



Fig. 1: Project location

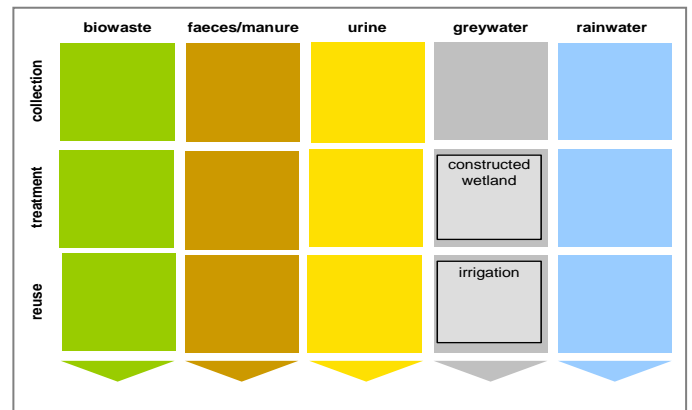


Fig. 2: Applied sanitation components in this project

1 General data

Type of project:

The NaWaTech project aims to optimise the use of different urban water flows by treating each of these flows via modular natural systems appropriate for urban and peri-urban areas of India.

The system considered in this case study will be implemented in the Dayanand Park, a multi-utility public garden. It provides sewage management for at least 1,000 population equivalent (p.e.). It consists of 5 parallel lines of constructed wetlands (CWs) and will provide water for gardening to prevent the use of raw sewage improving health and safety for park users.

Project period:

Start of construction: 12/2015 (estimated)
End of construction: 04/2016 (estimated)
Start of operation: 04/2016 (estimated)
Ongoing monitoring period planned for: three months
Project end: 06/2016

Project scale:

Number of people covered: 1,000 population equivalent.
Water flow: 100 m³/d
Total investment (in EUR): 120,000 € for capital and O&M for one year.

Address of project location:

Dayanand Park, Nara Rd, Dayanand Nagar, Jaripatka, Nagpur, Maharashtra 440014, India

Planning institution:

NaWaTech consortium (www.nawatech.net)

Executing institution:

National Environmental Engineering Research Institute (NEERI, Nagpur)

Supporting agencies:

Department of Science and Technology (DST), Government of India; European Commission (7th Framework Programme); Nagpur Improvement Trust.

2 Objective and motivation of the project

Dayanand Park is a multi-utility public garden spread over seven acres of land. It is the one of the well maintained parks of the Nagpur Improvement Trust (NIT), the responsible Development Authority of Nagpur. About 1,500-2,000 people use the garden daily for recreational and leisure activities, (such as yoga, laughter club, jogging) and as play area for children. The water requirements to maintain the garden are approx. 100 m³/d. Currently, groundwater from a nearby dug well is being used for irrigating the garden. However, due to the depletion of the groundwater levels, this water is often not available for irrigation between February and June. During the summer season untreated sewage is used for irrigating the garden, which poses a huge health risk for the park users.

The aim of this project is to treat the necessary water before re-using it, in order to improve the safety and the health of the park users. The solution proposed are natural treatment technologies integrated into the existing landscape. Such solutions can then be replicated in other gardens or parks in a modular fashion in the city and/or country.

3 Location and conditions

The system will be implemented in Dayanand Park, a multi-utility public garden located in Nagpur, Maharashtra. The general conditions include the following features:

- Tropical wet and dry climate with dry conditions prevailing for most of the year. Annual rainfall in the park area results in 1,205 mm stemming mainly from monsoon rains between June and September. The average annual high and low temperatures are 34°C and 20°C, respectively.
- About 1,500-2,000 park users per day .
- Currently groundwater and raw sewage are used for gardening/irrigation.
- Water requirement: 100 m³/d
- NIT is the responsible authority. The NEERI team involves different stakeholders such as the laughing club.
- Typical users are people with at least a high school education and almost 1/3 of the users have a university degree. Male park users are employed, students, or retired (if over 60). More than 40% of the female park users are housewives, even if most of them have a university degree.



