and tailor-made, additional questionnaires were used for the different technology groups, considering the already available information and technology specifications. The general questionnaire was targeted at collecting basic background information, especially non-technical information. The specific questionnaires focused on aspects important for each of the technology groups (e.g. certain risks that are only relevant for a certain technology, such as e.g. health risks and safety of wastewater reuse in food production). Expert visits and initial interviews with targeted stakeholders and users were conducted to fill in the questionnaires and get an overall impression of the functioning of the NTSs.

### 17.2.4 Step 4: SWOT analysis

To assess the potential of the technologies in India, a SWOT-analysis was conducted. SWOT analysis was initially developed for business management, but has also been used in natural resource management (e.g. Srivastava *et al.*, 2005; Terrados *et al.*, 2007).

The SWOT analysis provides a framework for analyzing a situation by identifying strengths and weaknesses, but also recognises challenges and develops strategies for the future (Srivastava *et al.*, 2005). Thus, in this analysis, the strengths are viewed as advantages that support the decision to implement a system; weaknesses show what can be improved or what needs to be investigated before implementation. Opportunities refer to possible chances and positive improvements, whereas threats show risks and obstacles for the future.

## 17.3 RESULTS AND DISCUSSION

### 17.3.1 WSP in the city of Mathura, state of Uttar Pradesh in northern India: Case study 1

The intended benefit of WSP is treatment of wastewater according to Indian standards and reuse of the effluent if possibilities for reuse exist within the nearby surrounding of the treatment plant. WSPs work without energy input and operation and maintenance (O&M) is limited to the removal of solids from the pre-treatment unit. The WSP in the city of Mathura consists of a pre-treatment unit with rack and grit chamber and two treatment chains consisting of four ponds (Figures 17.2 and 17.3). The first pond is an anaerobic pond, followed by two facultative anaerobic ponds (FAP) and a maturation pond (MP). However, at the time of assessment, only one set of ponds is functioning and the other is being dried out for repairs. Currently, water is not reused, but it had been attempted to cultivate fish in the FAP and MP. Due to problems (see below) this practice was stopped.

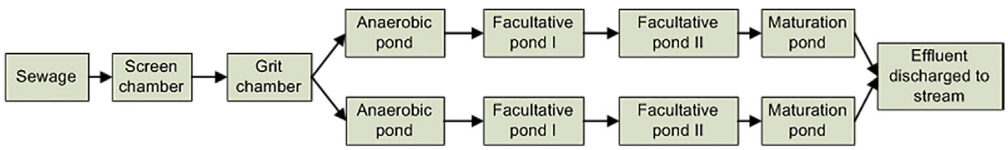


**Figure 17.2** Schematic flow chart of WSP Mathura.

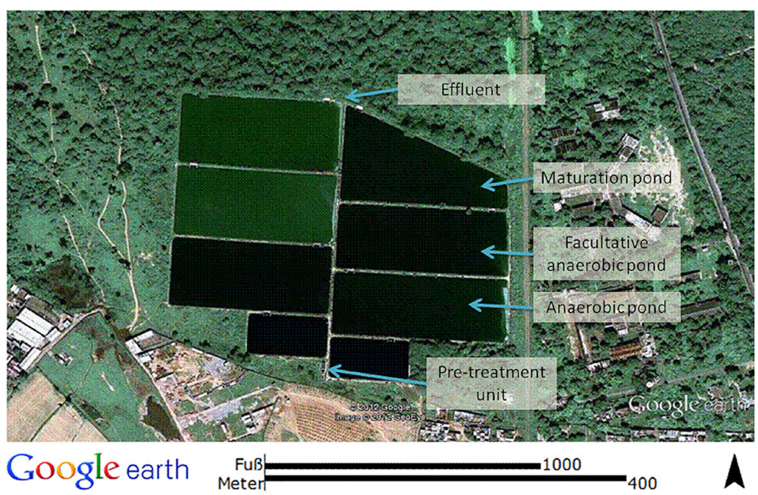


**Figure 17.3** WSP in Mathura, picture from 2009 (*Source*: Google Earth).

Domestic wastewater (13.59 MLD) from the city of Mathura is conveyed to this treatment plant, but the community living close to it is not connected to the sewer network. The WSP was constructed and commissioned by the National River Conservation Directorate and operated and maintained by Mathura Jal Board (Water Board).

#### *Health aspects*

There could be risks related to faecal transmission of pathogenic agents to operators as they have no special equipment for the handling of primary and secondary sludge; they use a shovel and have no gloves. However, the degree of risk could not be assessed as the quality of the incoming wastewater was not available for study.

