Saph Pani

Enhancement of Natural Water Systems and Treatment Methods for Safe and Sustainable Watersupply in India

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Deliverable D 3.1

Report on experiences with constructed wetlands and techno-economic evaluation

SAPHPANI

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Abbreviations and acronyms

Abbreviation	Description	Dimension
AP	Anaerobic Pond	
BOD_5	Biochemical Oxygen Demand (5 day basis)	$mg.L^{-1}$
CPCB	Central Pollution Control Board	
CW	Constructed Wetland	
DP	Duckweed Pond	
FC	Faecal Coliform	
FP	Facultative Pond	
HRT	Hydrolic Retention Time	
KT	Karnal Technology	
MLD	Million Liters per Day	
MP	Maturation Pond	
NTSs	Natural Treatment Systems	
PP	Polishing Pond	
RTD	Research Training and Development	
SFA	Sewage Feed Aquaculture	
SS	Suspended Solids	
STP	Sewage Treatment Plant	
SF	Sub-surface Flow	
TN	Total Nitrogen	$mg.L^{-1}$
TP	Total Phosphorus	$mg.L^{-1}$
WHP	Water Hyacinth Pond	
WSP	Waste Stabilization Pond	
UASB	Up-flow Anaerobic Sludge Blanket	

1 The context and overview

Urbanization, which is proceeding at an accelerated speed around the world, has posed several new problems before urban residents. Inadequate water supply and poor water quality have been provoking serious contemporary concerns for many municipalities, industries, agriculture, and the environment. Inadequate infrastructure for rural and urban sanitation coupled with improper wastewater management practices, including disposal of untreated or partially treated wastewaters into the natural water courses, have deteriorated the water quality of almost all the aquatic resources in India. Communities are thirsty for potable as well as process waters. It has not been possible for communities living in the slums to get even 10 L of water per person per day. On one hand, there is an escalating demand for water for domestic, agriculture, as well as industrial purposes. On the other hand the available water is getting deteriorated as a result of disposal of domestic and industrial effluents.

The conventional mechanised wastewater treatment systems turn out to be rather expensive in terms of both, the installation as well as operation and maintenance costs. It is argued here that the newer solutions should be such that the peri-urban and small communities should be able to own and operate their wastewater treatment systems. Interestingly, in the recent past, communities seem to accept the natural treatment systems (NTSs) that are capable of providing adequate treatment to wastewaters in conjunction with supplementing fish and nutrition to the food baskets of the fishing communities engaged in managing the systems as well as generating adequate water for irrigation of farms and agro-forests. Above all, the engineered NTSs blend well with the agricultural, peri-urban, and rural ecosystems.

Section 1 of this report emphasizes on the status of wastewater treatment in India and corresponding challenges for the treatment of urban and rural wastewater followed by scope and objective of the **Deliverable 3.1**. Organisation of this deliverable has been presented at the end of this chapter.

1.1. The imminent challenges in urban and rural wastewater treatment in India

A large volume of wastewater continues to be discharged into natural watercourses leading to pollution of the coastal zones and drinking water reservoirs in India (Asolekar, 2001). Disposal of partially treated and mostly untreated effluents into rivers and lakes and runoff from urban and agricultural areas are the two main reasons responsible for deterioration of drinking water resources. In addition, excessive withdrawal of water for agricultural and municipal utilities as well as use of rivers and lakes for religious and social practices, and perpetual droughts limits the capacity of river for dilution of wastes (Asolekar, 2002).

In spite of the unprecedented laws and policies in India including Policy Statement for the Abatement of Pollution (1992), the National Conservation Strategy (1992) and the Policy Statement on Environment and Development (1992) the National Water Policy of (2002), and the National Environmental Policy (2005), there has been a steady deterioration of all the environmental sub-systems during the past five decades. For example, a large volume of wastewater continues to discharge into natural watercourses leading to the pollution of Indian coastal zones and drinking water reservoirs (Asolekar, 2001). Surprisingly, existing regulation appears inadequate while looking at the pollution caused by Indian communities and industries. Existing regulations and the approach of regulatory agencies appear to be inadequate to address the pollution caused by domestic sewage emissions and industrial wastewaters (Asolekar, 2002).

Although, the number of wastewater treatment plants has increased over the years in urban India, this increase is not adequate to keep pace with escalating generation of wastewater as depicted in **Figure 1.1.**

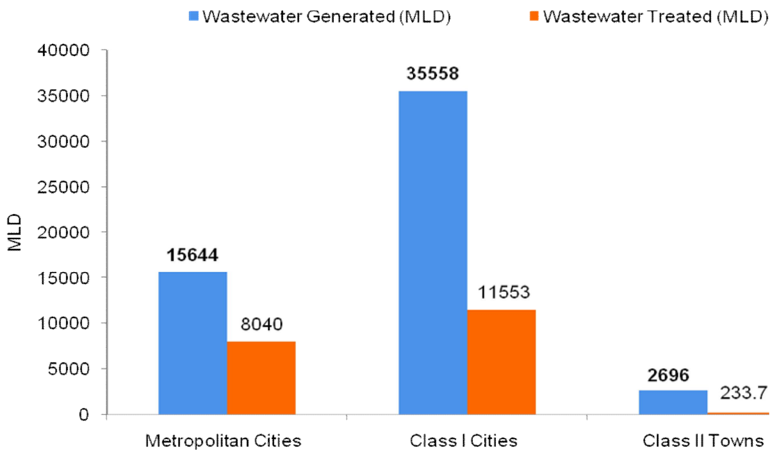


Figure 1.1 Trends of wastewater and management in India (CPCB, 2009)

1.2. Status on sewage generation and treatment in metropolitan cities, class-I cities and class-II towns of India

About 38,254 million litres per day (MLD) of sewage generated from Class I cities and Class II towns but only the treatment capacity of 12,000 MLD exists (CPCB, 2009). Thus, there is a large gap between amount of wastewater generation and treatment in India. Discharge of this untreated sewage into water courses both surface and ground waters is primarily responsible for water polluting in India. The bifurcation of sewage generated and treated in metropolitan cities, Class-I cities and Class-II Towns has been given in **Figure 1.2**. CPCB (2009) also reported the unsatisfactory operation and maintenance of existing plants and sewage pumping stations, as nearly 39% plants are not conforming to the general standards prescribed under the Environmental (Protection) laws for discharge into streams. Moreover, in a number of cities, the existing treatment capacity remains underutilized while a lot of sewage is discharged without treatment in the same city (CPCB, 2009).

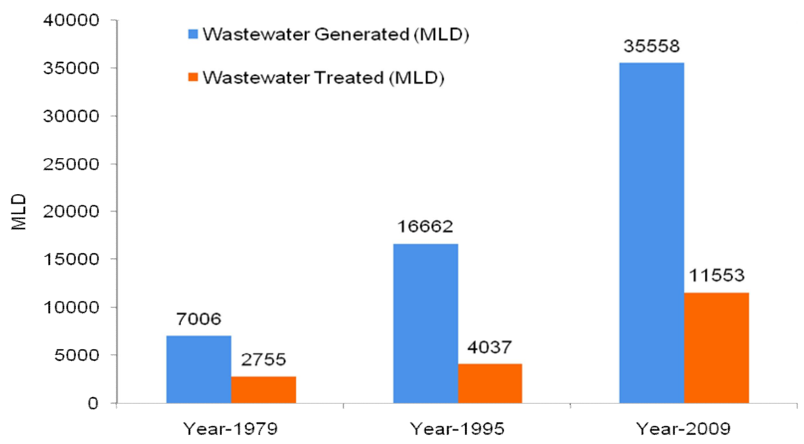


Figure 1.2 Status of wastewater generated and treated in metropolitan cities, class-I cities and class-II towns (CPCB, 2009)

Out of total sewage generated in all Class-I Cities and Class-II towns of India, 93 % is being contributed by Class-I cities only. There are 35 metropolitan cities (with population more than 10 Lakhs) from where 15,644 MLD of sewage is generated. The existing treatment capacity in metropolitan cities is 8040 MLD which is 51% of total generated sewage. The sewage generated in class-I cities was estimated as 35558.12 MLD and only treatment capacity 11553.68 MLD exists in these cities *i.e.* only 32% of wastewater has been disposed after the treatment. The generated sewage in class-II towns was estimated as 2696.70 MLD and only 233.7 MLD treatment capacities exists in these cities which shows only 8% of wastewater has been disposed after the treatment.

1.3. Natural systems for wastewater treatment: significance for India

Approximately 38,000 MLD wastewater generated from the 70% population of urban India (about 350 million populations), merely 27% receives some kind of treatment. The remaining 73% population of India is residing in small villages where wastewater collection at large-scale is not possible and the most suitable practices for Indian villages may be to establish the sewage treatment plants. The use of NTSs for domestic wastewater treatment is practically unrecorded in the past. The village tanks, which invariably receive pollution and are commonly green, can be taken as example, though unintended, of the early use of NTSs in the India. The natural depressions in the rural areas where all sullage finds its way, creating ponds, present another example of NTSs. In recent years NTSs have, however, been accepted to be installed as distinct treatment devices in India, designed based on certain empirical or rational criteria. According to the recent projections, by the year 2051, the domestic wastewater generation is going to be around 83,300 MLD in India (Bhardwaj, 2005). As the water availability per capita is going to reduce due to increase in population, there will be growing reliance on contaminated surface waters in any urban centre. Therefore, a definite road map needs to be chalked out by all the concerned stakeholders to improve the quality of surface waters.