Fig. 3: Schematic of the treatment system (source: Iridra and Kreta, 2014)



Fig. 4: Leisure activities in Dayanand Park (source: UPC, 2014)

4 Project history

The NaWaTech project is funded by the Seventh Framework Programme of the European Commission as well as the Department of Science and Technology (DST, Government of India) for cooperation in water technology and management. The consortium is composed by European and Indian entities (universities, research centres, non-profit organisations and small and medium-sized enterprises). Up to now the consortium developed the following activities with respect to the Dayanand Park case study site, which is one of six case studies within the entire NaWaTech project:

- Site selection and characterisation
- Design, drawing and landscaping
- Cost estimation
- Involvement of stakeholders
- Sustainability assessment (including social aspects)
- Safety planning (including mechanisms against thefts)

5 Technologies applied

CWs are wastewater treatment technologies which emphasize the processes happening in natural wetlands in order to improve their treatment capacity (Kadlec and Wallace, 2008). A CW is a shallow basin filled with some sort of filter material (substrate), usually sand or gravel, and planted with vegetation tolerant of saturated conditions.

Wastewater is introduced into the basin and flows over the surface or through the substrate (UN-HABITAT, 2008).

The mechanisms that occur in CW systems for wastewater treatment are complex and include chemical, physical and biological processes. CWs are used worldwide to treat various types of wastewater, such as domestic wastewater (Vymazal, 2005), combined sewer overflow (Ávila et al., 2013) or refinery effluent (Kadlec and Wallace, 2008). They have proven to be efficient at achieving not only conventional water quality parameters but also have a great potential for the elimination of emerging organic contaminants (Hijosa-Valsero et al., 2010).

Basically, there are two types of CW, the sub-superficial flow constructed wetlands (SSF CWs) and the superficial flow constructed wetlands (FWS CWs).

In SSF CW water flows through permeable substrates which are made of a mixture of soil and gravel in medium in contact with the roots and rhizomes of plants. SSF CWs are constructed for both secondary and tertiary treatment of wastewater. Depending on the direction of the water flow in a subsurface flow wetland it can be vertical flow (VF) or horizontal flow (HF) CW.

In FWS CWs the water flows in free surface (without filter media) (Kadlec et al. 2000). It consists of a series of flooded planted channels or basins. It aims to replicate the naturally occurring processes of a natural wetland.

SSF CWs are preferred to FWS CWs due to significant advantages, including lack of odours, lack of mosquitoes and minimal risk of public exposure and contact with the water in the system (García and Corzo, 2008).

Various CW configurations may be combined to increase their treatment efficiency, especially for nitrogen removal. These hybrid systems are normally comprised of VF and HF CWs arranged in many possible manners. In these systems, FWS CWs as final treatment may contribute to pathogens removal. Their presence may also act as water storage as well as providing a buffer capacity to the system since it allows for high flow fluctuations (Ávila et al., 2014). In case artificial aeration is included in the system, the system is called aerated CW. Aeration improves pollutant removal and can reduce the surface needed for CW implementation.

The configurations used in the considered system at Dayanand Park, Nagpur, are based on VF and HF CWs. The various combinations are HF-HF, HF-VF, VF-HF, VF-VF and Aerated engineered wetland (AEW) of equal capacity.

6 Design information

The design consists of 5 parallel lines based on different configurations of CWs integrated into the existing landscape. The system will treat 100 m³/day which is the water needed for irrigation. The selected primary treatment is a three stage septic tank.

The technical characteristics are the following:

- Proposed quantity of wastewater to be treated: 100 m³/d.
- Type of treatment system:
 - o Primary treatment: three stage septic tank.
 - o Secondary treatment: 5 different combinations of various SSF VF and HF CWs. The combinations are HF-HF, HF-VF, VF-HF, VF-VF and AEW.
 - o Tertiary treatment: disinfection (UV).
- Quality of treated water: comply with State and Central Regulatory Discharge Norms for reuse in land applications.