Communities living close to the treatment system appeared to have been affected by the WSP as commented by some members. According to these comments some members became sick due to the nearby drinking water pumps having become contaminated. While there is no water quality data available to support this, possible contamination of the groundwater could have occurred due to a hole in the cement lining in the FAP (Figure 17.4). At present, the WSPs are undergoing repairs and are therefore not functioning. Treated wastewater is not reused in agriculture; so there are no risks to farmers and consumers.

**Figure 17.4** Hole in lining of facultative anearobic pond.

### *Social aspects*

The field visit has revealed a problem of acceptance: according to three local people who were interviewed during the site visit, the last of the four ponds was used for cultivation of fish. One local user has informed that after a community member fell sick, the practice of rearing fish was stopped. Local people believed that the reason for the illness of the community member was due to eating contaminated fish from the pond.

As mentioned above, due to the problem related to contamination of groundwater, communities are unhappy with the placement of the WSP as the system is not even serving their community by collecting the sewage. These tensions could become a problem in the future.

### *Institutional aspects*

The main institutions involved are the Mathura Jal Board, the Central Pollution Control Board (CPCB) and a private company that is contracted for one year by the Mathura Jal Board. One technical supervisor of the Mathura Jal Board was responsible for supervising all wastewater treatment plants (WWTPs) in Mathura.

The treatment performance is monitored every month by the Mathura Jal Board and the CPCB, but the information on the performance is not available to the public. The actual O&M is handled by the private company. Two operators have been selected from the local community. The operators are responsible for cleaning the rack and guiding the plant. They did not receive specific training. The site visit showed that the institutional arrangements worked well since technical problems such as infiltrating wastewater were being tackled immediately.

### *Economic aspects*

The construction costs of the WSP are not known. The O&M of the WSP has been outsourced to a private company at a cost of 400,000 INR per year (≈5,000 EUR)[1] according to the operators. The salary of the operators was reported as 32,000 INR per year (≈400 EUR) and free housing was provided by the company close to the plant.

According to the operators, there is no revenue from selling any by-products. The treated water is discharged to the nearby stream and sludge is stacked around the premises of the treatment plant. The maturation pond was successfully used for rearing, but this practice was stopped due to acceptance problems.

### *Summary of evaluation results*

The intended benefits of the treatment plant are mainly fulfilled (Table 17.1). Effluent quality could not be assessed as the monitoring results are not available public, but it seems that the system is working well based on the visual impression during the field visit. Reuse of the treated water for irrigation is not possible within the near surroundings as there is no farmland adjacent to the treatment plant (Figure 17.5). No energy is required to operate the treatment plant, but nevertheless power cuts appear to affect the system as the wastewater is pumped to the pond system. The operators who were selected from the local community have no special skills. Their main task is removing solids from the pre-treatment unit.

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[1]Average currency exchange rate of year 2014: INR EUR = 0.0123 (Online Currency Converter, 2015). All amounts indicated in EUR are calculated with this currency exchange rate.

**Table 17.1** WSP Mathura – Fulfilment of intended benefits.

| Intended Benefit/Purpose | Fulfilled (yes/no) | Comments |
|---|---|---|
| Treatment of wastewater according to Indian standard | not available | Monitoring results not available. Based on the impression during the field visit, the system seems to be working well, even though only 50% of the treatment plant were operational, the effluent was clear (visual impression). |
| Reuse of treated wastewater | not applicable | Reuse within the surrounding not possible as no agriculture is practiced. |
| No energy requirements | yes | The treatment plant itself requires no energy to be functional. Pumping is required to transport wastewater to the treatment plant. |
| No skills for O&M required | yes | The operators are from the local community and need no special training; their main task is removal of solids from pre-treatment unit. |

**Figure 17.5** Maturation ponds: left side operational, right side not functional.

## 17.3.2 WSP in the city of Agra, state of Uttar Pradesh in northern India: Case study 2

This waste stabilization pond (WSP) was built 17 years ago in Agra by the local water board. It has a capacity of 10 MLD and treats mixed domestic and industrial wastewater. The water is passing two treatment chains with an anaerobic pond; two facultative ponds and one maturation pond on each side (Figures 17.6–17.8). Treated effluent is being discharged into a stream.