1.4. Scope and objectives of the deliverable D3.1

The **deliverable D3.1** titled "Report on experiences with constructed wetlands and techno-economic evaluation" is scheduled to be submitted at the end of M18 (i.e. before 31st March, 2013). During this period, the main objective was "to capture the existing experiences with CWs and other NTSs for wastewater treatment in India". This objective has been addressed during the past 18 months by performing the respective sub-tasks listed under **Tasks 3.1 and 3.2** – which are elaborated further in this report. . It would be useful to recall the contents and focus of Tasks 3.1 and 3.2 as elaborated in DOW as follows:

Task 3.1: Assessment of the potential of existing CWs and other NTSsfor wastewater treatment and reuse across

The overall aim of this task was to survey of existing CWs and other NTSs across India and selection of engineered CWs and NTSs with special reuse potential and social relevance. Based on the national survey and assessment of CWs and other NTSs a few case studies were selected for further in-depth evaluation. The different sub-tasks performed for completion of Task 3.1 were as follows-

Sub-Task 3.1.1: A national survey of engineered CWs and other natural treatment systems

Physical, geographical and social aspects as well as performance capacity of the engineered CWs and other NTSs has been compiled.

Sub-Task 3.1.2: Classification of constructed wetland and natural treatment systems with an emphasis on reuse and/or social relevance

Based on the survey results, all systems have been classified and a few case studies has been selected for further investigation. This selection was based on type, quantity, and special features of reuse of treated wastewater.

Sub-Task 3.1.3: In-depth evaluation of selected case studies

Selected case studies from sub-task 3.1.2 have been evaluated in detail for their reuse potential and other special functions. Integrated assessments linking health, environment, society, and institutions have been dealt with WP6.

Task 3.2: Identification of strategies for enhancement of the potential of shortlisted constructed wetlands and other natural treatment systems.

This task was aims at identifying strategies for the enhancements of CWs and other NTSs. Concepts to improve their potential for treating wastewater to achieve reuse standards.

Sub-Task 3.2.1: Estimation of design parameters from existing plants (IITB and IWMI)

A detailed study on design of CWs and other NTSs of selected existing plants were carried out to estimate the design parameters. It was essential to study how a particular plant is designed and how it is being operated under the realistic situations and associated performance of the plant.

Based on these data, design parameters for the treatment systems were decided.

<u>Sub-Task 3.2.2</u>: *Elaboration of possible ways to improve the treatment systems through incorporation of advanced mechanized as well as natural treatment technologies (IITB and IWMI)*

Under this task improvement options for NTSs such as wetlands were elaborated in the following areas:

- Improving operational stability (e.g. reducing the clogging propensity) through incorporation of advanced pre-treatment mechanized treatment technologies.
- Selection of an ideally suited plant system and timing of harvesting periods
- Optimal arrangement of flow paths.
- Improving operational reliability with varying feed water qualities

The dependency on operational procedures and maintenance of the alternative systems were taken into account.

Optimal conditions were determined based on an India-wide review of good practice examples as identified in Task 3. 1. These parameters were determined for alternative uses such as:

- Providing water resources or grey water supplies to communities after appropriate disinfection
- Providing process water for industry
- Utilisation as pre-treatment before an advanced water reclamation system as investigated in the pilot study (Task 3.4)

1.5. Organization of the deliverable D3.1

During preparation of this report, efforts have been to capture the existing experiences with NTSs for wastewater treatment in India (Section 1 to 6). In section 1, efforts have been made to articulate the context and overview of NTSs and imminent challenges of wastewater treatment and management in India followed by the scope and objectives of deliverable D3.1. Section 2 covers understanding NTSs as well as their advantages, disadvantages, and future prospects. Section 3 describes the methodologies adopted for nationa survey and assessment and visited NTSs across India (Sub-task 3.1.1). Section 4, covers the classification of NTSs with its existing knowledge and new proposed approach of classification (Sub-task 3.1.2). Section 5 presents the detailed in-depth evaluation of selected case studies for their reuse potential and other special functions (Sub-task 3.1.3).

In the end, three annexures (Annexure A, Annexure B, Annexure C) comprising of brief description of visited engineered natural treatment systems across India, detailed survey of visited engineered natural treatment systems across India and available post-treatment and reuse of the wastewater effluents from engineered NTSs across India have been provided.

2 Literature review on natural treatment systems

The literature review and experience in the field of NTSs in past one decade suggests that the possible methods of NTSs apart from CWs includes, hyacinth and duckweed ponds, lemna ponds, fish ponds, waste stabilization ponds, oxidation ponds and lagoons and algal-bacterial ponds. Before starting the activities related with Task 3.1 and Task 3.2, the most possible methods for assessment of NTSs were reviewed. This section includes the possible methods of NTSs for wastewater treatment, their ecology, wastewater treatment scheme and removal mechanisms, usages, advantages, disadvantages, and the future prospects as well as their performance in different parts of the world.

Natural treatment systems have been proven a better alternative of wastewater treatment worldwide because it has minimum energy requirements, reduced maintenance and higher degree of treatment as compared with conventional treatment systems (such as activated sludge process) for the sanitation of small communities in the last few years as an alternative to conventional systems (Mara *et al.*, 1992; Brix, 1994; Vymazal, 2002; Bécares, 2006; Puigagut *et al.*, 2007). There are different type of NTSs available and the most common includes, hyacinth and duckweed ponds, lemna ponds, fish ponds, waste stabilization ponds, oxidation ponds and lagoons and, algal-bacterial ponds. The brief description of NTSs, their ecology, usage, advantages, disadvantages, and future prospects are as follows:

2.1 Waste stabilization ponds

The term pond refers to a relatively shallow body of water, contained in an earthen basin, artificial or natural, retaining sewage or organic wastewaters to stable the wastes and to make them inoffensive for discharge into receiving water body or on land through various physical, chemical, and biological processes, involved therein. In the relatively short period of history, ponds have been referred to by many different names including oxidation ponds, maturation ponds, sewage lagoons, anaerobic lagoons, facultative lagoons and waste stabilization ponds. The term “waste stabilization ponds (WSPs)” has been more widely adopted, as it is more descriptive of the real function, and includes aerobic as well as anaerobic modes of stabilization (Arceivala et al, 1970).

WSPs are the simplest of all waste treatment techniques available for sewered wastewaters. Their advantages stem from their extreme simplicity and reliability of operation. Nature cannot go wrong; there is no equipment to fail; no tricks to successful operation. But, nature is slow, requiring long detention periods, which in turn imply large land requirements. Biological activity is also considerably affected by temperature, more so in the pond’s natural conditions. Thus, WSPs are most appropriate where land is inexpensive, climate favourable, and a simple method of treatment is desired not requiring equipment and operating skills (Gloyna, 1971). WSPs are the most frequently examined configurations and many large-scale applications have been constructed and operated (Cauchie *et al.*, 2000). Other related systems of WSPs like high rate algal ponds, anaerobic ponds, floating aquatic plant ponds have also been studied in past but in many of the cases cited in the literature; no special reference is made to practical applications of these methods for wastewater reuse. Therefore, to assess the realistic application of WSPs at large scale setups are the utmost need in order to replicate this technology in different parts of the world.

Ecology of WSPs: In a WSP ecosystem, the principal abiotic components are oxygen, carbon dioxide, water, sunlight, and nutrients while the biotic components include algae, bacteria, protozoa and a variety of other organisms. **Figure 2.1** shows the different components of the pond system and their interrelationships.

Removal mechanisms: Based on biological processes taking place, WSPs can be classified in three classes: 1) aerobic, 2) facultative, and 3) anaerobic ponds. On the basis of water depth, ponds can also be classified into two classes: a) shallow ponds and b) deep ponds. Shallow ponds (1 - 1.5 m water depth) include conventional aerobic wastewater treatment ponds and polishing or maturation ponds. The deep ponds (1.5 - 6 m water depth) typically include facultative ponds having aerobic, facultative and anaerobic layers. The deep ponds also include anaerobic ponds having 5 - 10 m depth.

In Indian conditions scheme for sewage treatment plant based on waste stabilization ponds includes grit chamber and screen followed by ponds (anaerobic, facultative, and then maturation ponds) in series or parallel depending on the availability of lands and other process considerations. Being a representative natural treatment system WSPs employs nature's potential to for the treatment of wastewater. The principle mechanisms includes sedimentation, nitrification, denitrification, enhanced biodegradation by using physical components of the systems including oxygen transferred at air-water interface as well as solar radiation.

Literature describing performance of WSPs: The performance of each type of can be judged from there different viewpoints: (i) BOD Removal, (ii) micro-organism reduction, and (iii) nutrient removal. It should also be noted that being a natural system, its performance varies from day to day, and even hour to hour, depending upon its location, temperature, sunlight and other climatic factors. Performance must also be judged in the light of possible undesirable developments (e.g., sulphides odours, mosquito breeding and ground water pollution) which may occur (Arceivala and Asolekar, 2007). Engineering performance is detected in large measures by various factors, without creating offensive conditions. The presence of both bacteria and algae symbiotic action is essential to convert the complex organic substrate contained in the wastewater to simpler inorganic end-products like the nitrates and phosphate whose uptake lead to the production of more bacteria and algae, some of which flow out with the effluent.

WSP are usually arranged in series of anaerobic, facultative and maturation ponds to improve the efficiency of their performance (Marais, 1974). The quality of the treated effluent by WSPs depends on both the process design and the physical design of the WSP. Arthur (1983) and Mara *et al.* (1992) have reported that poor performance of WSP in developing countries can be attributed to both poor process design and poor physical design. Each type of WSP components carries the unique function; for this reason different ponds in the system should be correctly designed in order to achieve their proposed purpose. Anaerobic and facultative ponds are normally designed for BOD removal, while maturation ponds are designed to remove excreted fecal coliformss.

