Safeguarding Water resources in India with Green and Sustainable technologies – SWINGS

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SWINGS

SAFEGUARDING WATER RESOURCES IN INDIA WITH GREEN AND SUSTAINABLE TECHNOLOGIES

Final Report

Publishable Summary

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Table of Contents

1. AN EXECUTIVE SUMMARY

India as the rest of world as a result of climate change and over exploitation of resources is facing a water crisis. Although over the past decades, the Indian Government has made improvements as regards availability and quality of water, the subcontinent is on track to become the world's most populated country in less than a decade, therefore increasing the demand in water use. Additionally, effective wastewater treatment is scarce and the existing facilities are poorly operated, discharging contaminants or fouled treated waters to natural courses and therefore jeopardizing public health and the environment. "Safeguarding Water Resources in India with Green and Sustainable Technologies (SWINGS)" was a cooperation project, financed under the umbrella of the joint EU-India call where the funding was provided by the FP7 program and the Department of Science and Technology of the Government of India (DST), aiming at investigating low-cost and sustainable solutions for water treatment and reuse in the country.

The consortium included 20 partners 10 of which were European and 10 from India and in Europe was coordinated by AIMEN from Spain, while in India Aligarh Muslim University (AMU) was responsible for the coordination. Figure 1 presents the geographical location of the partners. The consortium included Research Institutions, SMEs, NGOs as well as local municipal bodies that guaranteed the participation of all the sectors of society.

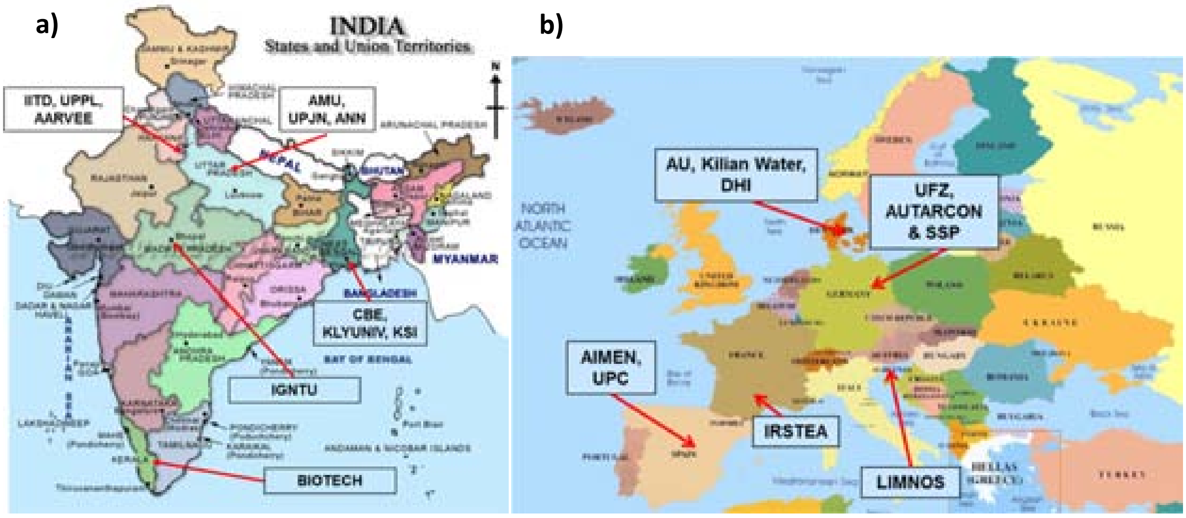

Figure 1: a) Indian partner and their geographical location b) European partners and geographical location.

Different low cost treatment alternatives for wastewater were implemented and operated through combined configurations. Amongst them: Anaerobic Digestion (AD) and Constructed Wetlands (CW) were the main technologies. These two methods operate on zero energy input and therefore regarded as sustainable approach for wastewater treatment. During the degradation of organic materials through AD process, biogas is produced. Combined AD and CW systems were complemented with low cost disinfection units based on filtration, lagooning and solar methods to provide a feasible solution for Indian WW sanitation and reuse. Besides, a decision supporting system (DSS) for selection of sustainable WW treatment technologies and an optimised sustainable pathogen technique were also carried out.

2. A SUMMARY DESCRIPTION OF PROJECT CONTEXT AND OBJECTIVES

The SWINGS project aimed to develop/deploy optimized schemes for low-cost wastewater management (municipal wastewater) in order to make full use of water resources (irrigation, cleaning, public and/or private demands, aquaculture farm feed) and to maximise energy savings for rural areas and community levels.

Various eco-technologies have been designed, constructed and operated to provide treatment of contaminated groundwater and municipal wastewater. These comprise constructed wetlands (CWs) for secondary treatment of urban wastewater, and solar powered disinfection technologies for tertiary treatment of the water, so as to produce a final effluent which can be reused in further applications.

The project objectives as included in GA-Annex I are as follows:

WP1:

Global objective: To identify and specify the anaerobic, constructed wetlands and low cost disinfection application cases and to establish a stakeholder forum to discuss and agree the business and opportunities of introducing the technologies proposed to water management in India regions.

Specific objectives:

- To specify combined system cases providing specific information of anaerobic, constructed wetland and disinfection systems (month 2).
- To contact with relevant stakeholder groups using a variety of media in order to configure a Stakeholder forum and organise stakeholder meetings in order to exploit SWINGS technologies and configure the decision support system (month 42).

WP2:

Global objective: To design and test combined technologies from anaerobic, CW and disinfection systems to promote water reuse and to develop new innovative technologies for organic, nutrient and pathogen pollutant removal from WW.

Specific objectives:

- To construct and implement an UASB reactor to be implemented at large AMU pilot plant (anaerobic digestion- constructed wetland – AD-CW plant for 1000 PE) (month 30).
- To construct and implement constructed wetland systems to be implemented at AMU pilot plants (horizontal and vertical units of 1000PE pilot plant and French system pilot plant) (month 30).
- To implement solar disinfection systems at IGNTU site and at large AMU pilot plant specifying each part or piece of the water tower and filtration systems (month 30).

WP3:

Global objective: To prove and validate the AD-CW configuration operation at design parameters. Organic matter and nutrient removal efficiency will be the control parameter to evaluate the operation of the systems. The aim is to achieve a BOD, COD and nutrient (N and P) removal of 80-90%, 70-80% and 40-60%, respectively.

Specific objectives:

- To adjust and start AD-CW configurations, implementing at each unit: influent and effluent distribution; biogas collection; recirculation pipes, pump wells, vegetation plantation, etc. (month 33).
- To get start-up of AD-CW configuration operation. Proper operation of influent and effluent distribution, biomass developed and organic and nutrient removal efficiency, etc. (month 33).
- To get steady-state of AD-CW configuration operation and achieve organic matter and nutrient removal efficiency stipulated by design (month 35).

WP4:

Global objective: To know the behavior of combined AD-CW technologies when they are exposed to an organic and hydraulic overload. In addition, general guidelines for the AD-CW configuration operation will be developed.

Specific objectives:

- To reach stable operation at OLR (organic loading rate) of 15-20 $gBOD_5/Ld$ and 10-15 $gBOD_5/m^2d$ on anaerobic and CW systems, respectively, and to study the effect on removal efficiency in the range of OLR operated (month 42).
- To reach stable operation at HRT (hydraulic retention time) of 4-6 h and HLR (hydraulic loading rate) of 200-1200 L/m^2d on anaerobic and CW systems, respectively (month 42).
- To study the effect of the gravel bed depth, oxygen concentration effect and GHG emissions on the constructed wetlands implemented in AMU pilot plants (month 42).

WP5:

Global objective: To develop low-cost, sustainable disinfection methods to treat, and especially disinfect, the effluent of the AD-CW configuration. A second objective is to performance a rapid, reliable and cost-effective monitoring technique for the measurement of pathogens in water.

Specific objectives:

- To get start up and steady state operation of low cost filtration and solar disinfection system disinfecting treated WW by AD-CW systems or ground water at different sites along India (month 42).
- To integrate and validate a low-cost pathogen monitoring technique (month 42).

WP6:

Global objective: To obtain a decision support system which consists in determination of the treatment levels to be achieved and sequencing of the treatment units to be applied in order to meet the ecological, environmental and sanitation requirements. The treatment units will be evaluated against some criteria of environmental economic and social nature.

Specific objectives:

- To identify economic, social and environmental indicators in order to elaborate the weighted conjunction and decision tables to be used to implement the DSS tool (month 36).
- To implement, calibrate and validate the decision support system (DSS) for SWINGS technologies (month 42).

WP7:

Global objective: To disseminate the project results, making them well known to all relevant stakeholders, end-user relate to WW treatment and water management. To foster exploitation of the project results for the benefit of the SWINGS partners and to improve the competitiveness of the water management sector.

Specific objectives:

- To carry out different dissemination and exploitation activities of the project (month 42).

Taking into account that the main RTD activities (all pilot plant implementation and operation) in SWINGS project were carried out in India, the execution of SWINGS has been delayed due to several circumstances. The project has incurred in deviations in the achievement of some of the objectives defined (mainly in WP4) as well as on the schedule.

Specifically, periodic delays of funding availability from DST delayed significantly the construction and implementation of large and small AMU pilot plants (WP2 and WP3). Additionally, the complicated supervision of the pilot plant construction and installation, the unavailability of specific material for pilot plant implementation, the long time necessary to get the materials, the necessity to update the pilot plant design due to unexpected issues out of the consortium scope (drainage of KALYANI ponds, low quality of IGNTU campus STP effluent, etc.) led to a delay in the adjustment and starting operation of SWINGS pilot plants in WP3.