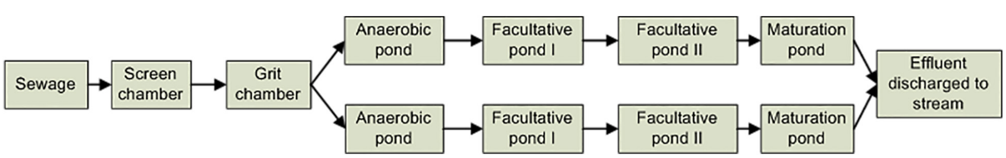


**Figure 17.6** Schematic flow chart of WSP Agra.

### *Health aspects*

The risks to operators are similar as in the WSP Mathura case study (Chapter 17.3.1). The operator reported that when the system was built 18 years ago, the ponds were not lined and water could infiltrate which caused groundwater pollution. Then the system was lined with concrete. Now there is a monitoring well to ensure that groundwater is not contaminated. Treated wastewater is not reused in agriculture, therefore no risks to farmers and consumers occur.

### *Social aspects*

According to the operator, farmers do not want to use the water for irrigation due to the high salinity levels caused by the wastewater coming from the textile industry. It was reported that farmers also do not want to use the sludge because they believe that it is harmful to the plants due to an overdose of nutrients. According to the operator, there is no problem of acceptance of the treatment plant by the nearby residing local community.

**Figure 17.7** Pre-treatment unit.

**Figure 17.8** Maturation pond.

### *Institutional aspects*

The main institutions involved are the local water board, the CPCB and a private company contracted for O&M. The local water board is responsible for monitoring of effluent quality and groundwater wells. The CPCB is conducting additional monitoring. Neither institution publishes the monitoring results.

The private company is responsible for O&M of the treatment plant. There were three operators and one supervisor working in the treatment plant. Their main tasks were cleaning the racks and the surrounding of the pond. Once a year each side of the treatment chain is being cleaned.

### *Economic aspects*

The construction costs are not known. According to the operator the contracted company receives 700,000 INR annually (≈8,500 EUR) for the O&M of the treatment plant. The staffs receive a salary of 2,500 INR/month (≈30 EUR/month) (operator) and 5,000 INR/month (≈60 EUR/month) (supervisor). There are no benefits from the reuse of side products.

### *Summary of evaluation results*

The intended benefits are partly fulfilled (Table 17.2). Based on the visual impression during the site visit, the WWTP seems to be working well. Effluent is not reused even though reuse was initially intended. No monitoring results are available to the public. No energy is required for the treatment process and O&M works well. No further risk was identified.

**Table 17.2** WSP Agra – Fulfilment of intended benefit.

| Intended Benefit/Purpose | Fulfilled (yes/no) | Comments |
|---|---|---|
| Treatment of wastewater according to Indian standard | not available | No monitoring results available. System seems to be working well. |
| Reuse of treated wastewater | no | The treated wastewater is not used for irrigation as farmers have reservations against the water quality. |
| No energy requirements | yes | The treatment plant itself requires no energy to be functional. Pumping is required to transport wastewater to the treatment plant. |
| No skills for O&M required | yes | The operators are from the local community and need no special training. Their main task is removal of solids from pre-treatment unit. |

### 17.3.3 HSSF-CW in Katchpura slum, city of Agra, state of Uttar Pradesh in northern India: Case study 3

The horizontal sub-surface flow constructed wetland (HSSF-CW) is the last part of a treatment system consisting of a baffled septic tank, anaerobic baffled reactor and/or anaerobic filter. The intended benefit is treatment of wastewater according to Indian norms and reuse of treated wastewater. The system is easy to operate and maintain and requires no energy. The system consists of a pre-treatment unit, a baffled septic tank, a baffled HSSF-CW planted with reed beds (Figures 17.9 and 17.10). The assessment was made for the whole treatment plant, which receives 0.05 MLD of domestic wastewater per day.

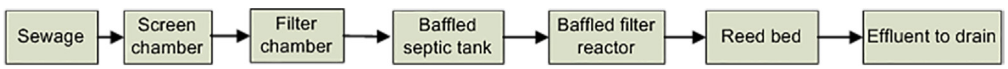


**Figure 17.9** Schematic flow chart of HSSF-CW in Katchpura slum.

**Figure 17.10** Treatment unit planted with Canna indica.

The treated wastewater is being reused for gardening. The remaining wastewater at the site enters into the storm water drainage (as the system is very small) and is conveyed to the Yamuna River. An additional intended benefit of the system is the improvement of the environmental situation in the area. It is planned to up-scale the system in the near future. For the larger system, reuse of water for irrigation purposes is intended. The location of the treatment system within the slum area can be seen in Figure 17.11.