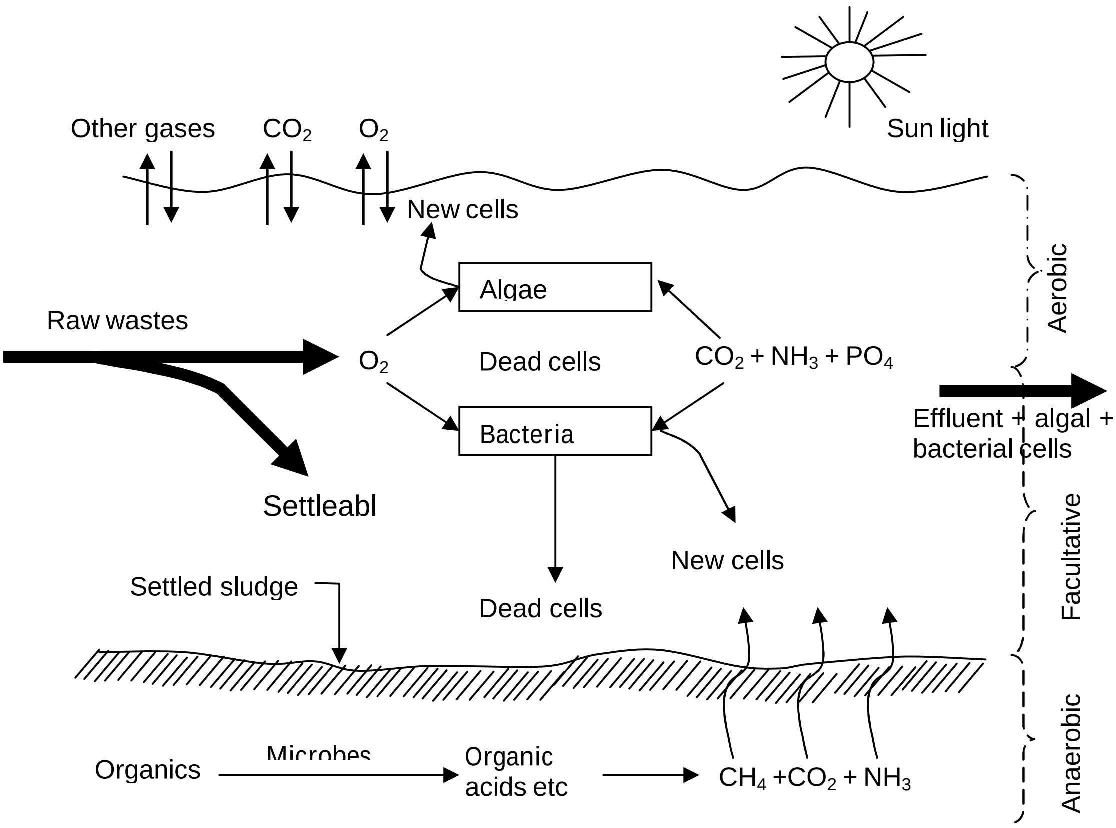


Figure 2.1 Ecology of a typical facultative waste stabilization pond (Adopted from Arcievala, 1998)

Based on different kind of biological processes taking place in WSPs, they may be classified under three groups, namely, aerobic, anaerobic and facultative. WSPs are the most appropriate natural technology for treating sewered wastewater where the land is inexpensive, climate favourable and a simple method not requiring equipment and operating skills is desired (Gloyna, 1971). WSPs are the simplest of all waste treatment techniques available for treatment of sewered wastewaters (Arceivala, 1980, 1999); but contain a complex ecological system, consist of algae, virus, protozoa, rotifers, insects, crustaceans, and fungi. These microbial communities stabilize the organic waste and lower the effluent pathogen levels. Due to which their advantages stem from their extreme simplicity and reliability of operation, WSPs have been implemented in both small-and large-scale communities around the world (Cauchie *et al.*, 2000).

The functional performance of WSPs systems is dependent upon numerous factors, including: the type of wastewater; the organic loading regime; the geometry and physical configuration of the pond system; climatologically and environmental conditions (Cauchie *et al.*, 2000). In addition to these criteria, the overall treatment efficiency of WSPs has been determined by the hydraulic behaviour of wastewater within the system, since it controls the hydraulic residence time (HRT) and also the residence time distribution (RTD) which governs the dispersion (mixing) of targeted waste substrates and biological entities within the reactor basin (Uhlmann, 1979; Kilani and Ogunrombi, 1984; Naméche and Vasel, 1996). Performance of WSPs in context with various wastewater treatment can be greatly influenced by problems directly related to the HRT and stemming from anomalies in the hydrodynamic flow pattern (e.g., recirculation, short-circuiting or the existence of dead spaces) (Ferrara and Harleman, 1981; Cauchie *et al.*, 2000; Sweeney *et al.*, 2007). The hydrodynamic behaviour is one of the few operational parameters that pond designers and operators actually have a degree of control over (Short *et al.* 2010).

In order to calculate the yield of various reactions with kinetic parameters taking place in WSPs -detailed information on flow behaviour is required (Baléo *et al.*, 2001). Recent refinements in design, and improved operation and maintenance enable the ponds to be approached as reactors; that affected by the reaction kinetics and flow patterns of systems. Different models use large quantity of parametric assumptions during formulations of different kinetics involved in physical, chemical and biological processes; which take place in the reactor that may gives the different outcomes when small variations in the parameters of the model have been subjected. The reliability of any model has been examined with realistic results obtained by analytical investigations in a convinced episode.

2.2 Duckweed ponds

It has already been recognized among the community of ecological engineers and scientists that plants are capable of denaturing several pollutants and the biomass generated during the course of treatment which could eventually be fed to fishes or animals. Cost effectiveness of the plant-based technologies would depend on two: 1) selection of the most suitable plant species and 2) the employment of suitable engineering of landscape that would efficiently bring polluted waters (or soils) in contact with the competent root zones.

Categorized as the hybrid systems among engineered natural systems, duckweed ponds (DPs) are now emerging as one of the appropriate sewage treatment options around the world. Although the use of duckweed systems in sewage-fed fisheries has been explored at lab-scale or pilot-scale, the awareness about the technology is still in its infancy. So far, only a few demonstration projects or pilot-scale systems have come up, around the world. In Indian subcontinent too, there are not many experiences of use of DPs for treatment of sewage. In this section, an attempt has been made to address the engineering and ecological issues related to performance of duckweed-fed fishponds for treatment of community wastewater.

<u>Ecology</u>: Duckweed refers to family of floating aquatic plants with the scientific name *Lemnaceae*. The *Lemnaceae* are monocots (like grasses and palms) and are divided into five genera: *Lemna, Spirodela, Wolffia, Landoltia*, and *Wolffiella*. Duckweed species are

the smallest of all flowering plants. Their structural and functional features have been simplified by natural selection to only those necessary to survive in an aquatic environment. A typical Indian duckweed plant consists of a pair of leaf-like flat structure (called as fronds), which function like leaf as well as stem and rootlets. Some species may have relatively more developed hair like rootlets. In either case, the rootlets are mere extension of stem and are not in true sense the roots (Chaturvedi *et al.*, Langote, and Asolekar, 2003). Species of the genus *Spirodela* have the largest fronds, measuring as much as 20 mm across, while those of *Wolffia* species are 2 mm or shorter in diameter. *Lemna* species are intermediate size at 6 to 8 mm. Compared with most other plants, duckweed fronds have little fibre (<5% w/w) because they do not need structural tissue to support leaves or stems. Thus, duckweed produces more protein on average and therefore has great potential as a feedstock for aquaculture.

<u>Removal mechanisms</u>: Configuration of the system would vary according to the situation including characteristics of the wastewater to be treated as well as objective of the treatment (for e.g. treatment and disposal versus treatment and reuse). Typical duckweed fed pisciculture for treatment of sewage is depicted in **Figure 2.2**.

The mechanisms of treatment of wastewater in a DP are rather simple to explain. Hungry duckweed plants (*i.e.*, plants unable to find sufficient nutrients to maintain their rapid growth) undergo a notable metamorphosis wherein plant protein drops below the normal content, fiber content goes up, roots become long and stringy, fronds become larger and discolored, and most importantly, the plants begin processing (*i.e.* absorbing, containing, and degrading) contaminants present in the wastewater bulk in their search of nutrients for their sustenance. A schematic of processing of wastewater in a duckweed pond is depicted in **Figure 2.2**. Environmental conditions and treatment processes prevalent in DPs differ significantly from those found in facultative ponds (FPs) for wastewater treatment, based on algal-bacterial systems.

The various mechanisms involved in removal and treatment of TSS, BOD, nitrogen, phosphorous, heavy metals, and organic toxins, as assumed by various authors can be summarized as follow (SANDEC, 1999):

- TSSs are removed mainly by sedimentation and biodegradation of organic particles in the pre-treatment and DP. The roots of the duckweed absorb a minor fraction where organic particles undergo aerobic biodegradation by microorganisms, and the plants assimilate part of the degraded products.
- Algal contribution to TSS is low in duckweed systems since penetration of sunlight is greatly reduced by a dense duckweed cover, which inhibits subsequent algal growth.
- Microorganisms attached to the duckweed fronds aerobically digest BOD. Anaerobic processes are responsible for BOD removal in the sediment.
- Aerobic degradation of BOD may be less important in duckweed systems than in other natural systems like water hyacinth-systems due to lower oxygen supply and smaller plant surface area for attached bacterial growth.

- Besides plant uptake, denitrification and volatilization of ammonia are quantitatively relevant processes for nitrogen removal duckweed systems.
- Plant uptake and sedimentation are quantitatively relevant for phosphorous removal in duckweed systems.
- The two mechanisms viz. phyto-filtration and phytoaccumulation are involved in heavy metal removal.
- The dense mat of duckweed acts as physical and chemical barrier against mosquito larvae and odour development.