The situation above has caused the delay in WP2 and consequently in WP3 and WP5. Therefore, WP4 "Optimisation of AD-CW configurations" was only initiated. Additionally, dissemination activities related to optimization results have been postponed until the Pilot Plants are operated and validated.

In this moment, all SWINGS pilot plants are under operation and Indian partners will be the responsible to achieve their validation since India side SWINGS project is extended until 30th November 2016. EU partners responsible (AU, UPC, KILIAN, LIMNOS, AUTARCON, SSP) of SWINGS technologies have offered their support to Indian partners in order to push up the validation and optimization of SWINGS systems.

3. A DESCRIPTION OF THE MAIN S&T RESULTS/FOREGROUNDS

Several activities were carried out in order to obtain the construction and implementation of the pilot plants proposed in SWINGS project. The final designs, construction, implementation and operation steps of the anaerobic system, horizontal and vertical constructed wetlands and the disinfection systems were elaborated, discussed and executed. Additionally, during the process, there has been continuous video and e-mail communication and multiple periodical video-link meetings have taken place during the establishment of the treatment plants.

Several stays of EU partners responsible of the pilot plant construction (KILIAN, LIMNOS, SSP, AUTARCON, AU, UPC) were carried out in order to supervise and advance the construction of each treatment unit to be implemented at each pilot plant.

Five treatment plants were deployed at pilot scale in Aligarh (Uttar Pradesh) (AMU site), Kalyani (West Bengal) (KALYANI site), Lalpur and Amarkantak (Madhya Pradesh) (IGNTU site):

- Pilot plants at AMU site:
    - <u>Large AMU AD-CW-disinfection pilot plant</u>: The largest treatment system was established in a surface area of 1900 m^2 foe 1000 PE. The pilot plant consists of a combination of anaerobic digestion (AD) primary treatment, constructed wetlands (CW) systems and solar driven disinfection units.
    - <u>Small AMU FS pilot plant</u>: The French system (FS) consists of two stages: a vertical flow stage with 3 beds followed by a horizontal flow wetland. The two stages of the French system have a net area of around 82 m^2 and were designed for approximately 30 PE.

- <u>Pilot plant at KALYANI site</u>: The KALYANI pilot plant treats contaminated ground water and comprises bank filtration process followed by two solar-based AO and UV disinfection systems. Depending on the quality the systems can treat up to 1000 L/h.

- Pilot plants at IGNTU site:
  - Lalpur disinfection pilot plant: An anodic oxidation (AO) disinfection system was implemented and operated at Lalpur village providing drinking water from contaminated ground water a t a flow of 10 m^3/d.
  - Amarkantak disinfection pilot plant: In order to provide disinfected water from a sewage treatment plant (STP), a horizontal gravity fed gravel filter of 35 m^2 followed by an AO system was implemented and operated at a flow of 10 m^3/d.

Pilot plants at AMU site

Large AMU AD-CW-disinfection pilot plant

The large pilot plant at AMU treats municipal wastewater generated at the campus for 1,000 population equivalent (PE). The plant comprises the construction of a combination of anaerobic primary treatment, CW systems and disinfection units. The primary treatment was achieved with a UASB methanogenic reactor of 50 m^3. The secondary treatment consists of two parallel treatment trains with CW units; each treatment train is fitted with a combination of an unsaturated vertical flow constructed wetland (480 m^2), followed by a horizontal subsurface flow constructed wetland (460 m^2). The design also included flexibility in the operation and is fitted with alternatives, for recirculation of treated effluents to the different treatment stages to permit different operational options and exploitation strategies. Following the CWs, the plant was fitted with a solar-driven UV and an anodic oxidation (AO) disinfection units designed to disinfect 10 m^3/d, to be used for toilet flushing, irrigation and fish cultivation.

The pilot plant area calculation and design was made based on characterisation campaigns that AMU ran for about a month, together with historical data. The calculated treatment area needed for the establishment of the CW system is of around 1900 m^2 and treats an average flow of 100 m^3/d. Additional areas were needed for the establishment of the primary treatment, pumping units, recirculation and sampling wells and the water disinfection unit.

Primary treatment: UASB reactor

The UASB reactor designed for the primary treatment has a total volume of 50 m^3 with a nominal hydraulic residence time of 12 h. The raw wastewater enter the reactor through a grit channel, is pumped to a feeder box mounted on the upper wall of the UASB reactor where the flow is divided in four streams and fed at different points on the floor of the reactor. Once the water is treated, the effluent is collected on top part of the reactor by 2 gutters fixed on either side of the gas dome head and conducted to a common effluent point just below the water level in the reactor. The reactor was fitted with a gas collection system from the top. The gas-liquid-solid separator was made of fibre reinforced plastic and was connected with a flaring system away from the reactor to burn the excess methane produced by the anaerobic digestion.

The flow from the reactor is collected in a common chamber on the top of the reactor. From this chamber, the primary treated water is divided into two streams each of 50 m^3/d and conducted to the respective constructed wetland treatment train. Figure 2 shows the implementation phases of the UASB reactor.

Secondary treatment: Vertical and horizontal constructed wetlands

After the primary treatment, the system has two parallel treatment trains (west and east) both comprising vertical flow (VF) beds followed by horizontal subsurface flow (HF) beds, with the necessary wells and structures to allow sampling recycling and hydraulic control. Initially, both trains treat equal water volumes but the flow can be regulated at will and different loading can be treated by the trains increasing the flexibility of the plant for both research and treatment capacity.

Figure 2: Implementation steps of UASB reactor at large AMU pilot plant.

The treatment trains are loaded using two different methods, the western train is fed using a siphon that works without the use of electricity, while the eastern train is load using a centrifugal pump. The siphon was installed in a loading tank that stores the necessary water volume to load and cover the entire bed. The loading of each bed was calculated to satisfy the hydraulic loading rated, so that every pulse loads the beds totally and uniformly. The capacity of the loading well is 10 m^3. Figure 4 shows the implementation steps of the siphon loading chamber.

Figure 3: Implementation steps of the siphon loading chamber for western treatment trains.

The calculated area for the VF beds was of 970 m^2 and each treatment train has a VF surface of 485 m^2 with an effective depth of the beds of 1 m. The bed dimensions are 61 m by 8 m separated by sections. The beds were designed according to the expected quality of the effluent after the anaerobic treatment with a calculated organic load of 19 g BOD_5/m^2d while the calculated ammonia nitrogen loading is of 7.5 g NH_4-N/m^2d. The beds are pulse-loaded at a rate of 8 to 10 pulses/d. The media selected for the beds consists of top 10 cm of 8-16 mm Ø gravel covering the distribution system to improve the distribution, followed by a 1.0 m layer deep of washed sand of 1-4 mm Ø. The bottom 20 cm layer of the bed was filled of 16-32 mm Ø gravel engulfing the drainage and aeration system. The plants selected for the VFCW included *Phragmites australis* and *Phragmites karka* planted at a density of 4 plant/m^2. Additional materials were used for the construction including liners, membranes and geotextiles to avoid the infiltration or gain to or from ground water (Figure 4).

Figure 4: Implementation phases of vertical constructed wetlands in large AMU pilot plant.

Following the VF beds, the treated water is transported to a homogenization distribution and measuring well that controls the feeding of the HFCW beds. The division well receives the water from the VF beds in an equalization chamber that regulates the flow to the HF beds by means of a V 60º three notch well that allows the accurate measurements of the flow. After the weir, water is fed to the horizontal beds by gravity and with the same flow to both beds by means of levelled pipes.

The horizontal subsurface flow beds provides a final water polishing step, increase the total nitrogen removal and enhances the removal of pathogens. Since horizontal flow CW's are water saturated, dissolved oxygen availability is limited in the bed organic carbon is available from root exudates, denitrification increasing the removal of total nitrogen. The water is distributed evenly across the inlet of the beds through perforated pipes perpendicular to the water flow at 10 cm below the surface and collected by drainage pipes which were installed perpendicular to the flow at the end and the bottom of the bed.

Each treatment train has its own subsurface bed each with a surface of 460 m2. For research purposes with different hydraulic retention time the two beds have different effective depths, the eastern bed with 0.60 m while the western bed is shallower with 0.40 m effective depth. The media selected for the beds was a 1:1 mixture of washed, clay free, sand Ø 2–4 mm and gravel Ø 4 - 8 mm. The distribution and collection systems were embedded in gravel Ø 16-32 mm. The distribution system was made from perforated PVC pipes Ø 110 mm. The drainage systems were placed at the bottom at the end of the beds built from perforated PVC 160 mm. The plants selected for the beds were *Canna glauca, Iris spp*. and *Sagittaria sagittafolia* in equal coverage. Figure 5 shows the implementation steps of HF constructed wetlands.

Figure 5: Horizontal constructed wetlands implementation.

Solar driven disinfection systems

After the discharge from the HFCW, water is collected in a well and water is pumped to the disinfection units. Basic infrastructure settings were installed. This mainly comprises the construction of a laboratory building for security and for holding solar-PV-modules, two water storage tanks and piping from the wetlands. A robust aluminium frame for the solar panels of the UV system was imported and installed on the rooftop. The PV system for the AO unit was installed on a locally made aluminium frame. Both were immured onto the brick walls for wind and vandalism protection. Two 1 m^3 tanks, one for each system, were positioned on the roof for the collection and storage of disinfected water. Pipes and cables from the common sump to the disinfection system, from disinfection systems to the tanks and solar PV modules, and from tanks to sampling points, user taps and toilets were also installed. In the laboratory room with the disinfection systems, a drainage pipe was implemented to enable spillage runoff. Furthermore, a drainage and sump was built to discharge the water from the pre-filters after back wash. The construction and implementation of both disinfection systems are showed in Figure 6.