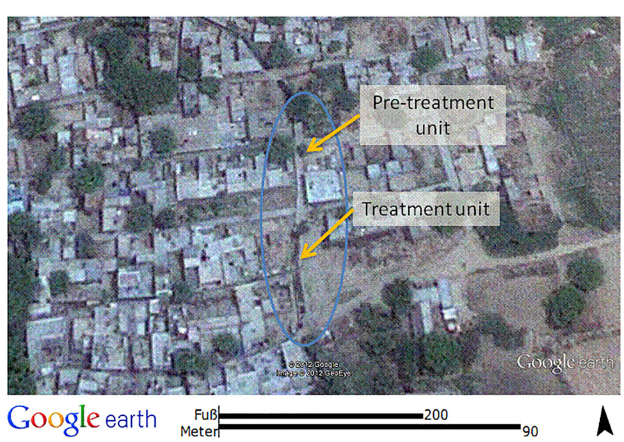


**Figure 17.11** Planted gravel filter in Agra (Source: Google Earth).

### *Health aspects*

Operators are exposed to a possible risk of faecal transmission when emptying the grit chamber. It is located under the pavement (Figure 17.12) and even more difficult to empty than conventional pre-treatment units. However, the risk cannot be quantified as the quality of the incoming wastewater is not known.

**Figure 17.12** Primary treatment unit (baffled septic tank).

The system is located in a residential area. According to the operator, there were no complaints about mosquitoes or other nuisances affecting the health so far. There is no health risk emanating from the treatment system for farmers.

### *Social aspects*

Treated wastewater is being well accepted in the nearby community for irrigation of gardens. There were no problems related to acceptance of the treatment plant so far. With the implementation of the system, employment opportunities during construction and for O&M were created and the environmental situation is improving. The community was involved in the construction and the newly created pavement on the top of the pre-treatment unit is a meeting place for the villagers. Community participation was an integral part of implementation and the community is also involved in the operation of the treatment plants.

### *Institutional aspects*

The main institutions involved in the O&M of the treatment system is the Centre for Urban and Regional Excellence (CURE) which has already assisted in construction, with additional support provided by the Agra Nagar Nigam, USAID FIRE (D), Cities Alliance and financial assistance from Water Trust, United Kingdom and London Metropolitan University.

Two operators from the community are operating the treatment plant. They were trained and in case of problems the implementing NGO (CURE) can be contacted. Their main task is the cleaning of the rack, while all other task e.g. cleaning of filter material or removing of solids from grit chamber are done when necessary. Every three months, the effluent quality is monitored by the local NGO, but the results are not public.

The current institutional arrangement works well as in case of problems the local NGO provides support to the operators. Until now, only one problem occurred due to flooding of sewers, which could be solved by the operators in cooperation with the NGO: the system was blocked in March 2012 and the operators had to remove the filter material, wash it manually and put it back in the system.

### *Economic aspects*

The overall O&M of the system was found to be satisfactory. Reportedly, the capital cost incurred for establishing this WWTP was ≈15,000 EUR and the O&M costs are currently of the order of ≈3,500 EUR per year. Cost recovery is done in an unconventional way: the revenues from the "Mughal Heritage Trail", which was initiated by the same NGO that implemented the WWTP (see institutional aspects), are used to pay the salary of the operators. The revenues from the trail are sufficient to pay five guides on the trail and two operators in the treatment plant (Table 17.3). The operators receive a salary of 3,500 INR/month (≈50 EUR/month) each.

**Table 17.3** Costs and revenue for O&M of HSSF-CW in Katchpura slum, City of Agra.

| Components | Value (INR/yr) | Value (EUR/yr)* |
|---|---|---|
| Revenue per visitor (=700 INR) × Number of visitors per year (=450) | 315,000 | 3,900 |
| Costs per operator/tour guide: 12 × 3,500 INR | 42,000 | 520 |
| **Total revenues** | **357,000** | **4,400** |
| Salary 5 guides | 210,000 | 2,600 |
| Salary 2 operators | 84,000 | 1,000 |
| **Total costs** | **294,000** | **3,600** |

*Average exchange rate of year 2014: INR EUR = 0.0123 (Online Currency Converter, 2015).

### *Summary of evaluation results*

The intended benefits are mainly fulfilled (Table 17.4). The monitoring results were not available, but based on the visual impression the treatment system seemed to work well. Water is being reused in gardening.

Apart from the treatment of domestic wastewater, another intended benefit was to improve the quality of the environment of the poor families in Katchpura. As reported by the National Institute of Urban Affairs (2011), the environmental situation has improved. The open channel that conveyed the wastewater to the Yamuna River is now covered and can be crossed easily even during monsoon.