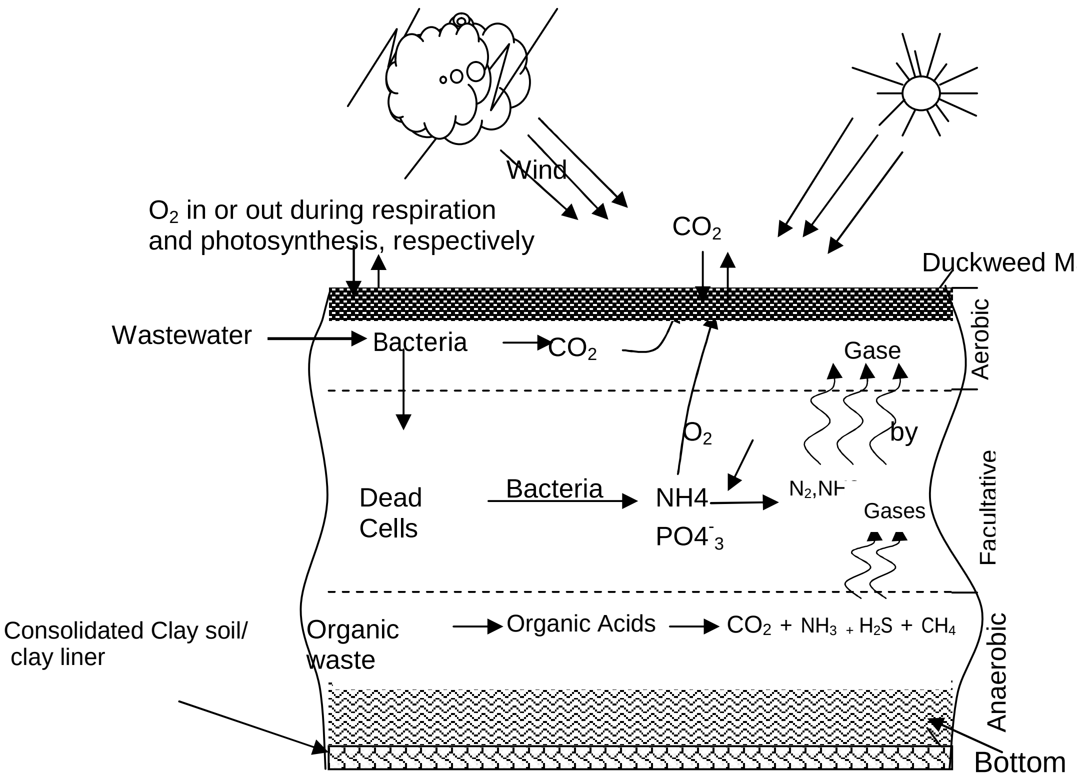


Figure 2.2 A schematic of processing of wastewater in a duckweed pond (Source: Chaturvedi, Langote, and Asolekar, 2003)

Duckweed based sewage-fed fisheries: In Indian subcontinent, there are not many experiments of duckweed for sewage treatment in the large-scale engineered treatment systems; though duckweed grows in abundance in the natural ponds and lakes, particularly in the eastern parts of the country, and contributes in pollution removal as part of natural wastewater treatment. The typical flow sheet for duckweed-fed aquaculture for sewage treatment is depicted in **Figure 2.3**.

Advantages, disadvantages and future prospects: This technology is most suitable in tropical climates. It is inexpensive to construct and operate, and easy to implement. Since duckweeds are prolific plants, especially in nitrogen-rich environments, and therefore can be easily used as a natural soil organic enrichment. If the flows through the FP are not properly controlled, there is a possibility that the duckweed will flow out with the effluent. Treatment capacity may also be lost during high floods, if the area is not protected.

More research through field trials is needed in order to refine the sizing of the ponds used and to determine the correct inoculums of plant material to achieve a predetermined effluent quality. The need to study and model the oxygen transfer in such systems at air-water interface cannot be overemphasized.

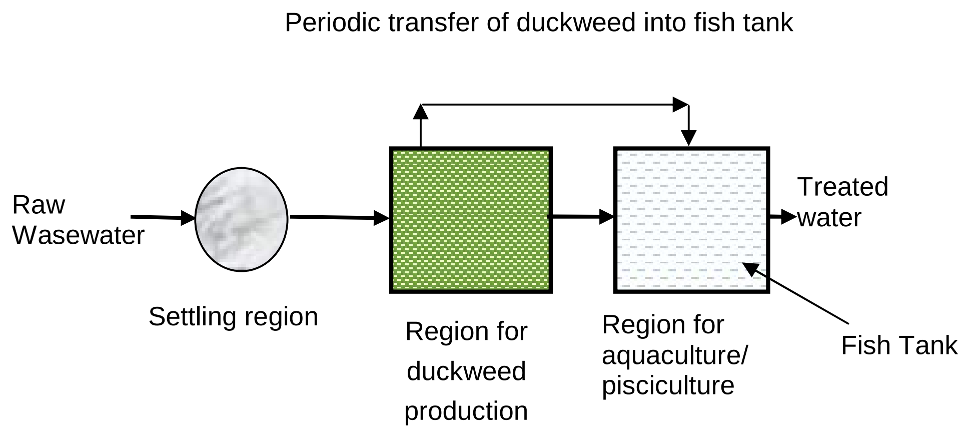


Figure 2.3 Typical flow sheet for duckweed-fed aquaculture for sewage treatment

The pollutant removal performance of some duckweed pond has been given in **Table 2.1** The eco-technologies like duckweed based wastewater treatments are still in their infancy. Utilizing nature's potential to treat domestic wastewater may work-out to be inexpensive than the conventional options. The installation costs are typically lower because these installations use standard or slightly modified earthen structures and practices. Because the primary energy input is solar, operating costs are also low. Although, the low cost is attractive, the technology has just begun to gain some commercial acceptance in India during the past few years by the virtue of encouraging findings from research on field scale. The rate and extent of treatment of various constituent of domestic wastewater in the Indian context, however, is yet to be determined.

Table 2.1 Pollutants removal performance of in duckweed ponds

Sr.No	% Removal of Pollutant											Reference
	BOD	COD	TSS	Nitrogen			Phosphorus			Bacteriological		
				TN	NH_3	Nitrate	TP	Phosphate	Ortho-Phosphate	Entero cocci	E Coli	
1	50	50	90	NA	NA	70	NA	65	NA	NA	NA	(Dalu and Ndamba, 2003)
2	NA	83.67	-	86.49	NA	NA	71.72	NA	83.26	NA	NA	(Ozengin and Elmaci, 2007)
3	NA	74.55	-	83.69	NA	NA	85.4	NA	94.99	NA	NA	(Kheir *et al.*, 2007)
4	90.6	89	96.3	-	80	NA	NA	43.6	64.4	NA	NA	(Kheir *et al.*, 2007)
5	NA	64.4		21.78	NA	NA	23.02	NA	NA	NA	NA	(Jianbo *et al.*, 2008)
6	94	NA	63	NA	72	NA	NA	NA	1.1	91.76	99.65	(Papadopoulos and Tsihrintzis, 2011)

NA = Not Available; BOD_5 = Five day BOD; TN = Total Nitrogen; TP = Total Phosphorus

2.3 Constructed wetlands

CWs are typical l engineered NTSs, designed and constructed to utilize the natural processes involving wetland vegetation, soils, and their associated microbial assemblages to assist in treating the wastewater. They have been gaining increased international interest and now being assumed highly applicable in developing countries, due to their characteristics like utilization of natural processes, simple construction, simple operation and maintenance (O/M), process stability, and above all their cost effectiveness.

Recognizing the widespread potential usage of this eco-technology approach, in this section an attempt has been made to discuss the aspects related to the structure (components) and function (working mechanisms) of this manmade model ecosystem. Implicit design and observed performance as well as potential usage of the technology have also been given appropriate pace.

There are two types of CW: free water surface CWs (FWS CWs) and sub-surface CWs. In FWS CWs, wastewater flows through a shallow water layer over a soil substrate. Sub-surface CWs may be either subsurface horizontal flow CWs (SSHF CWs) or sub-surface vertical flow CWs (SSVF CWs). In SSHF CWs, wastewater flows horizontally through the substrate whereas in SSVF CWs, wastewater is dosed intermittently onto the surface of sand and gravel filters and gradually drains through the filter media before collecting in a drain at the base. CWs may be planted with a mixture of submerged, emergent and, in case of FWS CWs, floating vegetation (Healy *et al.* 2007). The CWs provides the large area as well as appropriate environment for the physical/physico-chemical retention and biological reduction of organic matter and nutrients (Geary and Moore, 1999; Knight *et al.*, 2000).

Ecology of CWs: Wetlands, being defined as representative transitional areas between land and water, encircle a broad range of wet environments; including marshes, bogs, swamps, meadows, tidal wetlands, floodplain, and ribbon (riparian) wetlands along stream channels, behave like a kidney of the earth ecosystem. The larger aquatic plants growing in wetlands are usually called macrophytes. These include aquatic vascular plants, aquatic mosses and some larger algae (Brix, 1997).

As depicted in **Figure 2.4**, wetlands are often located at the ecotones between dry terrestrial systems and permanently flooded deepwater aquatic systems such as rivers, lakes, estuaries, or oceans. As such they have an intermediate hydrology, a biogeochemical role as source, sink or transformer of the chemicals and generally high productivity if they are open to hydrologic and chemical fluxes.

Wastewater treatment mechanisms: The CWs appears to perform all of the biochemical transformations of wastewater constituents that take place in conventional energy intensive, environmental engineering based systems including activated sludge process, septic tanks, drain fields and other form of land treatments. Transformation of these naturalized treatment systems have been shown to have a significant capacity for both wastewater treatment and resource recovery (Hofmann, 1996). The removal mechanism in CW systems is summarized in **Table 2.2**.