Table 1: Influent quality parameters and discharge standards of the Central Pollution Control Board (CPCB)

| Major Parameters | Raw sewage | Proposed Treated Effluent Quality | Discharge Standards for Inland surface water |
|------------------|------------|-----------------------------------|--|
| pH | 6.75 – 7.0 | 6.8 – 7.2 | 5.5 – 9.0 |
| BOD | 70 – 90 | <30 | 30 |
| COD | 72 -144 | 50 – 60 | 250 |
| Suspended Solids | 76 - 110 | 20 – 30 | 100 |
| Oil & grease | 32 – 36 | <10 | 10 |

- Population served: the park is utilized by 1,500 – 2,000 people per day. The treatment scheme will provide sewage management for at least 1,000 p.e.
- Designated end-use: gardening/irrigation to prevent the use of raw sewage.
- Potential benefits:
 - o Treatment scheme minimizes health risks for park users.
 - o Conservation of groundwater.
- Design was carried out taking into account water flow/requirement; influent quality (BOD), surface availability.

7 Type and level of reuse

Treated water will be reused for park irrigation. Currently, groundwater from a nearby dug well is being used for irrigating the garden. However, due to the depletion of the groundwater level, water is not available for irrigation between February and June. Therefore, during the summer season untreated sewage is used for irrigating the garden which poses a huge health risk for the park users.

Thanks to system implementation, the garden can be irrigated daily with 100 m³/d of treated and safe water. The public garden is spread over 7 acres of land, mainly planted with grass and trees.

8 Further project components

The aim of the project is to treat needed water before reusing it in the park in order to improve the safety and health of the park users. The solution proposed were natural treatment technologies integrated into the existing landscape. Such solutions can then be replicated at other gardens or parks in a modular fashion in the city and country.

Moreover, this case study will offer great opportunities for research, because it will be possible to monitor and compare five different treatment lines treating the same wastewater (high replicability). Plus, it will act as a good example of how landscaping architecture can transform treatment units into attractive ecosystem services with high performance potentials and positive effects on the quality of life.

9 Costs and economics

The project is co-funded by the DST, Govt. of India as well as the European Commission. The NIT is funding part of the construction works. NIT and NEERI will be in charge of any maintenance costs.

Table 2: Capital and maintenance costs

| | Euros |
|------------------------------|------------|
| Capital costs | 106.873,26 |
| Maintenance works for 1 year | 16.242,58 |
| Total | 123.115,84 |

10 Operation and maintenance

The NaWaTech consortium developed evaluation, adaptation and finalization of frameworks for Safety Plans and O&M schemes.

O&M guidelines were developed by identifying and assessing potential hazards per unit that could lead to poor functioning of wastewater treatment systems. The risk for these hazards was estimated and respective corrective and preventive measures as well as maintenance protocols were developed for various unit operations.

Initially, i.e. as long as project funding is available, the treatment system shall be maintained by CSIR – NEERI, through third party outsourcing (e.g. by the contractor selected for the construction works). Later it will be handed over to the NIT. After handing over, the treatment system and the seven acres of garden will be maintained by the NIT

11 Practical experience and lessons learnt

A social assessment carried out by interviewing park users before system implementation pointed out that:

- The majority of interviewees agreed with the construction of a CW system for wastewater treatment in Dayanand Park;
- Some users highlighted the importance of NIT involvement in order to ensure a correct implementation, operation and maintenance of the system;
- Around 95% of interviewees agreed with water reuse for irrigation;
- 55% of the interviewees had no knowledge about the importance of wastewater reuse;
- Around 60% of interviewees were not informed about wastewater treatment and management in the city, and a high proportion of these people were also unconscious about river pollution.