**Table 17.4** Planted gravel filter Agra – fulfilment of intended benefits.

| Intended Benefit/Purpose | Fulfilled (yes/no) | Comments |
|---|---|---|
| Treatment of wastewater according to Indian standard | yes | Monitoring is conducted, but information about performance is not available in public. |
| Reuse of treatedwastewater | yes | The treated wastewater is being reused in gardening. |
| No energy requirements | yes | No energy is required for the treatment process. Wastewater is collected by a gravity sewer. |
| No skills for O&M required | partly | The operators have no special skills, but they received a short training from the supporting NGO. |
| Improvement of environmental situation | yes | Compared to the situation before, the environmental situation has improved. This was confirmed during the site visit by local people. |

The treatment process requires no energy and only basic skills are required. However, continuous support from the NGO proved to be a reason for success. No additional risks could be detected.

## 17.3.4 HSSF-CW in Ekant Park, city of Bhopal, state of Madhya Pradesh in central India: Case study 4

The intended benefit of CWs are treatment of wastewater according to Indian norms and low energy requirements. Additional expected benefits may depend on local circumstances. Figure 17.13 shows the components of the treatment system: around 25% of the total wastewater is entering the HSSF-CW, the remaining 75% are directly entering the natural wetland with *canna indica* (Figure 17.15) as the capacity of the CW is not enough to treat the entire wastewater stream.

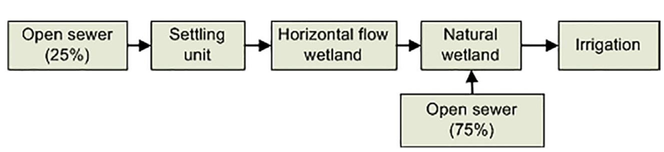


**Figure 17.13** Flow chart of HSSF-CW in Ekant Park.

Treated effluent from the natural wetland is released to a small pond from where it is pumped off for irrigation. Nearby an open stream of untreated wastewater is crossing the park without being treated or used for any purpose. Additional intended benefits are the avoidance of problems with mosquitoes and the reuse of water.

### *Health aspects*

There are no formally assigned operators. The park operators employed for the maintenance of the park have no special equipment and come directly into contact with the treated wastewater. The results of the monitoring in 2003 showed *E.Coli* of $8 \times 10^3$ MPN/100 mL in the effluent which is lower than the recommended standard of $10^4$ MPN/100 mL, but higher than the desirable $10^3$ MPN/100 mL. As no recent monitoring results are available, the risk cannot be quantified.

Visitors of the park are the main stakeholder group that is impacted by the CWs. As the systems are not well maintained, accumulated wastewater can become a breeding ground for mosquitoes. In the park area raw wastewater is conveyed to the treatment plant in an open unlined channel. Visitors, especially children who are not aware of the water quality, can easily come into contact with the untreated wastewater. Besides, a large stream of untreated wastewater is crossing the park.

The treated wastewater is used for gardening within the park. As mentioned above, there is a risk for the park staff that is getting into contact with the water. As water is not produced for agricultural purposes, there are no consumers who could get into contact with products irrigated with treated wastewater.

### *Social aspects*

Park staff is handling the treated wastewater for gardening. Three operators were interviewed. They think that the use of treated wastewater contributes to water conservation. There are no communities around the treatment plant, however visitors to the park can be affected due to the quality of the water used for irrigating the lawns. Eleven visitors were interviewed and those who come regularly to the park were aware of the treatment plant located within the park area. There is also a stream of untreated wastewater crossing the park and 50% of the respondents reported odour emanating from this stream.

Also the appearance of mosquitoes was mentioned as problem, but the respondents think that the mosquitoes are not originating from the treatment plant, but from the untreated wastewater. One respondent reported that he had seen children playing at the outlet of the treatment plant where water accumulates to be later used for irrigation. All respondents think that wastewater is a safe water source for the irrigation of the park. Table 17.5 shows the sample characteristics and the results of the small survey.

**Table 17.5** Sample characteristics and results, HSSF-CW in Ekant Park.

| Descriptive Statistics | Sample Description | n = 11 Respondents |
|---|---|---|
| Gender | Male | 64% |
| | Female | 36% |
| Age | 20–30 | 27% |
| | 31–40 | 18% |
| | 41–50 | 18% |
| | 51–60 | 37% |
| **Question** | **Answers** | **Percentage** |
| How often are you visiting the park? | First time | 18% |
| | Two times per week | 27% |
| | Everyday | 55% |
| Do you know which water is used in this park for irrigation? | Treated wastewater | 45% |
| | No | 55% |
| Did you experience any problems/risks related to the (treated) wastewater? (multiple answers possible) | Mosquitoes | 45% |
| | Children playing with the treated water | 9% |
| | Bad smell of untreated wastewater* | 45% |
| | No | 6% |
| Do you think that treated wastewater is safe to be used for irrigation? | Yes | 100% |
| | No | 0% |

*note: not related to treatment plant.