Table 2.2 Removal mechanisms in CW systems

Constituents	Free water systems	Subsurface flow
Biodegradable organics	Bioconversion by aerobic, facultative, and anaerobic bacteria on plant and debris surfaces of soluble BOD, adsorption, filtration, and sedimentation of particulate BOD	Bioconversion by facultative and anaerobic bacteria on plant and debris surfaces
Suspended solids	Sedimentation, filtration	Filtration, sedimentation,
Nitrogen	Nitrification/denitrification, plant uptake, volatilization	Nitrification/denitrification, plant uptake, volatilization
Phosphorous	Sedimentation, plant uptake	Filtration, sedimentation, plant uptake
Heavy Metals	Adsorption of plant and debris surfaces, sedimentation	Adsorption of plant and debris surfaces, sedimentation
Trace organics	Volatilization, adsorption, biodegradation	Adsorption, biodegradation
fecal coliformss	Natural decay, perdition, UV irradiation, sedimentation, exertion of antibiotics from roots of plants	Natural decay, perdition, sedimentation, exertion of antibiotics from roots of plants

(Adopted from Crites and Techobanoglous, 1998)

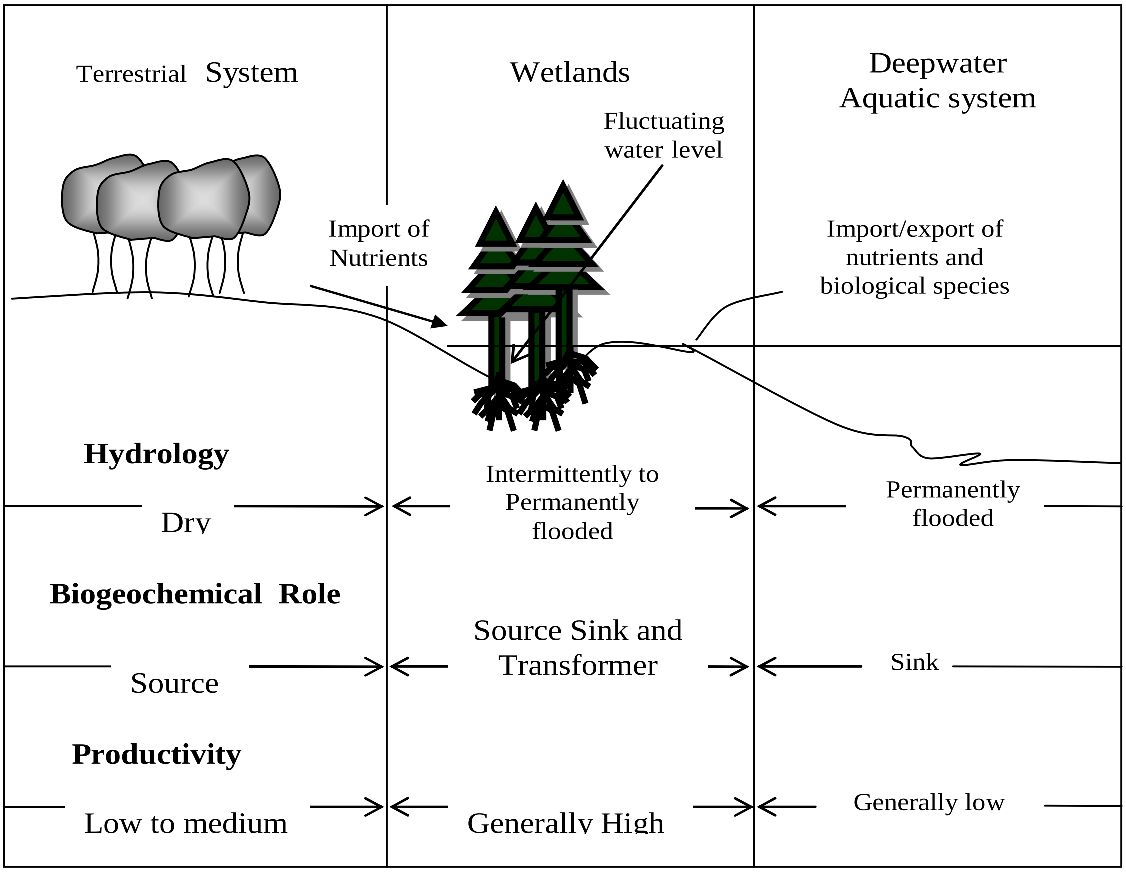


Figure 2.4 Position of wetland in nature (Adopted from Mitsch and Gosselink, 1993)

These systems have also been found to be very effective in removal of BOD, SS, and nitrogen, phosphorous, metals, trace organics, and fecal coliformss more effectively than conventional means. However phosphorous removal capacity varies from system to system and depends largely on site-specific factors. This reduction is accomplished by diverse treatment mechanisms viz. sedimentation, filtration, chemical precipitation and adsorption, microbial interactions, and uptake by vegetation. The principal removal and/or transformation mechanism involved in the CW systems has been summarized in **Table 2.2**. As shown in **Table 2.2**, it is difficult to separate constituent removal and transformation processes, as both occur simultaneously in these systems.

The macrophytes growing in CWs have several properties in relation to the treatment process that make them an essential component of the design (Brix, 1997). Choosing of plant species for treatment of wastewater by CWs always remains a difficulty to scientists working in this area because metabolism of the macrophytes affects the treatment processes to different extents depending on the type of the CW. The plants species used in CWs designed for wastewater treatment should therefore: (1) be tolerant of high organic and nutrient loadings, (2) have rich below-ground organs (*i.e.* roots and rhizomes) in order to provide substrate for attached bacteria and oxygenation (even very limited) of areas adjacent to roots and rhizomes and (3) have high above-ground biomass for winter insulation in cold and temperate regions and for nutrient removal via harvesting (Alova *et* *al.*, 1996; Kv *et al.*, 1999). Vymazal (2011) has reviewed the plants used in CWs with horizontal subsurface flow and concluded that local species which are easily available and grow well under local climatic conditions. Among those plants, many ornamental species have been used, especially for on-site treatment where aesthetic and pleasing look is often a part of the design (Vymazal, 2011).

Usage of CWs: CWs are used extensively to treat domestic (Kadlec and Knight, 1996) and industrial wastewater (Hammer, 1989; Cooper *et al.*, 1996; Billore *et al.* 2001). They have also been applied to passive treatment of diffuse pollution including mine wastewater drainage (Hammer, 1989; Jing *et al.*, 2001), and highway runoff following storm events (McNeill and Olley, 1998). Besides, wetlands, being a model ecosystem, can serve as wildlife habitats and can be perceived as natural recreational areas for the local community (Hawke and José, 1996). The performance of some CWs systems is given in **Table 2.3**

<u>Advantages, disadvantages, and future prospects</u>: This emerging technology has enormous potential for application in India, as climate is conducive for higher biological activity and productivity, hence can harness better performance of wetland systems. Further to this, Indian regions are known to sustain a rich diversity of biota that may be used in wetlands. Although land may be a limiting factor in dense urban areas in India (class 1 cities), CWs are potentially well suited to smaller communities (class-2 & 3 cities and for 5 lakhs villages, where municipal land surrounding schools, hospitals, hotels and rural areas is not in short supply. If, for the sake of simplicity, capital investment costs are taken into account, conventional activated sludge process costs Rs. 600-700 per capita; assuming each person contributes average 180 L volume and 50 g of BODL every day. Whereas the cost for stabilisation ponds could be Rs. 150-200 per capita. As stated earlier, that CWs are very similar to waste stabilization lagoons from a maintenance and operational perspective, therefore the cost for waste stabilization can be taken as 200 per capita/day

CWs have been implemented as wastewater treatment facilities in many parts of the world, but to date, the technology has been largely ignored in developing countries in general and Indian sub-continent in particular, where effective, low cost wastewater treatment strategies are urgently needed. In the appropriate climatic condition of India, CWs may be successfully established with plant species acclimated to the tropical environment and able to be harvested for use in secondary functions like fuel production.

The performance of CW depends on many factors including their type, its design, organic loading rate and HRT (Karpiscak *et al.*, 1999). Inspite of having significant nutrient removal capability, the effect of changing temperatures, the treatment efficiency of CW tends to change throughout the year (Bachand and Horne, 2000; Healy and Cawley, 2002).

Table 2.3 Performance of some CWs systems

Sr. No.	% Removal Performance							Reference
	BOD_5	COD	TSS	TN	TP	Faecal Coli form	E Coli	
1.	86	NA	39	75	80	99.8	NA	(Nelson,1998)
2.	65	53	53	42	42	97	NA	(Knight *et al.*, 2000)
3.	87.5	89	66.5	NA	NA	99.99	NA	(Ansola *et al.*, 2003)
4.	57-78	71-77	70.7	NA	NA	100	NA	(Billore *et al.*, 2007)
5.	91–99	NA	52–90	72–92	72–77	NA	NA	(Sohsalam *et al.*, 2008)
6.	75	36	41	76	75	NA	NA	(Baskar *et al.*,2009)
7.	96.2	97.6	84.3	NA	21.4	99.99	99.99	(Kelvin and Tole, 2011)
8.	64.5	68	79.7	20.7	21	NA	NA	(Erkan Kalipci, 2011)
9.	47.8	67.8	90	60.7	52.7	NA	NA	(Kimani *et al.*, 2012)

BOD_5 = Five day BOD; TN = Total Nitrogen; TP = Total Phosphorus

2.4 Sewage-fed aquaculture

Aquaculture referes to the farming of aquatic organisms including crocodiles, alligators, amphibians, finfish, molluscs, crustaceans and plants - where farming implies some forms of intervention in the rearing process to enhance production. Periodic stocking, feeding, protection from predators, etc. are the integral steps in this farming practice. Normally three components must be fulfilled for an activity to be classified as aquaculture namely: 1) the cultured organism, 2) the practice, and 3) the ownership of product. Aquaculture, a relatively less developed farming practice compared to agriculture and animal husbandry, has now been found as rapidly expanding industry around the world in general and particularly in Asian countries. The reason behind unprecedented enthusiasm and acceptance lies with its positive social attributes viz. exceptional nutritional characteristics to alleviate under-nutrition, relatively high value and marketability to generate income, and the prospects offering agricultural diversification through construction of ponds as on-farm reservoirs. While considering integrated development paradigm, it is important to emphasize environmental constraints associated therewith. In this research, an attempt has been made to identify the technological challenges associated with wastewater aquaculture followed by a summary of the silent issues faced by the sector in the direction of greening of wastewater aquaculture.