Figure 6: Laboratory building, solar PV panels, water tanks and UV and AO disinfection systems implemented at large AMU pilot plant.

After star-up operation, a first monitoring campaign had successfully taken place delivering very promising results of performance. The overall performance shows an organic matter removal higher than 95% while nitrification is around 99%, total N removal of ca. 45% and P removal of 70%. Additionally TSS removal is above 99% and the final concentration is below 1 mg/L, which allows the use of the treated water for the disinfection. The two disinfection units are producing water with indicator bacteria well below the concentrations recommended by the WHO. The water produced is being used for irrigation and to feed a pond for the production of fish.

Small AMU FS pilot plant

The French system (FS) pilot plant consists of two stages: a vertical flow stage with 3 beds followed by a horizontal flow wetland. The vertical stage will operate in batch mode: each bed is fed with wastewater for 3.5 days followed by twice the time resting period. The vertical stage is loaded with raw wastewater from the equalization tank.

The two stages of the FS have a net area of around 82 m^2 (36.75 m^2 for first stage and 45 m^2 for second stage), and were designed for approximately 30 PE. A layout of the FS projected for the AMU for the SWINGS project is indicated in Figure 7.

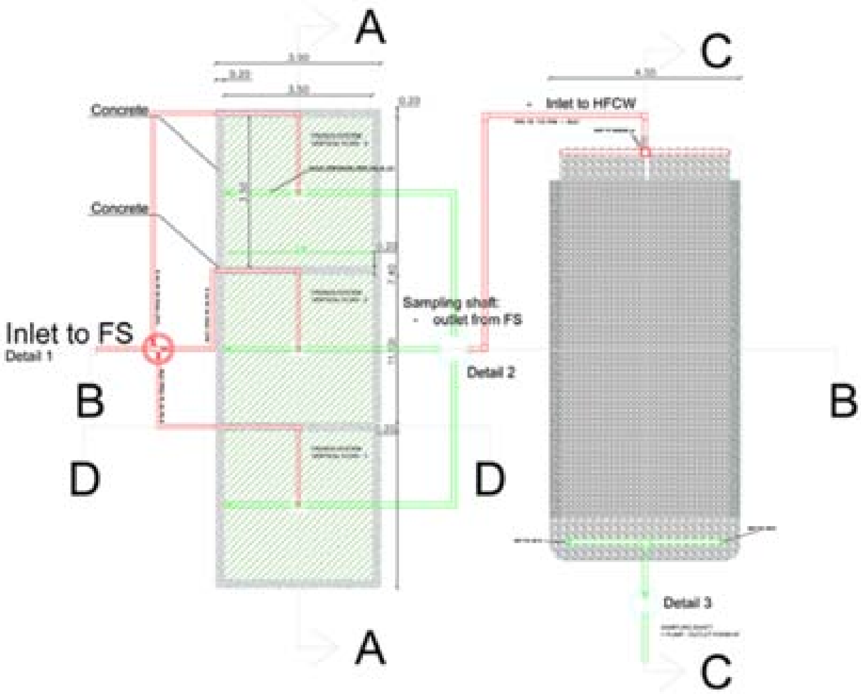

Figure 7: Layout of the French system implemented at AMU.

<u>First stage: FS vertical subsurface flow beds</u>

The first stage consists of three vertical flow parallel beds that will be loaded sequentially with raw wastewater pumped from the homogenization tank without primary treatment. The three beds are similar in size with a surface of 12.3 m^2 and volume of 12 m^3. The beds are lined with HDEP and covered with geotextil. The beds have a drainage system on the bottom consisting of Ø 110 mm perforated pie and are filled with coarse gravel. The distribution system is a single Ø 110 mm pipe that will load a calculated flow on the planted bed surface. Once the calculated load is discharged the following discharge will be to the next bed. The selection of the bed will be done using manually controlled valves (Figure 7, 8, 9).

Figure 7: View of the installation of the distribution pipes (left) and the draining pipes (right).

Figure 8: View of the initiation of filling of the FS VF beds.

Figure 9: Sewing the geotextile for the VF beds of the FS pilot plant.

<u>Second stage: Horizontal subsurface flow beds</u>

After water trickles through the vertical beds designed to remove TSS, BOD and transform NH_4, drained water is conducted by gravity to a horizontal flow constructed wetland to improve the quality of the water. The horizontal flow bed has a surface of 45 m^2 and a volume 25 m^3. Water is distributed in one of the ends and across the bed and by gravity drains to the other end of the bed and is collected at the bottom of the bed by a Ø110 mm perforated pipe. Both the distribution pipes and the collection pipes are embedded in coarse gravel to reduce the risk of clogging (Figure 10). The vertical flow beds will be planted with *Canna, iris spp.* and *Phragmites australis* at a density of 4 plants/m^2.

Figure 10: The horizontal flow bed during the gravel filling stage.

Third stage: Maturation pond for aquaculture

The water discharged from the French system as well as the water discharged from the large system will feed a maturation and aquaculture pond. The pond is being impermeabilized to fill it and to host fish.

Finally, Figure 11 shows the whole FS under construction, including VF bed, HF bed and maturation pond.

Figure 11: View of the whole FS under construction, including VF bed, HF bed and maturation pond. To the left the large AMU pilot plant in operation can be also observed.

Pilot plant at KALYANI site

Bank filtration (BF) or soil aquifer treatments (SAT) systems in combination with solar driven disinfections technologies were implemented and tested at KALIANI site. The site for system testing comprised the existing wastewater treatment pond system of Kalyani sewage treatment plant (STP). Treated wastewater was disinfected to permit its reuse in e.g. agriculture and in in-house applications using innovative solar driven UV and AO technology.

Pre-installation tasks and hydrogeological survey

Preliminary work at the site was carried out in order to select a place for the construction of a building and the infiltration wells. As most adequate site, an area next to the existing fishermen building on a pond bank of the facultative pond has been identified (marked green in Figure 12).

Figure 12: Top view of Kalyani STP Pond system (green square – disinfection system building; stars indicate the location of the BF wells and sampling wells forming the hydrological triangle).

In order to determine the site suitability for the installation of BF wells, a hydro-geological survey was conducted by a local geologist and European partners. Soil layer distributions and permeability of the soil were evaluated. Further, in order to analyze the underground flow-pattern two sampling wells were drilled. Together with the bank filtration wells (BF wells) they are forming a hydrological triangle, marked yellow in Figure 12.

Construction of wells

The first well was constructed into the bank with a distance of 1 meter to the pond surface. The second well was placed in the middle of the bank with a distance of 5 meter to the pond surface of the facultative pond (Figure 13). The depth of the wells was 14 and 16 ft and precisely chosen in order to assure that no ground water, but only water infiltrated by the bank is flowing into the well. A profile of the bank with the two wells can be seen in Figure 14.

The new wells were developed and cleaned. In order to estimate water infiltration rate, yield tests were conducted in month 23 (July 2014). Furthermore, the wells were secured against surface water intrusion, especially during rainy season. This was realized by a thick clay layer around the well head. To further secure the well against pollution and vandalism the well head was closed with a lockable lid (Figure 15)

Figure 13: Drilling of bank filtration well 1 and well 2.

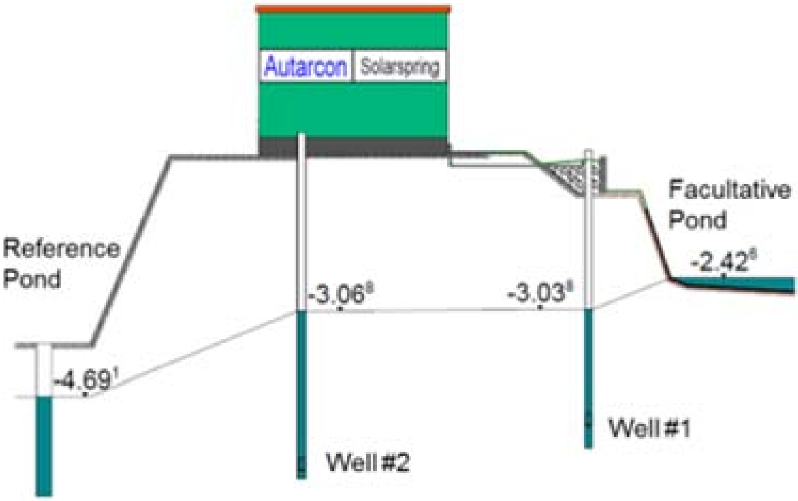

Figure 14: Water levels in Ponds and wells.