### *Institutional aspects*

The main stakeholder involved in O&M of the treatment plant is the Bhopal Municipal Corporation that is not continously operating the treatment plant, but reduces the activities to annual cleaning of the pre-treatment unit. Wild growth of plants (Figure 17.14) in the treatment unit was observed, but the initially planted *Phragmites karka* still prevails. The Madhya Pradesh Pollution Control Board monitored the effluent quality every month, but the results were not available for the case study.

**Figure 17.14** HSSF-CW at Ekant Park.

**Figure 17.15** Natural wetland at Ekant Park.

### *Economic aspects*

The system was constructed 20 years ago and the costs were 1.4 million INR (≈17,000 EUR) according to a sign in the park. No O&M costs occur as there are no operators assigned and no electricity and spare material are required. The pre-treatment unit is cleaned when necessary by the park staff. Water is used for irrigating the entire park which has a size of 65 acres (≈26 ha).

### *Summary of evaluation results*

The intended benefits are mainly fulfilled (Table 17.6), but odour and mosquitoes were evident in the stream of untreated wastewater crossing the park. Evaluation results from the year 2003 showed good performance of the treatment plant, no energy is required for the treatment process and water is completely reused. At present, the system appears to have degraded, and there could be health risks to the staff who come into contact with the treated water and children who play with the treated water that is collected for irrigation.

**Table 17.6** Results of evaluation – Fulfilment of intended benefits.

| Intended Benefit/Purpose | Fulfilled (yes/no) | Comments |
|---|---|---|
| Treatment of wastewater according to Indian standard | yes | Published evaluation results are 15 years old, data from central and local pollution control board not available. |
| Reuse of treatedwastewater | yes | The treated wastewater is used for gardening within the park (Figure 17.16). |
| No energy requirements | yes | The treatment unit requires no energy. |
| No odour and mosquito problem | partly | Odour and mosquitoes are a problem; they do not emanate from the treatment unit but from the stream of untreated wastewater crossing the park (Figure 17.17). |

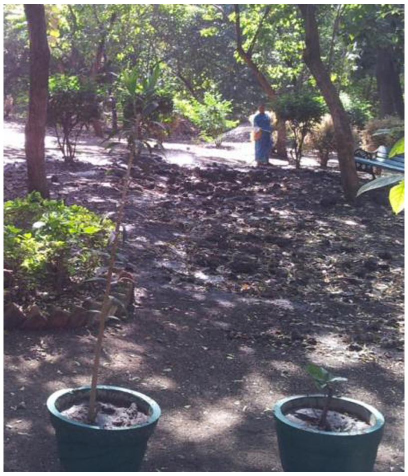

**Figure 17.16** Treated water used for irrigation (without using gloves).

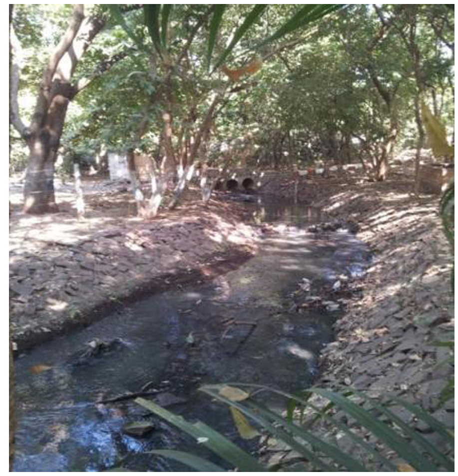

**Figure 17.17** Wastewater stream crossing park.

## 17.3.5 Duckweed pond in village Saidpur, District Ludhiana, State of Punjab, northern India: Case study 5

The intended benefits of duckweed ponds (DPs) are treatment of wastewater according to Indian norms, reuse of treated wastewater and use of by-products such as duckweed and fish.

The DP was established in year 2004 and receives 0.35 MLD domestic wastewater from the village community. As depicted in Figure 17.18, wastewater enters the DP (Figure 17.19) via an open sewer (Figure 17.20) and then flows into the fish pond (Figure 17.21) after which it is extracted for irrigation (Figure 17.22). There is no outlet and only surplus water is used for irrigation to keep the level in the fish pond high.

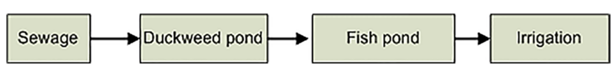


**Figure 17.18** Flow chart of DP in village Saidpur.

**Figure 17.19** Duckweed pond.

**Figure 17.20** Inlet of duckweed pond.

**Figure 17.21** Fish pond with orange trees planted around.

**Figure 17.22** Agriculture around treatment plant.

### *Health aspects*

There is a possible risk to the operators who remove the duckweed from the water surface. Currently, removal is carried out without any special equipment, and the cleaners are exposed to the contaminants. The treatment plant is not located in a residential area; therefore, no risks to the communities were detected.