It can be concluded that more awareness about water scarcity and general environmental awareness is needed. Therefore, workshops, campaigns and other participatory activities should be conducted in order to increase users' environmental awareness and their knowledge about wastewater treatment and reuse.

Further lessons learnt were identified by the project partners:

- **Stakeholder selection and participation is essential.** In this case the NIT is the main stakeholder with high interest in the site. Communication and capacity building with the stakeholders have to be guaranteed to create an overall supportive environment. As Dayanand Park is a public park, the consultative processes (such as different meetings/workshops with the NIT and other important stakeholders of the park, e.g. laughter club, as well as park users via the social assessment) were highly important in order to create awareness amongst the park users and gain their willingness, acceptance, and support. Involvement of stakeholders needs to continue after the implementation (e.g. by means of training for

O&M for involved personnel). Park users should also become involved in the monitoring (e.g. reporting potential smells or leakages of the system).

- A proper design must be considered. Collaboration between landscape architects and engineers was of great importance. The entire system should not interfere with the activities of the park users but should rather occupy only a relatively small area. It was very helpful that for this site geotechnical profiling was carried out and groundwater level was identified. Furthermore, it is important to know the status of electricity availability in public sites before system implementation.
- Regarding tendering requirements, proper material management and procurement are important for contractor selection. Moreover, legal arbitration issues should be avoided as much as possible.
- Health and safety represents a core issue. It needs to constantly be considered during construction as well as during the entire lifetime of the site as it is located in a public area.

These lessons should help implementing sites at other public areas.

12 Sustainability assessment and long-term impacts

A basic assessment (Table 3) was carried out to indicate in which of the five sustainability criteria for sanitation (according to the SuSanA Vision Document 1) this project has its strengths and which aspects were not emphasised (weaknesses).

Table 3: Qualitative indication of sustainability of system. A cross in the respective column shows assessment of the relative sustainability of project (+ means: strong point of project; o means: average strength for this aspect and – means: no emphasis on this aspect for this project).

| Sustainability criteria: | collection and transport | | | Treatment | | | transport and reuse | | |
|---------------------------------------|--------------------------|---|---|-----------|---|---|---------------------|---|---|
| | + | o | - | + | o | - | + | o | - |
| • health and hygiene | | X | | X | | | X | | |
| • environmental and natural resources | | X | | X | | | X | | |
| • technology and operation | | X | | X | | | X | | |
| • finance and economics | X | | | | | X | | X | |
| • socio-cultural and institutional | | X | | X | | | X | | |

Sustainability criteria for sanitation:

Health and hygiene include the risk of exposure to pathogens and hazardous substances and improvement of livelihood achieved by the application of a certain sanitation system.

Environment and natural resources involve the resources needed in the project as well as the degree of recycling and reuse practiced and the effects of these.

Technology and operation relate to the functionality and ease of constructing, operating and monitoring the entire system as well as its robustness and adaptability to existing systems.

Financial and economic issues include the capacity of households and communities to cover the costs for sanitation as well as the benefit, such as from fertiliser and the external impact on the economy.

Socio-cultural and institutional aspects refer to the socio-cultural acceptance and appropriateness of the system, perceptions, gender issues and compliance with legal and institutional frameworks.

For details on these criteria, please see www.susana.org: the SuSanA Vision document "Towards more sustainable solutions" (www.susana.org).

With regards to long-term impacts of the project, the main expected impact of the project is public health improvement (e.g. improve safety and health of the park users). Furthermore, groundwater depletion should be prevented.

13 Available documents and references

Relevant documents:

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- UN-HABITAT. 2008. *Constructed Wetlands Manual.* UN-HABITAT Water for Asian Cities Programme Nepal. Kathmandu

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14 Institutions, organisations and contact persons

Contact details of all parties involved in the project, including description of role and responsibility within the project (including e-mail addresses and websites of organisations).

Case study of NaWaTech project

NaWaTech-Natural water systems and treatment technologies to cope with water shortages in urbanized areas in India

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