Fish and aquatic plants are farmed for food or feed almost entirely in traditional wastewater-fed aquaculture systems; and mainly in East, South and Southeast Asia. Major systems in China and Vietnam are threatened by urbanization and industrialization, leading to declining areas, and contamination of fish with toxic substances, respectively. The Calcutta system is threatened by urbanization but several new systems have been implemented in smaller cities. Wastewater-fed aquaculture may progress through three successive developmental phases: a phase in densely populated pre-industrial societies in which scarcity of resources led to the development of the practice; a phase in early or rapidly industrializing societies with numerous constraining factors which characterizes most current systems; and possibly a phase in late industrial societies with widespread safe reuse from a public health point of view. Phase 3 is forecast as unlikely to occur, with the possible disappearance of most wastewater-fed aquaculture systems as most developing countries in Phase 2 are currently experiencing constraints which may lead to its disappearance; and today’s developed countries are unlikely to introduce the practice. Perhaps the best prospect for implementation of new wastewater-fed systems is in semi-arid and arid countries such as Egypt and Peru where pilot projects have demonstrated feasibility of practice and where there is increasing pressure to reuse wastewater. A second prospect is to produce fish meal for formulated animal feed.

Ecology of Sewage Fed Aquaculture: Ecology of the SFA system is same as of WSPs. The only addition to the later is a new kind of biological system: the fishes. The use of organic residues in aquaculture is best discussed with awareness of the following facts about aquatic biology: (i) Limitations to biological production in fresh, brackish, or ocean waters are predominantly dissolved nutrients and/or food as well as shelter or substrate. Seasonality and intensity of the input of solar energy are also important. (ii) In aquaculture (and incidentally in fisheries), what is eventually to be harvested has to be contained or concentrated.

Among these inputs, nutrients and/or food can be supplied, at least in part, by organic materials or residues. As aquaculture practices increase in magnitude and hasten the flow of materials and energy through the systems, compared to natural conditions, it stands to reason that fertilization wastes can, under certain conditions, save both monetary and caloric inputs. Likewise, judicious use of agricultural or organic industrial wastes as feed materials can lower the cost of growing aquatic animals.

<u>Wastewater treatment scheme and removal mechanisms</u>: Same as of DPs and WSPs.

<u>Usage of Sewage Fed Aquaculture</u>: Basically, the aquaculture employ flow through systems whereby residual feed and metabolic products are discharged to a nearby water body. In many countries, the discharge of nutrients rich aquaculture waters has contributed to the degradation of water quality in receiving water bodies. It is generally not perceived that the cultivation of seaweeds, mussels, and fish are ecologically completely different, putting entirely different demands on the environment, and affecting the ecosystem in completely different and even opposite ways.

Different aquaculture feeding strategies used within semi-intensive and intensive farming systems in selected Asian countries, and in particular the examination of their relative impacts upon the aquatic environment has been reviewed with due emphasis to environmental compatibility and central role played by small scale polyculture based integrated farming systems in Asian aquaculture, and the need to carefully balance exogenous supplementary feed inputs with the endogenous supply of natural food organisms within semi-intensive pond farming systems. In the case of intensive pond/cage-based farming systems attention was found focused on the need to further improve feed formulation, feed manufacture, and on-farm feed and water management so as to maximize feed intake and feed efficiency, and minimize feed wastage and water pollution.

Considering the cost-benefit analysis a certain amount of environmental cost should be included to enable safekeeping of the nature from aquaculture hazards. The form of association would be established to streamline and control the hazards and to make the ways obtaining better quality products through proper research. In this process, some of the remedies are as follows:

- Water quality control techniques like filtration, mechanical filter, air filter, bio filtration, chemical filtration, coagulation, oxidation, aeration and liming which assists in removing the impurities of water and make it reusable.
- Ozonization and Ultraviolet radiation of the wastewater not only eliminate the organic compounds by neutralization and oxidation, but also kills bacteria in the circulating water.

- Fly ash can be used for the removal of organic matter from shrimp farm effluent. The treatment with fly ash could remove all categories of organic matter and metallic ions present in the shrimp effluent which otherwise deteriorate the quality of waters.

Comparison of the energy requirements and nutrient recycling potential of wastewater aquaculture in conjunction with CWs facilities with that of conventional wastewater treatment technologies have suggested that the energy requirements of CWs are very low. If significant reuse of nutrients is included (aquaculture), the energy requirements increase significantly and usually beyond the energy equivalent of the biomass produced especially in context to cold temperate climates where the aquaculture systems need to be housed in heated greenhouses and artificial light must be provided to secure operation throughout the year. However, because CWs, besides the water quality improvement function, perform a multitude of other functions such as biodiversity, habitat, climatic, hydrological and public use functions, methodologies need to be developed to evaluate these functions and to weigh them in relation to the water quality issues.

While recent years have witnessed dramatic advances in the reduction of aquaculture waste production, primarily due to advances in feed technology, the co-implementation of new bioengineering and biotechnological strategies are vital for alleviating the environmental impact of the rapidly expanding global aquaculture industry. The development of a new generation of automated feeding devices and continued advances in recirculation technologies for land-based systems is amongst the more significant bioengineering advances that have resulted in reduced waste production. Advances in feed technologies will continue to play a pivotal role in the reduction of aquaculture waste.

Furthermore, the advent of modern recombinant DNA technologies now allows for the economic production of a variety of feed supplements, most notably microbial phytases. Other, often overlooked, biotechnological strategies for achieving improved growth and conversion efficiencies include such physiological modifications as sustained exercise and compensatory growth. Somewhat more controversial biotechnological methods, which may be beneficial in reducing waste management, include endocrine manipulations and genetic engineering. Again, recent advances in recombinant DNA and transgenic technologies have also led to renewed interest in these strategies.

<u>Advantages, disadvantages, and future prospects</u>: In view of the negative experiences of some countries in the region with deteriorating water quality and disease outbreaks within intensive pond/cage-based farming systems, there was an urgent need to improve farm husbandry methods and reduce the current reliance of the aquaculture sector on chemotherapeutants; including limiting the use of the antibiotics only to qualified personnel by developing appropriate codes of practice.

The utilization of sewage to fertilize fish ponds has become a common practice in many part of the world (Govindan, 1989). Annual global aquaculture production has more than tripled within the past 15 years, and by 2015, aquaculture is predicted to account for 39% of total global seafood production by weight (FAO and Fishery Information Data and

Statistics Unit, 2005). The global aquaculture industry is dominated primarily by production facilities located in a few Asian countries: eleven of the top 15 aquaculture-producing countries, accounting for 94% of total global production, are in Asia and India alone producing 115,884 tons of aquacultures from brackish water (FAB, 2005). According to Sapkota *et al.* (2008) the current aquaculture practices can lead to elevated levels of antibiotic residues, antibiotic-resistant bacteria, persistent organic pollutants, metals, parasites, and viruses in aquacultured finfish and shellfish. Specific populations at risk of exposure to these contaminants include individuals working in aquaculture facilities, populations living around these facilities, and consumers of aquacultured food products (Sapkota *et al.*, 2008).

Wastewater-fed aquaculture systems provide high fish yields at a low cost, such as formulated feeds, are administered to the fish (1), but the use of excreta in aquaculture systems could also have negative impacts on human health that should be properly assessed. The fishes cultivated from wastewater-fed ponds may anchorage pathogens from excreta in their scales, gills, intra peritoneal fluid, digestive tracts and muscle tissue (Edwards, 1992; Khalil and Hussein, 1997; Howgate, 1998).

Presently it has become necessary to recognize the important role played by nutrition in disease resistance. In addition, attention should also be given to legislative controls concerning aqua-feed manufacture and implications of applying government feed legislative controls (*i.e.* relating to feed composition, feed manufacture, feed efficiency or water pollution) directly from one environmental setting, and respective countries should develop their own solutions depending upon the farming system employed (*i.e.* intensive or semi-intensive; tank, cage or pond; cold water or warm water; freshwater or seawater), national government policies and priorities, and the resources available to them.

Obviously, some progress has been made in recent years through the use of people-centered approaches in research and development, even in areas in which aquaculture is not a traditional practice viz. reuse of industrial gray water, polishing of treated domestic as well as industrial waste water. But the way, the aquaculture practice is growing world-wide, redirection with a well thought out provision to shift towards the green thinking of this neo environment management paradigm is urgently needed.

It should be understood that with these kinds of biological occupation, research on the environmental and socio-economic factors of aquaculture should be focused in a higher ratio rather than the technological development and transportability. Despite, the worldwide awareness is also needed to raise the large potential contribution of aquaculture along with its environmental components as it has been poorly unappreciated and ignored by most of the agricultural and rural development professionals and policy makers throughout the globe in general and in Asian counties in particular. Only then its potential contribution towards elimination of poverty without altering the contiguous ecosystem leading to green aquaculture practice be realized.

3 National survey of engineered constructed wetlands and other natural treatment systems

Physical, geographical and social aspects as well as performance capacity of the engineered CWs and other NTSs were compiled during the India wide survey. The various activities performed for completion of national survey are as follows:

3.1 Methodology of survey and assessment

The methodology of survey was focused on CWs and other NTSs for wastewater treatment and reuse. The literature review (which is already discussed in Section 2) suggests the possible methods of NTSs apart from CWs includes, hyacinth and DPs, Lemna Ponds, Fish Ponds, WSPs, Oxidation Ponds and Lagoons and Algal-bacterial Ponds, Polishing Ponds, Karnal Technology *etc*. Before starting the activities related with assessment of the potential of existing CWs and other NTSs for wastewater treatment and reuse across India, the most possible methods of NTSs were reviewed and a questionnaire was developed for collecting data from the field. The questionnaire was developed after a broad discussion with experts as well as taking the inputs from WP3 partners and other partners of *Saph Pani* Project.