There is a possible risk to farmers who come into contact with treated wastewater, which is used to irrigate wheat, sorghum and cotton. However, the risk cannot be quantified as the quality of the treated wastewater was not known at the time of assessment.

The quality of the fish was tested twice by the Food Corporation of India for heavy metals and pathogens and showed that fish was suitable for eating. The risk for the consumer of irrigated plants is low, as the types of crops grown are not eaten raw.

### *Social aspects*

The treated effluent is being well accepted for irrigation and the two interviewed farmers even prefer it over groundwater as it contains more nutrients. According to the two farmers, there are no problems with the community as this treatment system is located outside the residential area.

### *Institutional aspects*

The main institutions involved are the local government and the Punjab Pollution Control Board. One person was assigned by the local government to remove the duckweed from the pond every week. The quality of the effluent is monitored twice a year by the Punjab Pollution Control Board, but the information about the performance is not public.

### *Economic aspects*

The construction costs are not known. Labour for construction was provided within the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) which is a guarantee scheme for hundred days of work at minimum wage for every adult living in rural households.

According to two local people who were interviewed, O&M costs are recovered with the revenues from auctioning of the fish 25% of the annual earnings of 50,000 INR (≈600 EUR) are used to pay the operator. The remaining money goes to the village fund. As an additional benefit, orange trees are planted around the treatment unit and villagers can pick oranges whenever they want.

### *Summary of evaluation results*

The intended benefits are mainly fulfilled (Table 17.7) and no further risks were detected. As no monitoring results are available, no statement about the performance can be made, but the treatment plant seemed to work well based on the visual impression during the field visit. Treated water is used for irrigation. Operation costs can be recovered by the earnings made from selling the fish.

**Table 17.7** Results of evaluation – Fulfilment of intended benefits.

| Intended Benefit/Purpose | Fulfilled (yes/no) | Comments |
|---|---|---|
| Treatment of wastewater according to Indian standard | not available | Monitoring is conducted, but results are not public. Treatment plant seemed to work well. |
| Reuse of treatedwastewater | yes | Treated wastewater is used for irrigation. |
| Use of side-products | yes | Duckweed is used as fish fodder. Fish are cultivated in fish pond. Orange trees around ponds generate additional benefit. |
| No energy requirements | yes | No energy is required for the treatment process. Wastewater is collected by a gravity sewer. |

## 17.3.6 Water hyacinth pond in village community in district Bathinda, state of Punjab, northern India: Case study 6

The intended benefit of the water hyacinth pond is treatment of wastewater from the local community and reuse of water for irrigation. The water hyacinth pond in Bathinda Distrcit is not a constructed but a natural system. It receives 0.25 MLD wastewater from a village community and has no outlet (Figure 17.23). The wastewater is conveyed in an open sewer (Figure 17.24) to a pond where water hyacinths (Figure 17.25) were planted around five years ago.

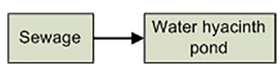


**Figure 17.23** Flow chart of water hyacinth pond in village community in District Bathinda.

**Figure 17.24** Inlet of water hyacinth pond.

**Figure 17.25** Village pond covered with water hyacinths.

### *Health aspects*

There is no formal arrangement for O&M. Therefore, the operating staff is not exposed to any risk. When attempting to remove the plants from the pond, people can come into contact with the wastewater and can become exposed to possible health risks.

Wastewater in the water hyacinth pond is hardly accessible as it is covered by a thick layer of water hyacinths. Neither smell nor problems with mosquitoes were reported by the community members. Water from the pond is not used for any purpose, therefore no health risk emanate from treated water.

### *Social aspects*

Ten persons from the village expressed their opinion about the pond system. Treated water cannot be used due to the thick layer of plants covering the surface. Before the plants grew in the pond, villagers used to irrigate their fields with the water from the pond, but now the water is no longer accessible which is considered as problem by local people.

According to villagers, bad odour from the wastewater has disappeared, but the excessive grow of water hyacinths in the pond makes its use for cattle watering and irrigation impossible as the water disappears under a thick layer of plants. Local people are not aware of the beneficial effect of water hyacinths on wastewater but instead think that this plant is deterring them from using the pond water.

### *Institutional aspects*

The local government is the only institution involved in O&M of the system. There is no arrangement for operation. An attempt was made to remove the water hyacinths with the help of 30 workers employed under the MGNREGA scheme, but after one month the water hyacinths once again covered the surface of the village pond. The villagers did not try to remove them again.