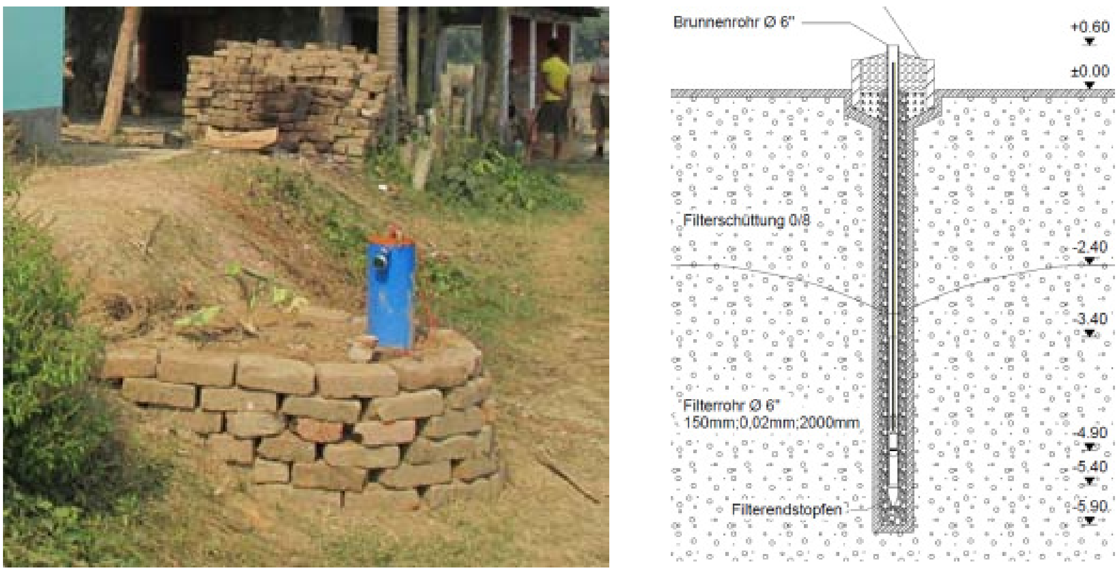

Figure 15: Protected head of well 1.

Building construction

For the disinfection systems, a building was constructed. This building offers enough space for the conduction of simple laboratory tests and the maintenance of the units. It further provides sufficient space for the water storage tanks and the solar (PV) modules (Figure 16).

Figure 16: Finished building for disinfection systems.

Installation of solar driven disinfection system

In month 27 (November 2014), the UV and AO disinfection systems were installed at the KALIANI site by SSP and AUT, respectively, with the support of KALYANI personnel. The units were preassembled and tested by AUT (AO-disinfection) and SSP (UV-disinfection) at their own facilities in Germany. The systems were partly disassembled and send to the partner KALYANI.

A robust and corrosion resistant aluminum frame for the solar panels was installed on the rooftop of the house and fixed onto the brick walls for wind and vandalism protection. The structure serves as support for the solar PV systems of both disinfection units as well as shading of the water storage tanks (Figure 17). In order to avoid incompatibilities, this frame was shipped from Germany as well. In a non-research application these components could be acquired locally once a trusted relationship to a local provider is established. The solar PV systems was mounted and connected to the energy supply units of the disinfection systems (solar modules were bolted to the structure, not screwed).

Figure 17: Transport of PV substructure and installation of PV System at KALYANI site.

Two 1 m³ water storage tanks, one for each system, were bought locally and positioned underneath the solar panels for storage of disinfected water (Figure 18). Each tank was equipped with sensors to be operated with the respective disinfection system and connected to the piping system. The pumps were installed in the well and adequately secured. Additionally, sampling taps for each system were installed on each side of the building. Warning signs were put up at the taps stating that the water is only to be used for cleaning purposes. For the installation of the piping a local plumber was employed.

Figure 18: Water tank installation and sampling taps.

The preassembled disinfection systems were installed into the building and interconnected to piping and cabling. Water can be pumped from the wells to the system for disinfection and further pumped into the overhead tanks for storage. Both systems were successfully tested and commissioned and were ready to start operation any time water becomes available in the wells.

<u>Preliminary testing and standardization of testing</u>

Already before the system installation, micro-biological testing of the raw water source was done showing a high pathogen concentration. It is assumed that the well was polluted during construction. However, further microbial tests revealed that also deeper wells reaching the natural ground water table were highly contaminated by indicator pathogens.

During these test SWINGS partners became aware that different methods and test standards of the Indian partners are applied. Therefore, it was decided to conduct a 3-day training course with all involved Indian partners at KALIANI in order to equalize methods and standards. This will allow a smooth comparison of achieved results. The course will be prepared by DHI partner.

<u>Testing of KALYANI pilot plant</u>

Along with planned construction work at the STP, all wastewater treatment ponds were emptied for their refurbishment. All ponds were newly dug out and banks were reinforced. It was planned to refill the ponds along with the start-up of disinfection systems operation. However, the construction company has not yet reestablished the wastewater supply lines, and does not make any statements about when to expect refilling of the ponds. Eventually the ponds will only be filled after SWINGS project completion.

As no water was infiltrating since month 28 (December 2014), the ground water table dropped and infiltration rates into well 1 and 2 decreased substantially. In fact, they cannot was used as raw water source for the disinfection systems.

In order to continue with research work at the site, it was decided to extend the existing infrastructures by a Soil Aquifer Treatment (SAT) unit (Figure 19). This required the installation of one additional deeper well

(16 m) to reach the natural ground water table. Also, these ground water sources were highly influenced by infiltrated pond water and were highly contaminated by pathogens. Further, it was highly contaminated by dissolved iron and manganese. This required appropriate pre-filtration units.

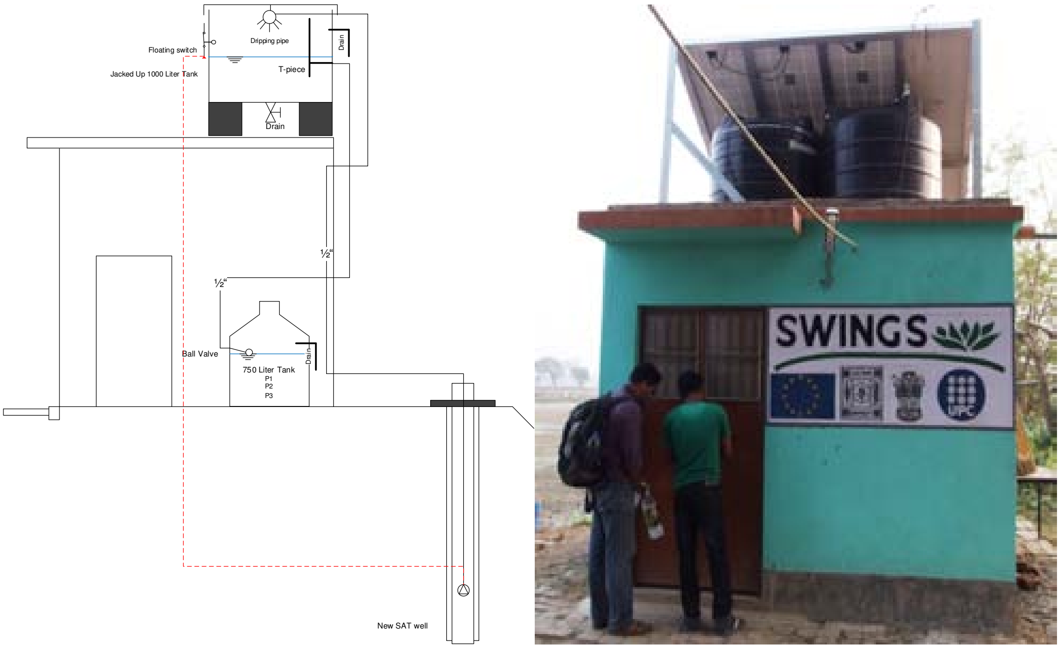

Figure 19: Setting of SAT system at KALYANI site.

<u>Green sand filtration</u>

Due to high iron (4.5 mg/L) and manganese (1.2 mg/L) content in well water at KALYANI site, the water turned reddish brown and turbid after pumping. In order to assure efficient disinfection, a green sand based filtration module was introduced into the disinfection system settings. The applied media is generally based on a manganese dioxide coated silica sand core. The coating catalyses the oxidation of non-oxidized iron and manganese. Dissolved manganese (Mn^{2+}) becomes adsorbed and forms a surface complex with this coating. Stronger oxidants such as hydrochloric acid then can oxidize the manganese to form solids (Mn^{3+} and Mn^{4+}), which themselves create new sites for adsorption. When no oxidants are supplied, the media acts as a redox buffer and the higher oxides of the media itself are reduced by oxidizing Mn^{2+} and Fe^{2+}. Constant oxidant supply such as free chlorine or $KMnO_4$ is required to keep the media in operating conditions on a long term.

The formed iron precipitates are trapped in the green sand granules and have to be backwashed frequently in order to clean the media and free the adsorption/oxidation sites. Vigorous backwash will prevent media growth especially when manganese is removed.

At the KALYANI site, the pumped water is at first aerated by air. In the oxidation tank, settling of already precipitated iron occurs. In the case of UV disinfection system, the aerated water is then fed into a manganese dioxide filter, passes a candle filter for the removal of breakthrough precipitates and then through the UV reactor into the storage tank. In case of AO system, the aerated water is pumped through AO process to provide additional oxidant to the water. The water is then fed through the Greensand filter and then to the storage tank. The iron-manganese filter has 3 cycles of operations: - Operating; - Backwash; and – Rinsing.

First analytic results have shown that iron was completely removed by this process. Manganese was removed by about 50%.

Operation of KALYANI pilot plant

The solar driven well pump pumps ground water from the 16 m deep well into an oxidation tank. As pre-oxidation facilitates the removal of iron and manganese, a 1.000 L oxidation tank was installed on the roof of the pilot system building. From here, the water flows into a 750 L “common tank”, from where UV and AO systems can pump their water respectively. They will turn on and off automatically depending on the filling stage. The analytical work performed in the last period of operation shows removal of higher than 99% and producing waters meeting drinking water quality standards.