<u>Development of questionnaire</u>: The first draft of questionnaire was developed by IITB and sent to projects partners (Dr. Saroj Kumar Sharma (WP4), Dr. Starkl Markus (WP6), Dr. Declan Page (WP6) and WP3 partners (IWMI, BRGM and NGRI) in order to get comments and suggestion for improvement. The valuable suggestions given by Dr. Saroj Kumar Sharma, Dr. Starkl Markus and Dr. Declan Page were included in draft version and final version of questionnaire was developed. A similar approach were taken for obtaining inputs from WP3 partners in Hyderabad meeting (NGRI Hyderabad). The final version of questionnaire covers three kinds of data about a given wastewater treatment system, especially NTSs, firstly technical data, second economical data and third social data. The final version of questionnaire was circulated to the project partners to collect data related to CWs and other NTSs for wastewater treatment and reuse.

<u>Identification of potential sites NTSs across India</u>: The primary aim of identification of prospective sites of NTSs was to investigate the potential of these systems as the most appropriate and representative systems so that the experiences incurred may be replicated in any part of India or world. Numerous sites of CWs and other NTSs are available in India, however for this study only engineered ones were selected so that the treatment process and governing equations may simulated in any place if the treatment systems gives the overall better pollutant removal efficiency in relevance with recycle and reuse of treated wastewater.

A tentative list of engineered CWs and other NTSs was prepared after discussion with various water and wastewater practitioners as well as governing and regulatory bodies, including state pollution control boards, public health engineering departments of different states, and water and sewerage boards. Literature review were also used in order to select the most appropriate and representative sites for assessment. After identifying the potential representative sites of CWs and other NTSs across the country, two IITB research engineers were visited the identified sites in order to obtain the relevant information mentioned in the questionnaire. The specifications related with tentative list of identified sites of CWs and other NTSs were cross check with plant operators during onsite data collection. Aiming at understating, wastewater treatment and management in Indian cities and rural areas, forty sewage treatment plants (STPs) across India were visited during last twelve months (December 2011 to November 2012). The locations of visited CWs and other NTSs across India have been depicted in **Figure 3.1**.

Data collection and assessment: Identified sites of STPs based on CWs and other NTSs across India were visited and secondary data were collected by interviewing the operating staff of the respective STPs as well as by utilizing the literature, log books, and progress reports supplied by the respective personnel. The data were reported in the questionnaire in the sections covering technical, physical, geographical as well as social aspects of the engineered CWs and other NTSs. The assessment of selected STPs were planned to complete in two phases; first the rapid national survey of identified engineered CWs and other NTSs and secondly the detailed assessment of selected representative sites. During second phase of assessment, in-depth evaluations of selected case studies were carried out for their reuse potential and other special functions. These detailed assessments were aimed to link with health, environment, society, and institutions that may dealt with in WP6.

During the field visits, it was observed that most of the STPs come under the category of natural systems for wastewater treatment. *i.e.* WSPs, CWs, DPs, *etc*. In addition to onsite data collection of STPs, personal view related with performance, status of operation and maintenance were also recorded. The views of assessment for performance of STPs were based on onsite assessment as well as discussion with experts at IITB. During site visits of STPs, pictures of all different treatment units installed and surrounding location/community were also been taken from various angles which help during discussion with experts for making expert opinion regarding NTSs performance. The detailed data as well as photo gallery related with NTSs based STPs during national survey have been given in Annexure I.

3.2 Status of visited NTSs across India in achieving the treated effluent standards

The national survey of CWs and other NTSs indicates that the most of the wastewater treatment plants are achieving the standards set by Central Pollution Control Board (CBCB), New Delhi. The treated wastewater of those treatment plants which are not able to achieve the CPCB standards for wastewater disposal into a river, are being managed by operating authorities utilizing treated wastewater in land irrigation (which has relaxed standards as compared to discharge into the water body). The short descriptions, operating and maintenance conditions as well as specific issues (if any) of 41 NTSs visited across India for assessment in last twelve months have been given in **Annexture A**.

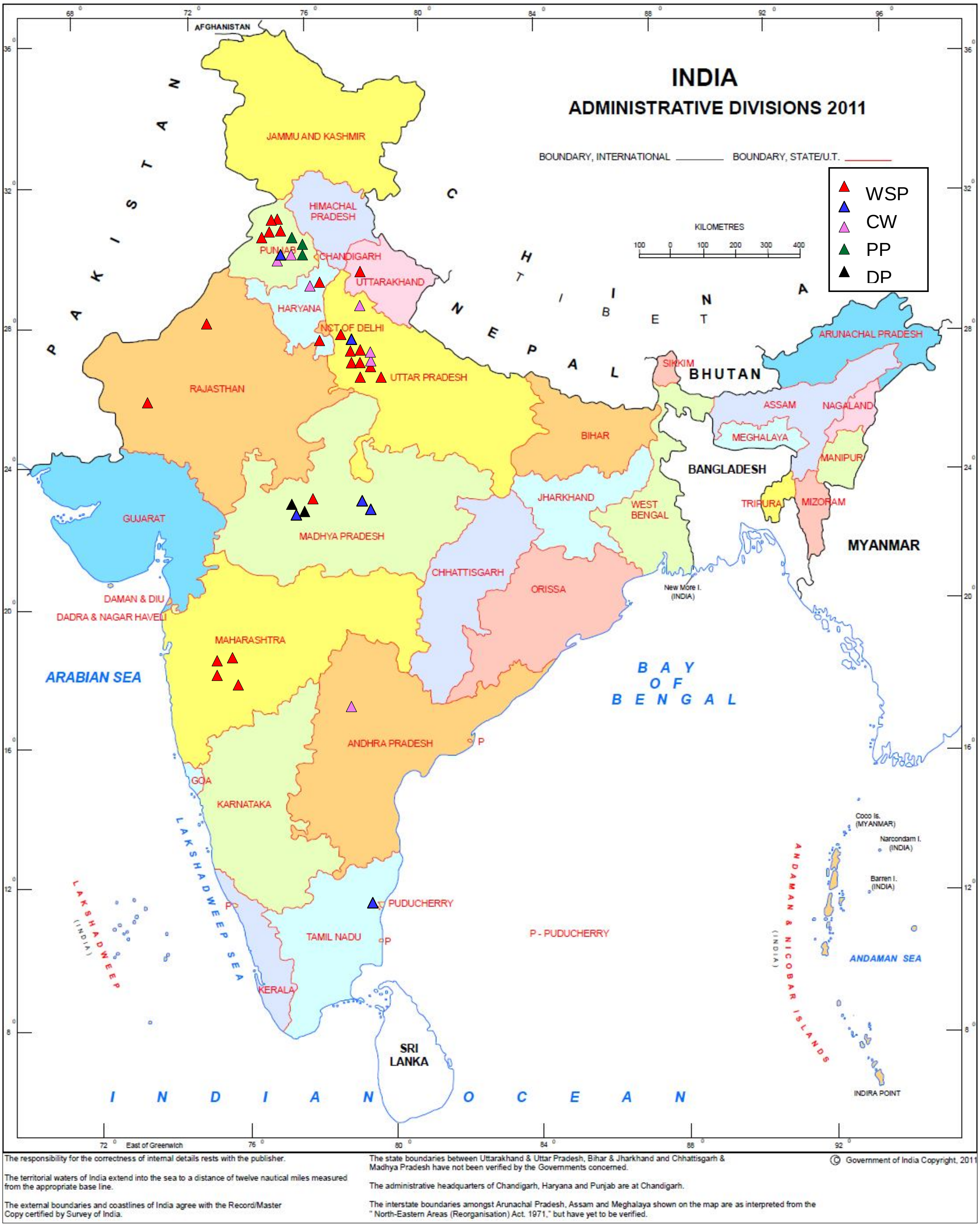


Figure 3.1: Locations of NTSs visited accros India during the field visits

3.3 Assessment of NTSs for wastewater treatment and reuse across India

During assessment, efforts have been made to articulate the results of survey (visit and data collected from forty NTSs) of CWs and other NTSs across India, which was undertaken from December 2011 to November 2012. Through extensive field visits to NTSs across India, a data set of 41 NTSs were prepared by using the final version of questionnaire, which has discussed earlier. The prepared data set typically covers general, technical, economic and social information related to the visited NTSs, which was structured through MS-Excel and stored. Data was gathered, compiled, and interpreted in order to integrate the various experiences and issues presently associated with NTSs in India. During the assessment of NTSs, various focuses included were as follows:

- Gap between sewage generation and treatment capacity for class I cities and class II towns,
- regulatory concerns of wastewater treatment, reuse and disposal
- Indian practices for using NTSs,
- various agencies involved for establishing as well as operation and maintenance of NTSs,
- generalized treatment train adopted for wastewater treatment at various types of NTSs,
- hydraulic loading, compliance status and overall performance for wastewater treatment,
- integrated practices of wastewater treatment, aquaculture production and post-treatment to treated wastewaters and,
- summary of the available post-treatment and reuse of the wastewater effluents from CWs and other NTSs in India

3.3.1 Gap between sewage generation and treatment capacity for class I cities and class II towns

Due to the gap between amount of sewage generated and their treatment, a large number of rivers stretches are severely polluted. In spite of the urgencies of saving large number of river stretches from pollution and recycling treated sewage for reducing ever-increasing pressure on Indian water resources, sewage treatment and reuse remains a widely neglected field. Indian government has already taken initiative and financed many sewage treatment plants in cities along bank of rivers under various river action plans. Presently, most of the sewage treatment capacity exists in India have been created under schemes financed by central government. Despite of huge funding provided in establishment of STPs, there still remains a large gap in sewage generation and sewage treatment capacity. This gap is widening because urban population is increasing at a higher rate and state governments continue their negligence towards this issue (CPCP, 2005). As mentioned earlier, all class I cities and class II towns together generate an estimated

38,254 MLD sewage. Against this, installed sewage treatment capacity is only 11,786 MLD. Out of this installed sewage treatment capacity, CWs and other NTSs are contributing nearly 1,838 MLD of sewage treatment. Presently a gap of 26,468 MLD exists between sewage generation and installed capacity (CPCB, 2009) *i.e.* 70% of the total sewage generated remains untreated which goes into different water or wastewater streams.