### *Economic aspects*

This system was not constructed; it is a village pond that has already existed since a long time. There is no formal arrangement for O&M. Water hyacinths are not used for any purpose even though examples for their use in India are reported in literature.

### *Summary of evaluation results*

The intended benefit is not fulfilled as the water in the pond is now not available for irrigation or cattle rearing (Table 17.8). This is due to the uncontrolled growth of water hyacinths. The people have thus lost a source of irrigation water. The treatment performance of the pond is not known as it is not monitored. Local people are not satisfied with the treatment system as they perceive the plants as an obstacle. However, according to local people, the bad smell has disappeared.

**Table 17.8** Results of evaluation – Fulfilment of intended benefits.

| Intended Benefit/Purpose | Fulfilled (yes/no) | Comments |
|---|---|---|
| Treatment of wastewater according to Indian standard | not available | No monitoring resultsavailable. |
| Reuse of treatedwastewater | no | Not possible due to thick layer of plants. |
| Use of sideproducts | no | No use of water hyacinths, no cultivation of fish. |
| No energy requirements | yes | No energy is required for the treatment process. Wastewater is collected by a gravity sewer. |

## 17.4 SWOT ANALYSIS

A SWOT analysis has resulted in the following strengths, weaknesses, opportunities and threats:

### 17.4.1 Strengths

An important aspect in all of the cases studied was that the system required low or even no energy input. The study showed that economic benefits from by-products of wastewater treatment are numerous and not only limited to the use of treated wastewater for irrigation, but also for rearing fish. The planting of fruit trees in the area of the treatment plant as done in Punjab appears to have good acceptance.

In all case studies where the treated wastewater was reused, users were satisfied with the quality. When used for irrigation, farmers appreciated the content of nutrients in the water, which replaced chemical fertilizer. In Ekant Park in Bhopal, the State of Madhya Pardesh operating staff agreed that the reuse of the treated wastewater contributes to water conservation.

### 17.4.2 Weaknesses

Land requirement of NTS is higher than for mechanised treatment systems and varies between 1.5 m² per person for CWs and 6 m² per person for a pond system (e.g. Arceivala and Asolekar, 2006). Lower space requirements can be achieved by combining mechanised and NTS. For systems located near communities, problems with odour and mosquitoes were reported due to inadequate O&M of the systems.

### 17.4.3 Opportunities

Due to high land prices in peri-urban and urban areas NTS are mainly suitable for rural areas. However, NTS may be used for green zones in urban areas and be integrated in urban landscaping as in the example of the CW in Ekant Park in Bhopal. In rural areas, space can be saved if the existing village ponds are integrated with the wastewater treatment systems as seen in the examples from Punjab, northern India. An even higher use of by-products, than shown in the case studies, can be achieved, if e.g. sludge treatment becomes more popular.

### 17.4.4 Threats

Institutional and organisational issues are considered to be of high importance, similar to studies reported from CWs in Mexico (Starkl *et al.*, 2010) and Thailand (Brix, 2010). It has been clearly demonstrated that this aspect is relevant for the long-term sustainability as systems where no formal arrangement for O&M exists are prone to clogging and flooding and problems cannot be tackled immediately.

As mentioned above, the NTSs require low or even no energy input. However, as water is usually pumped from pumping stations to the treatment plants, power cuts can affect their functionality.

Potential risks for affected stakeholder groups (operators, neighbours, farmers, consumers) need to be further investigated. Municipalities should take particular care if the NTS are close to human habitations and groundwater aquifers, to anticipate health-related issues and be ready to address them. For the water users health risk assessments should be mandatory, and for the products food safety measures and testing should be part of the agriculture production process. For consumers it is advisable to follow a multi-barrier-approach and take measures to reduce contamination even at household level by washing and disinfecting vegetables before consumption.

## 17.5 CONCLUSIONS

The assessment provided insights into challenges and the potential of NTS. A summary of the main SWOTs can be seen in Figure 17.26.

| STRENGTHS | WEAKNESSES |
|---|---|
| • low energy requirements<br>• benefit of side products<br>• high acceptance for reuse of treated wastewater | • high land requirements<br>• odour and mosquitoes (if located near human settlements) |
| **OPPORTUNITIES** | **THREATS** |
| • potential for rural areas<br>• increased use of side products possible | • improper O&M arrangement can endanger functioning<br>• power cuts of pumping system affect treatment system<br>• possible health risks to operators, neighbours, farmers and consumers |

**Figure 17.26** SWOT analysis based on existing evaluation results and rapid assessment.

One of the main problems was that monitoring results, even where they existed, were not accessible. An environmental information system providing information about monitoring results and updated information about WWTPs would be a desirable tool to ensure accessibility and increase transparency.

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