Pilot plants at IGNTU site

Lalpur disinfection pilot plant

The solar powered anodic oxidation (AO) system was installed in the village of Lalpur next to the IGNTU campus. At Lalpur, an adequate water quality control sensor setting and online monitoring unit was tested, evaluated and optimized. The system at Lalpur worked as follows:

- The water was lifted with a solar pump from an existing well.
- The required quantity of chlorine was produced from the salt ions present in the source water.
- The water was stored in a storage tank.
- In the storage tank, the oxidation stage of the water was measured and chlorine production adjusted to that.
- From the tank, the water was distributed to the village people using simple tap points.

For the conduction of these tests small infrastructure was necessary. This comprised a small room where the system and the batteries were installed and some basic laboratory equipment was hosted. On top of the room, the Solar-PV-system and the water storage tank were installed. The technical flow chart of Lalpur/IGNTU disinfection system is indicated in Figure 20.

Figure 20: Drawing of construction conducted at Lalpur Village.

Import of equipment

AO disinfection system was imported through Mumbai Air Port. Due to unknown bureaucratic issues, the system was only released by customs after two months of delay. This delay had a direct influence on system implementation, which was delayed to months 16/17 (December 2013/January 2014).

Water tower structure

Prior construction, the original plan for a building to hold the solar disinfection system was adapted slightly. It is now a one story building with 9 m³ room space and sufficient big to host a small on site laboratory (Figure 21).

Figure 21: Construction of the water tower structure at Lalpur disinfection pilot plant (IGNTU site).

Well construction

It was originally planned to use the existing well for both solar pump and hand pump. After disassembling the existing hand pump it became clear that the existing well would not allow fitting both pumps (solar pump and hand pump) at the same time. In order to assure constant water supply, even during the time when the solar AO system was operating at IGNTU campus from time to time, a new 90 m bore well was constructed. This work was arranged and organized by local authorities and accompanied by SWINGS Staff (Figure 22).

Figure 22: Drilling of new 90 m well at Lalpur disinfection pilot plant.

AO Disinfection System installation

Once the tower and the new bore well were constructed, the AO disinfection system including all necessary pipeline work was constructed (Figure 23). Next to the installation of solar PV system and battery bank this included also the immersion of the submersible pump into the well.

Figure 23: Installation and Explanation of AO Disinfection System.

Commissioning of solar AO disinfection system

After system installation and component check, the system was taken into operation. Data communication with server system in Germany had to be implemented. Due to weak GSM at IGNTU/Lalpur site and stringent data bundle regulation in India, the setup of online transmission was very challenging. The applied communication technology had to be completely replaced. By the end of month 17 (January 2014), the system sent data online for the first time (Figure 24).

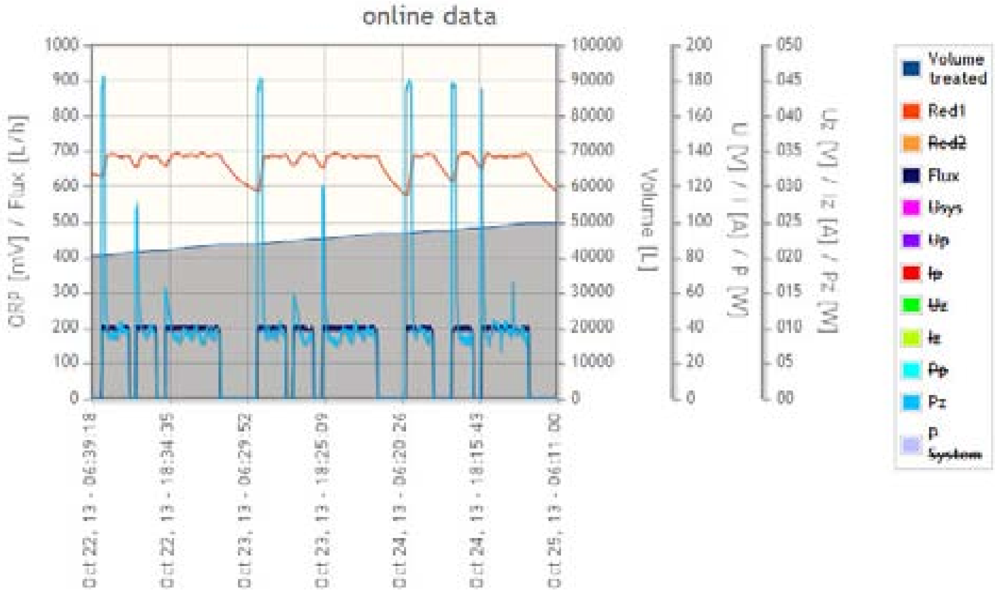

Figure 24: Online monitoring Interface for the system at Lalpur (IGNTU site).

<u>Operation at IGNTU site</u>

The system was disinfecting water to protect it against contamination. OPR measurements were continuously conducted and seemed to work satisfyingly with the currently used water. Considering the orange line in Figure it can be clearly seen, that a drop of water quality is automatically taken care of by the AO disinfection unit.

For data collection monitoring was done weekly following a monitoring protocol that was constantly being optimized for local use. The protocol was also taken as staff training for the measurements to be conducted with treated wastewater starting in month 22 (June 2014).

Amarkantak disinfection pilot plant

In month 16 (December 2013), the newly constructed STP of IGNTU campus started operation. The effluent, expected to have a very good quality, was supposed to be used by the solar driven AO System for the conduction of disinfection trails. A small gravity fed sand filter setting was designed to remove potentially existing particles or biofilm from the IGNTU STP effluent (Figure 25).

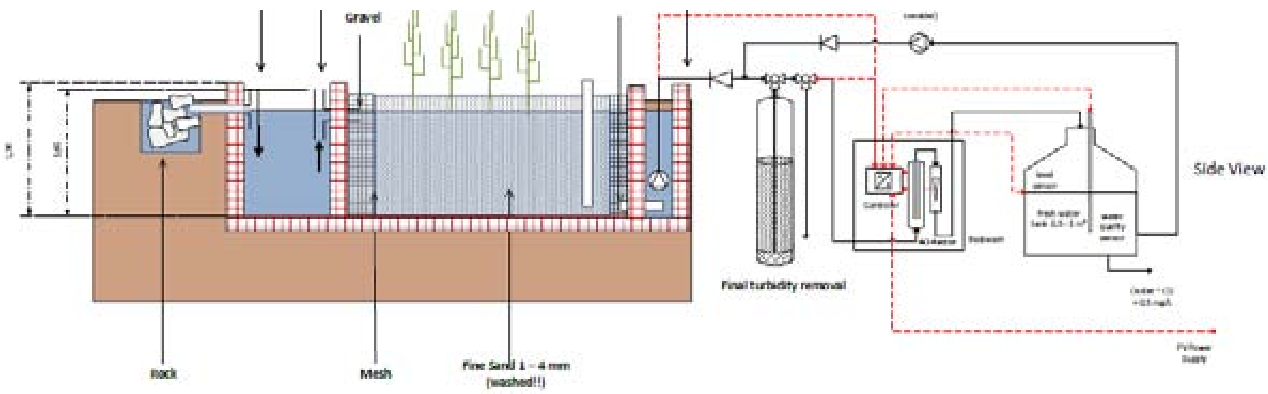

Figure 25: Original design of natural turbidity removal before AO disinfection at Amarkantak (IGNTU campus site).

In month 21 (May 2014), the first measurements of the STP effluent became available through IGNTU partner (Table 1).

Table 1: Range of inlet and outlet water quality of IGNTU STP.

Parameter	Raw Sewage	SEC TREATED Sewage
pH	7.86	8.3
temp	29	29.8
Conductivity [µS/cm]	1405-2250	700-1420
TDS mg/l	702-1124	330-709
Chloride mg/l	56-115	40-71
BOD mg/l	150-349	**30-80**
COD mg/l	209-450	**70-190**

As the minimum required effluent water quality could not be achieved, a direct application of AO disinfection was not possible. All the produced chlorine would become consumed by the organics before having any influence on the disinfection and the original plan of treating STP effluent had to be reconsidered.

Construction and installation of gravel bed

In order to fulfil SWINGS requirements of treating STP effluent at the IGNTU site, a tertiary treatment system was designed. This system is based on a "gravity fed planted gravel bed filter" (Figure 26). The bed is supposed to equalize the water quality fluctuations of the STP and reduces organic load and nutrients.

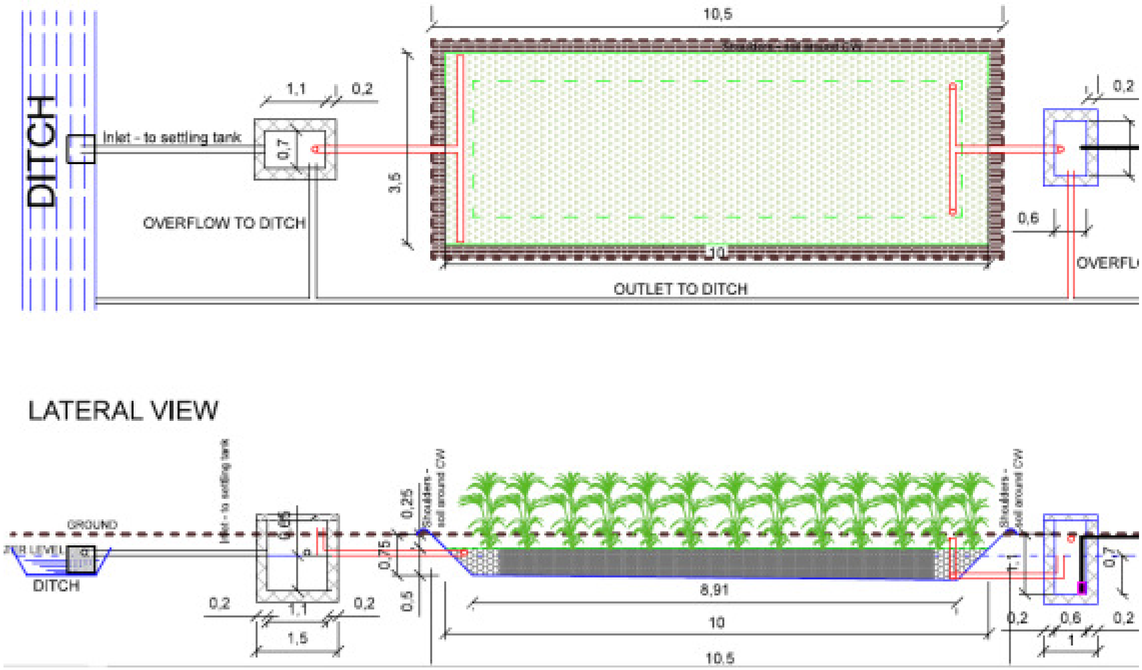

Figure 26: Design of planted gravel bed filter that has become necessary due to poor STP effluent quality.

In order to keep operation as simple and robust as possible, the treated water flows by gravity into a settling chamber and then through the gravel bed into an effluent chamber. From here, it is pumped out by the solar driven AO disinfection unit, which determines the flow through the gravel bed and adjusts automatically do given raw water qualities.

The construction of the 3.5 x 10 m large gravel bed started in month 22 (June 2014) (Figure 27). As the treated wastewater flows by gravity from the ditch into the gravel bed, the bed had to be placed below the bottom bed of the inlet ditch. Due to elevated landscape, this required the removal of a 2 m deep topsoil layer. Only parts of that work could be done by machine. Most removal of soil was conducted by locals, with a three month break during monsoon.

Figure 27: Construction of planted gravel bed filter at Amarkantak IGNTU site.

The inner part of the bed was filled with 600 ft³ of 10-16 mm gravel. The sides were filled with 180 ft³ of 16-32 mm gravel. The gravel was acquired just outside of IGNTU Campus as there were several rock braking facilities operating. The gravel was washed, filled into the bed, leveled and then flooded. Local available plants for gravel bed plantation were selected and tested for their feasibility.

Pre-filtration unit

Even though the gravel bed reduces turbidity, the expected effluent turbidity might still challenge its disinfection by AO technology. Therefore, AUTARCON developed and constructed a solar driven and automated back washable turbidity filter and tested this unit mechanically during monsoon period. For that commonly available components were acquired, transported to India and electronically adapted for its operation in off-grid environment. As filter media Ag Plus, a zeolith based material, was used and evaluated for its performance in treating the gravel effluent.

Building, solar panels and piping

Adjacent to the gravel bed, a small building was constructed. On the roof, a 500 L water storage tank was placed. Solar panels were mounted adjacent to the building and required pipes and wires laid. The AO unit, that has been in operation in the village of Lalpur since during 1st period was shifted and adjusted for wastewater treatment before installed at the campus site. Into the building, the filtration and the AO disinfection unit together with the energy supply unit was integrated. A pump was installed into the chamber receiving treated water from the gravel bed. Into the 500 L water storage tank, the water quality sensors were installed. The setting and final installation are indicated in Figure 28.

The complete setting (comprising of local sewage treatment plant; gravity fed planted gravel bed filter; turbidity Filter; AO system and; safe water storage and monitoring unit) was successfully tested, commissioned and inaugurated in month 27 (November 2014) by the vice chancellor of IGNTU (Figure 29).

Figure 28: Construction of building for water tank and solar panels and installation of disinfection unit at Amarkantak (IGNTU Campus site).

From the sump, the water is pumped to the AO system, passes a zeolite media filter at first and then the electrolytic cell, before the water flows to the 500 L storage tank. In the tank, the ORP is measured and gives a signal to the control unit which automatically adjusts the chlorine production. The zeolite filter is automatically backwashed every day around noon. The setting treats the effluent from the STP and its operation was online monitored. Only, common supervision is needed and water disinfected by the unit is used for campus irrigation and a vegetable plantation (Figure 30).

Figure 29: Inauguration ceremony of Amarkantak disinfection pilot plant at IGNTU Campus.

Figure 30: Irrigation of vegetable farm and maintenance at the IGNTU sample site.

Other important outputs of SWINGS project were the development of a sustainable pathogen monitoring technique and a decision support system (DSS).

Integration and validation of a sustainable pathogen monitoring technique

Culture independent and culture dependent methods have been reviewed for the purpose of applying them for surveillance of wastewater treated by constructed wetlands and disinfected by solar driven UV or AO disinfection in low resource rural areas.

All available culture independent methods were found to be too expensive, unsuitable for low resource settings or unavailable. Some promising methods such as the portable smartphone based MWK kit or the more exotic "No-hardware isothermal arm pit PCR" may be available in the future. As a consequence, WP5 partners have focussed on culture dependent methods.

There are no culture dependent methods that are able to detect all relevant pathogens. Therefore, faecal indicators are the preferred parameters. A faecal indicator is a parameter that indicates presence of faecal matter in the water. If faecal matter is present in water, then there is also a higher probability of presence of pathogens. The most widely used faecal indicator in fresh water is *E. coli*. DHI search for methods revealed a method, the compartment bag test (CBT), as the simplest method and probably the only available methods which is applicable in low resource rural settings.

The applicability of the CBT method and the Merck chlorine test (CT) were investigated at KALYANI, IGNTU and AMU during a visit by Claus Jørgensen, DHI, in the period from 27/11 to 16/12 2015 (month 39 and 40). Each partner was visited for 1 week. At the three locations, a person with rural relation and without any laboratory experience was trained. The training consisted of a 1 hour presentation in English given to the trainee by Claus Jørgensen. An interpreter was present to either translate or clarify when needed. At IGNTU the presentation was initially given without translation, but repeated with translation on the final day. The presentation included information on:

- Background of the project.
- Principles of transmission of pathogens via the water cycle.
- Presentation of the CBT.
- Presentation of the CT.
- Sampling.
- Hygiene.

On the same day as the training, the CBT and the CT was demonstrated on real samples from the test sites. Membrane filtration samples were analysed in parallel. The results were read the following day.

Initially, it was planned to have samples analysed using the CBT by the trainees and by Claus Jørgensen in parallel. For that purpose, 100 CBT tests were purchased in 2 sets of 50 tests and delivered to KALYANI and to IGNTU. Only 1 set arrived in due time. Fortunately, the test kits arrived in KALYANI. The set send to IGNTU, arrived in Mumbai on November 2nd 2015 and had not reached IGNTU on December 7th, the day where the analyses were carried out at IGNTU. Consequently, the samples planned to be analysed by Claus Jørgensen were not carried out. The trainees were selected by the KALYANI, AMU and IGNTU (Figure 31, 31 and 33).

Figure 31: Trainee at the University of Kalyani.

Figure 31: Trainee at the Indira Gandhi National Tribal University.

Figure 32: Trainees at the Aligarh Muslim University.

The CBT method was tested at KALYANI, IGNTU and AMU with respect to the possibility of implementation in low resource rural settings and by comparison to the ISO method for detection of *E. coli*.

The results showed the method can be applied in rural settings and used by rural people without any prior laboratory experience or knowledge of wastewater or drinking water. It was found, that five years of school attendance is sufficient. It was also found, that illiterate people can perform the analysis, but may need additional training with respect to recording and understanding the results.

The comparison between the CBT and the ISO9308-1 gave different results at the different test sites. Unfortunately, only 50 tests out of the 100 tests ordered made it through the Indian custom clearance, which reduced the number of comparative tests that could be performed, and made it impossible to conduct all planned.

The measurements at KALYANI gave a lower count for the CBT than the ISO-9308-1. There were some problems identifying the *E. coli* colonies, because the colours of the assumed E. coli colonies diverted from the normal colours produced on the Chromocult Agar. The measurements at IGNTU gave almost identical results for the CBT and the ISO9308-1. At AMU, the samples were unfortunately diluted too much to give positive results. Hence, at AMU the comparison was only related to the absence of false positives.

Implementation and calibration of a Decision Support System (DSS)

The intention of the decision support system is to assist potential users (planers, decision makers of local authorities, etc.) in the selection of appropriate configurations of wastewater treatment technologies that can be used in a specific context or project. To identify potential solutions, the decision support system has to generate and evaluate the different wastewater treatment alternatives according to technological, economic, social-environmental and planning criteria set by the user and defined by the available wastewater treatment technologies. The DSS therefore uses a “knowledge and rule” approach.

The DSS includes three main components:

1) A technological module based on the characteristics of the technologies integrated into the DSS and on the conditions of the project.
2) A criteria-selection module assessing the project through criteria whose importance is defined by the user.
3) An economic module providing a Dynamic Costs Comparison (DCC) (similar to a Life-Cycle Cost Assessment (LCCA)) assessing the cost of different treatment options.

The objective of the first module is to generate wastewater treatment configurations fulfilling, on a technical basis, the project requirements. The second module then provides a subsequent multi-criteria decision analysis to evaluate if the identified technical alternatives are able to meet the user's priorities. Finally, the third module compares the economic costs associated with the selected technical alternatives to allow the user to decide which technological solution is the most appropriate.

For the user, the DSS process consists of three main steps: (1) entering the design criteria referring to the project's context, (2) weighting the selection criteria and (3) evaluating the results. Figure 33 shows a schematic of how the DSS process works. The user inputs the design criteria setting the framework conditions for the generation of suitable treatment alternatives. Treatment configurations which do not fit the design criteria are excluded from further analysis. The user then has to weight the selection criteria according to their importance. Finally, the economic data produced and included in the results. The results can be seen and re-evaluated, if desired, to compare different scenarios in various contexts (different design or selection criteria).

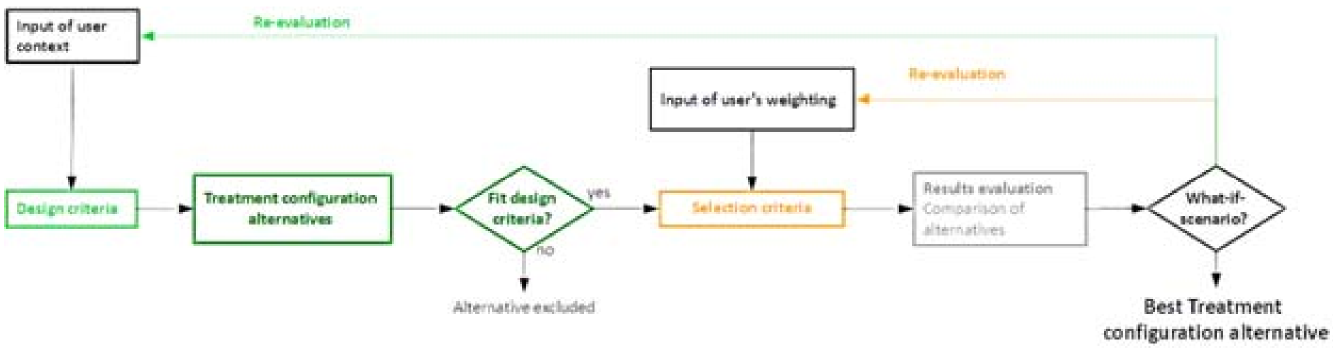

Figure 33: The DSS logical process.

Microsoft® Excel 2010 has been used to develop the DSS and is therefore required to execute it. The DSS contains a user's interface, a database with facts about the technologies (applications, criteria, etc.), a treatment configuration alternative computation tool and a tool based on the programming language VBA to present the final results.

The user interface consists of an excel sheet where the user enter the frame parameters of the project:

- The organic load of the wastewater.
- The wastewater production.
- The population served.
- The area available.
- The budget available.

On this interface, the SWINGS individual technologies **¡Error! No se encuentra el origen de la referencia.** are combined to produce the entire range of realistic treatment alternatives possible.

4. THE POTENTIAL IMPACT AND THE MAIN DISSEMINATION ACTIVITIES AND EXPLOITATION OF RESULTS

According to the last World Water Forum, globally the amount of wastewater discharge to water bodies is approximately 2 million tons a day and is rising with development and population growth (Global Water Framework of 6th World Water Forum, 2012). On the other hand, World Water Treatment Product Demand is estimated in 37 billion€ and world demand for water treatment products is projected to increase 6.2% per year to nearly 50 billion€ in 2015 (Freedonia, 2011). In Europe, the water and WW services play a major economic role in European countries, providing close to 600,000 jobs for more than 70,000 water services operators. Investments in the sector represent overall more than 33,000 million€ annually. The turnover for this sector is around 72,000 million€ annually (WssTP SRA, 2010).

Regarding EU regions, a potential market for SWINGS solutions is Urban WWTP in small and medium towns (between 2,000 – 150,000 PE). It is estimated that there are 22,240 agglomerations in EU with 2,000-150,000 PE. They represent 98% of total EU settlements, which generate 57% of the pollution load (EC, 2011). Some European countries, (i.e. Belgium, France, Ireland, Italy, Luxembourg, Poland, Portugal, and Spain) still need to make substantial efforts to improve their compliance with Directive 91/271/EEC (EC, 2011). Significant investments in these countries have to continue for the necessary improvements of WW treatment of these agglomerations.

Regarding India, 38 million m3/d of WW is generated and only 35% are treated mostly up to secondary stage (CPHEEO, 2012). The Environmental Impact Assessment Notification (2006) mentions all constructions with more than 20,000 m2 area will need prior clearance permission, which includes an important component of wastewater treatment unit. To address shortfall in wastewater treatment, the Delhi Development Authority in March 2012 made it mandatory for any new group of housing, institutional and commercial building plans to have dual plumbing systems and a mini-sewage treatment plant within the premises. This initiative has been implemented in Karnataka with encouraging results. The Karnataka State Pollution Control Board (KSPCB) specifies that housing complexes that are in excess of 10,000 m2 built up area or 50 flats need to have a sewage treatment plant on their premises and the flats should have dual plumbing. This allows the treated water to be put to non-human consumption use or secondary usage such as flushing, gardening, washing cars, etc. Along with this, KSPCB also stresses on rainwater harvesting in order to bolster the water table (The Pioneer, 2012). In 2011, Pune Municipal Corporation proposed a resolution to make mandatory for all constructions with more than 80 flats (new and old) to have an on-site wastewater treatment unit (TOI, 2011). Similarly, Jaipur too is in the process of initiating compulsory wastewater treatment units on site for all building complexes.

The SWINGS results will be exploited mainly in developing countries as India market although EU market could be also a potential market where integral and cost-effective wastewater treatment plants can be implemented for wastewater reuse in agriculture field or public uses. The commercialization of decision support systems (DSS) for selection of the best WW treatment alternative in a specific location and the use of a sustainable technique for pathogen detection can also be carried out either in India or EU. The exploitable SWINGS results are the following:

1. Decentralised pilot plant design and application procedures.
2. Design of low cost WW reuse technology based on AD and CW.
3. Optimization techniques of AD-CW configuration operation.
4. Performance of low-cost natural disinfection technologies.
5. Integral WW reuse systems.
6. Use of the DSS for selection of WW treatment alternative.
7. Development of sustainable pathogen monitoring technique.

The end-users or stakeholders of exploitable SWINGS results are the following:

- Companies working on wastewater management: Technology providers, WW pilot plant manufacturers, sanitation companies. These companies will buy the design and the guidelines for the construction and implementation of a cost- effective WW treatment plant for settlements up to 150,000 population equivalent (PE) (Results Nº 1, 2 and 5). In addition, these companies will use the procedures for the best operation of SWINGS WW treatment plants (Result Nº 3) through a technical advising. Finally, these companies will buy DSS (Result Nº 6) to select the best WW treatment plant configuration for a specific location and WW characterization.
- Companies working on drinking water provision: fresh water technology providers, sanitation companies. These companies will be interested on buying the design and the guidelines for performance of low cost disinfection systems (Result Nº 4) to be used on those locations where drinking water can be supplied from ground water. In addition, these companies will buy also the guidelines for implementation of a sustainable pathogen monitoring technique (Result Nº 7) in order to fulfill the legislated quality of the treated water to be used for human consumption.
- Authorities: Local (municipalities), regional or national bodies. These end-users will subcontract WW technology companies for implementing low cost WW treatment plants (Result Nº 1, 2 and 5) and drinking water technology companies for implementing low cost water disinfection systems (Result Nº 4). On the other hand, authorities who are in charge of the WW management could also acquire the procedures for the best operation of SWINGS WW treatment plants (Result Nº 3) through a technical advising. In addition, authorities will buy the DSS (Result Nº 6) in order to decide the best treatment option to a specific location.
- Agricultural cooperatives. Farmers and agricultural companies who are interested on re-using their own WW will be able to buy integral WW re-use systems (Result Nº 5) in order to use the treated WW into the agriculture field. In order to guarantee the disinfection of the treated water, these end-users will also buy the guidelines for implementation of a sustainable pathogen monitoring technique (Result Nº 7).

In order to extend the potential benefits of SWINGS project, a robust activity of dissemination and exploitation had been carried out. A brief quantification of these activities is:

- Peer-reviewed publications submitted: 3
- Press releases: 3
- Newsletter: 3
- Leaflets: 3
- Short video: 1
- Stakeholder forums: 3
- Conference, fair or seminar contributions: 22

Main dissemination activities on the website: www.swingsproject.com

5. USE AND DISSEMINATION OF FOREGROUND

LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES										
NO.	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Year of publication	Relevant pages	Permanent identifiers (if available)	Is/Will open access provided to this publication?
1	Implementing advanced CW technology in India: SWINGS a cooperation project aimed at providing integral domestic wastewater treatment and reuse	Carlos A. Arias	Wastewater Treatment	Submitted on May 2014 (rejected)	Ecological engineering	UK	-	-		-
2	SWINGS, treatment wetland technology and knowhow transfer for the treatment and reuse of wastewater in India	Carlos A. Arias	Wastewater Treatment	Submitted on October 2015 (rejected)	Water Practice & Technology	UK	-	-		-
3	Constructed wetland and disinfection technologies for the treatment and reuse of wastewater in India. SWINGS project	Juan A. Alvarez	Wastewater Treatment	Submitted on January 2016	Environmental Technology	UK	2016	8		-

LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities	Main leader	Title	Date/Period	Place	Type of audience	Size of audience	Countries addressed
1	Website	AIMEN	NA	20/12/2012	www.swingsproject.eu/	Scientific community; Industry; Civil society	180 visits/month	EU and India
2	Press releases	AIMEN	- Porrino-construira-depuradoras-low-cost-india. - Aimen-lidera-proyecto-sistemas-tratamiento-low-cost-agua-india	05/10/2012	http://www.lavozdegalicia.es/noticia/vigo/2012/10/04/porrino-construira-depuradoras-low-cost-india/00031349349617731631831.htm http://www.farodevigo.es/economia/2012/10/05/aimen-lidera-proyecto-sistemas-tratamiento-low-cost-agua-india/691476.html	Civil society	- 580,000 readers - 348,000 readers	Spain

LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities	Main leader	Title	Date/Period	Place	Type of audience	Size of audience	Countries addressed
3	Technical dissemination	AIMEN	India-EU Water projects: Cluster activities	10/10/2012	IISC Bangalore, Bangalore, India	Scientific community; Industry; policy makers	150 attendees	India
4	Newsletter	DHI	'SWING'ING INTO ACTION	20/02/2013	Published in Technology Bulletin	Scientific community; Industry; Civil society	NA	EU and India
5	Other (publication of SWINGS reference in partner's website)	DHI	The SWINGS project: Optimising waste water treatment in India	27/02/2013	http://www.dhigroup.com/News/2013/02/27/TheSWINGSProjectOptimisingWasteWaterTreatmentInIndia.aspx	Scientific community; Industry; Civil society	2300 visits/month	EU and India
6	Technical dissemination	UFZ	IWA Specialist Group on Wetland Systems for Water Pollution Control(SWINGS project - Session3: Effective sanitation in developing regions)	12/06/2013	UFZ Wetland Workshop; UFZ Campus, Leipzig, Germany	Scientific community and Industry specialised on CW technology	55 attendees	EU
7	Conference, Fair or Seminar contribution	SSP	Demonstration of Small Portable Solar Driven Water Treatment System	01/09/2013	World Water Week; Stockholm International Water Institute, Stockholm, Sweden	Scientific community; Industry;	800 attendees	Worldwide
8	Conference, Fair or Seminar contribution	AIMEN	Implementing advanced CW technology in India: SWINGS	14/10/2013	WETPOL 2013; Ecole des Mines de Nantes, Nantes, France	Scientific community; Industry;	500 attendees	Worldwide
9	Newsletter	AMU	EU -India cooperation in water technology and management	15/10/2013	For Department of Science and Technology (DST)	Scientific community; Industry; Civil society	NA	EU and India
10	Newsletter	AU	SWINGS a cooperation project aimed at implementing integral domestic wastewater treatment and reuse using Constructed	15/10/2013	Published in International Water Association (IWA)	Scientific community; Industry;	NA	EU and India

LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities	Main leader	Title	Date/Period	Place	Type of audience	Size of audience	Countries addressed
			Wetlands and advanced disinfection techniques					
11	Technical dissemination	UPC	SWINGS Project: Safeguarding Water Resources in India with Green and Sustainable Technologies: Cluster activities	29/11/2013	NAWATECH project Workshop; UPC, Barcelona, Spain	Scientific community; Industry;	80 attendees	Spain
12	Technical dissemination	AIMEN	SWINGS project profile	15/01/2014	http://www.wise-rtd.info/en/info/safeguarding-water-resources-india-green-and-sustainable-technologies	Scientific community; Industry; Civil society	NA	EU
13	Technical dissemination	SSP/AUTARCON	Bank filtration to polish STP effluents for safe wastewater reuse	08/04/2014	Indo-German Workshop on Science-based Master Planning for Bank Filtration Water Supply in India Dresden, Germany	Scientific community; Industry;	150 attendees	EU and India
14	Conference, Fair or Seminar contribution	AUTARCON	Best Practice : Safeguarding Water Resources in India with Green and Sustainable Technologies (EU FP 7)	05/05/2014	IFAT 2014; Messe München GmbH München, Germany	Scientific community; Industry;	1200 attendees	Worldwide
15	Leaflet	AMU	SWINGS. Safeguarding Water Resources in India with Green and Sustainable Technologies	May 2014	AMU Technical meeting, Aligarh, India	SWINGS consortium;Scientific community; Industry;	NA	Worldwide
16	Press releases	AMU	- AMU joins hands with European Nations for water recycling. (Times of India, July 2014).	July 2014	Times of India	Civil society	More than 13,000,000 readers	India
17	Short Video	UPC	River Bank Filtration operation and implementation at KALYANI	July 2014	KALYANI (https://www.youtube.com/watch?v=f3NEWb06jzo)	Scientific community; Industry; Civil society	NA	Worldwide
18	Conference, Fair or Seminar contribution	UPC	Constructed wetland technology and the SWINGS project.	16/07/2014	International Seminar on Sustainability and the Future of Environmental Engineering. Kalyani University.	Scientific community; Industry; Civil society	About 80 attendees	India

LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities	Main leader	Title	Date/Period	Place	Type of audience	Size of audience	Countries addressed
19	Conference, Fair or Seminar contribution	AIMEN	Development of Indian wastewater treatment with the SWINGS project	21-26/09/2014	IWA World Water Congress and Exhibition, Lisbon, Portugal.	Scientific community; Industry;	2000 attendees	Worldwide
20	Conference, Fair or Seminar contribution	AU	SWINGS, treatment wetland technology and knowhow transfer for the treatment and reuse of wastewater in India	12-16/10/2014	IWA 14th International Conference on Wetland Systems for Water Pollution Control (ICWS), Shanghai, China	Scientific community; Industry;	1200 attendees	Worldwide
21	Conference, Fair or Seminar contribution	AUTARCON	Water Disinfection for Remote Areas of Developing Regions – An Innovative and Sustainable Approach using Solar Technology and Anodic Oxidation	6-7/11/2014	International Conference on Solar Energy Technology in Development Cooperation. Frankfurt, Germany.	Scientific Community;; industries; politicans and solar energy technologies; financiers	600 attendees	EU
22	Leaflet	AIMEN	SWINGS. Safeguarding Water Resources in India with Green and Sustainable Technologies	Nov 2014	AMU Technical meeting, Aligarh, India	;Scientific community; Industry;	NA	Worldwide
23	Press releases	AMU	- AMU Vice Cancellor offers to help PM Modi in cleanning up Ganga. (Times of India, February 2015)	Feb 2015	Times of India	Civil society	More than 13,000,000 readers	India
24	Stakeholder forum	KILIAN	SWINGS Project	Feb 2015	KILIAN Water Open house	Denmark Stakeholders	50	Denmark
25	Technical report	UPC	Numerical simulation of organic and hydraulic overloads on the performance of horizontal subsurface flow constructed wetlands at AMU pilot-plant	March 2015	UPC, Barcelona, Spain	Scientific community; Industry;	NA	Worldwide
26	Conference, Fair or Seminar contribution	UPC	Safeguarding water resources in india with green and sustainable technologies	June 2015	6th European Bioremediation Conference. Chania, Crete, Greece.	Scientific community; Industry;	600 attendees	EU
27	Conference, Fair or Seminar contribution	UPC	Safeguarding water resources in India with green and sustainable technologies	2-7/8/ 2015	7th Asia Pacific Association of Hydrology and Water Resources (APHW). Singapore,	Scientific community; Industry;	600 attendees	EU

LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities	Main leader	Title	Date/Period	Place	Type of audience	Size of audience	Countries addressed
28	Conference, Fair or Seminar contribution	AIMEN	Constructed wetland and disinfection technologies for the treatment and reuse of wastewater in India. SWINGS project	13-18/09/2015	6th International Symposium on Wetland Pollutant Dynamics and Control (WETPOL 2015). York, UK.	Scientific community; Industry;	500 attendees	Worldwide
29	Conference, Fair or Seminar contribution	UPC	Implementation of green and sustainable technologies for wastewater treatment and reuse in India	18-22/10/2015	IWA Water and Development Congress & Exhibition. Jordan.	Scientific community; Industry;	600 attendees	Worldwide
30	Conference, Fair or Seminar contribution	AIMEN	High-rate anaerobic systems as low cost pre-treatment for wastewater treatment followed by constructed wetlands	15-18/11/2015	IWA14th World Congress on Anaerobic Digestion. Viña del Mar, Chile.	Scientific community; Industry;	750 attendees	Worldwide
31	Leaflet	AIMEN	SWINGS. Safeguarding Water Resources in India with Green and Sustainable Technologies	Feb 2016	EIP water Conference. Leeuwarden, Holland.	Scientific community; Industry;	550 attendees	EU
32	Conference, Fair or Seminar contribution	AU/AIMEN	Swinging from toilet to tap. Ensuring proper wastewater treatment and reuse	16-20/02/2016	RESURBE III. International conference on urban resilience. UNAM, México DF.	Scientific community; Industry;	250 attendees	Worldwide
33	Conference, Fair or Seminar contribution	UPC	Sustainable solutions based on constructed wetlands and solar powered disinfection for wastewater treatment and reuse in India (SWINGS project)	21-23 April 2016	INNOVATION IN SUSTAINABLE WATER AND WASTEWATER TREATMENT SYSTEMS (ISWATS) 2016 Pune, India	Scientific community; Industry;	About 300	Worldwide