3.3.2 Regulatory concerns of wastewater treatment, reuse and disposal

Wastewater treatment plants in India are being designed on the basis of downstream use of treated wastewater. In most of the cases, the treated wastewater effluent either discharged into an adjoining river or reused for irrigation. Therefore, mainly two criteria remains in the mind of designers, either wastewater treatment plant should achieve the standards of land irrigation or discharge to a river downstream.

CPCB, New Delhi, has fixed a set of standards for treated wastewater discharge into streams and on land disposal or irrigation. These set of standards are being used as minimum reference for treated wastewater quality standards that should be achieved by all wastewater treatment plants. The performance of any wastewater treatment plant is being assessed and regulated with these sets of standards as given in **Table 3.1**.

All of the wastewater treatment plants in India are being operated for achieving discharged standards prescribed by CPCB, which includes, *p*H, BOD, COD, TSS and TDS. In case of most of the wastewater treatment plants, microbial quality of treated wastewater has not been the focus, and hence the performances of treatment plants being assessed based on physicochemical parameters only.

Table 3.1: Regulatory concerns of wastewater quality for NTSs in India

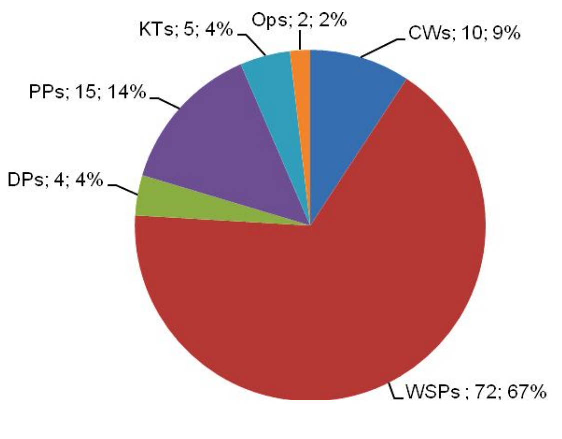
Parameters	*p*H	BOD_5 (mg/l)	COD (mg/l)	TSS (mg/l)	TDS (mg/l)
Standards for discharge in streams	5.5-9	30	250	100	2100
Standards for land irrigation	5.5-9	100	-	200	-

(Source: CPCB, 2005)

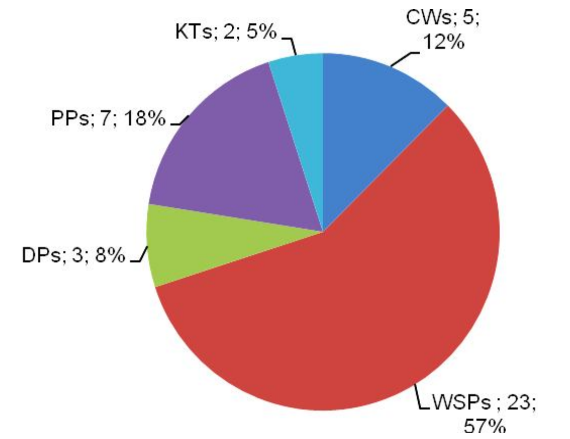
3.3.3 Indian practices for wastewater treatment using NTSs

All natural treatment systems in India are being practiced with some addition of mechanical pre-treatment for the removal of gross solids, where sufficient land suitable for the purpose is available, and these systems can often be the most cost-effective option in terms of both construction and operation especially in rural areas. During country-wide survey of CWs and other NTSs, 108 locations were identified which engaged for wastewater treatment by natural means. The number of treatment plants and their percentage contribution towards total wastewater treated by the means of NTSs are depicted in **Figure 3.2**.

During national survey across India for CWs and other NTSs for secondary data collection related to various aspects of systems as discussed earlier, 41 engineered treatment systems were selected for assessment. Out of these total 41 selected engineered NTSs comprises of WSPs (23 No.), DPs (3 No.), PPs (7 No.), CWs (5 No.) and KT (2 No.), as shown in **Figure 3.2**.



(A) Various types of NTSs practiced across India (their numbers and percentage contribution)



(B) Various types of NTSs visited across India by IITB team for assessment

Figure 3.2: Various types of NTSs practiced for wastewater treatment across India (A) and visited NTSs during national survey (B)

Polishing Ponds have been observed to be the most commonly practiced NTSs since many decades in India - which contributes nearly 53% of total wastewater treated by the means of NTSs (total load serviced by NTSs is around 1838 MLD) as depicted in **Figure 3.3**. One of the impressive features of polishing pond is its versatility. For example, several polishing ponds have been employed for municipal as well as industrial wastewater treatment all over India after UASB units for improving the quality of treated effluents by means of the anaerobic biological reactor.

WSPs have been also equally practiced since they account for nearly 45% of total wastewater treated by the means of NTSs in India. However, Karnal Technology for on-land disposal of wastewater, engineered CWs as well as DPs cater lower amount of wastewater as compared with total load serviced by NTSs, but their numbers are significant – which is the direct indication that these treatment technologies (KTs, CWs and DPs) are used as decentralized systems for wastewater treatment. Therefore, the NTSs including KTs, CWs and DPs, which are presently treating relatively lower amount of wastewater, may play a significant role in development of proper wastewater management and treatment in India where low-density communities and varying site conditions prevails.

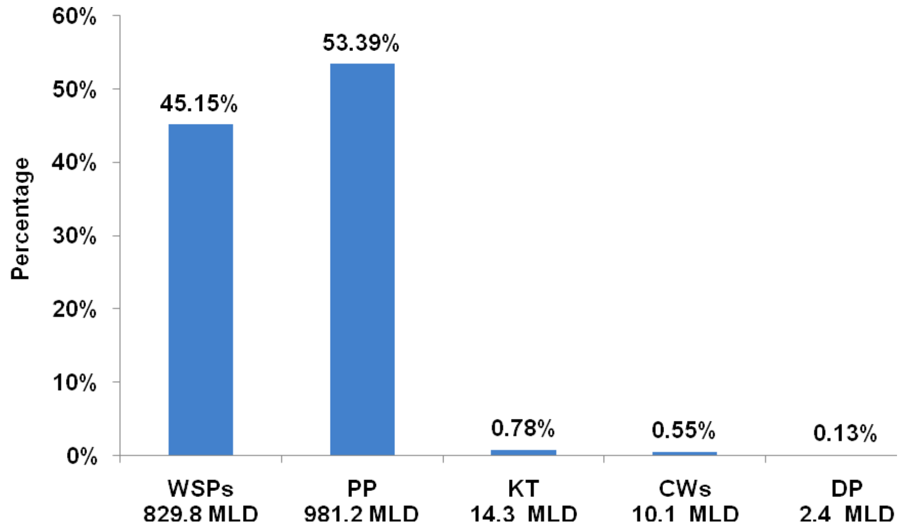
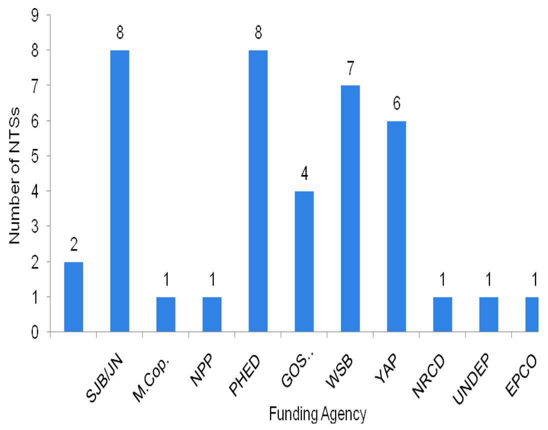


Figure 3.3: Practices of CWs and other NTSs for wastewater treatment in India

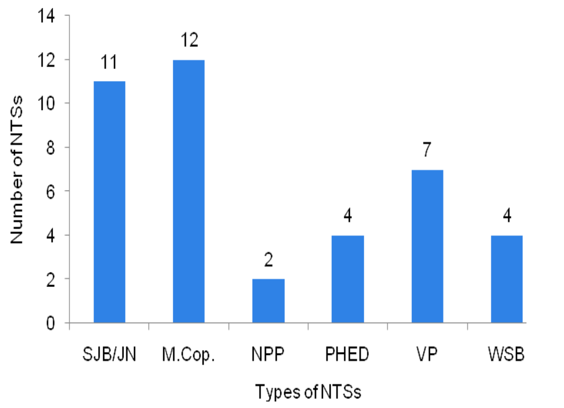
Decentralized or cluster wastewater treatment systems are designed to operate at small-scale (USEPA, 2004). Massoud et al (2009) argued that the decentralized systems not only reduce the effects on the environment and public health but also increase the ultimate reuse of wastewater depending on the community type, technical options and local settings. Moreover, decentralized systems can be installed on as needed basis, therefore evading the costly implementation of centralized treatment systems and when used effectively, decentralized systems promote the return of treated wastewater within the watershed of origin (Massoud et al, 2009). Unlike centralized wastewater treatment systems, decentralized systems are particularly more preferable for communities with improper zoning, such as scattered low-density populated rural areas (USEPA, 2005).

3.3.4 Agencies involved for establishing as well as operation and maintenance of NTSs

In Indian practices for establishment as well as operation and maintenance of NTSs, various agencies are involved directly or indirectly for wastewater collection, treatment and disposal. The primary aim of agencies (which are involved directly or indirectly) is to improve the sanitation facility as well as to protect human health or avoid unacceptable damage to the natural environment. The important agencies involved for establishment as well as operation and maintenance of NTSs includes, Govt. of State and Govt. of India, State Jal Board/Jal Nigam, Municipal Corporations of respective cities, Nagar Palika Prishad, Public Health Engineering Department (PHED), Water and Sewage Board, National River Conservation Directorate (NRCD), United Nations Development Programme (UNDP), Environmental Planning & Coordination Organization (EPCO), Village Council *etc*. The various agencies involved for sewerage collection, treatment and sanitation to provide hygienic sanitation facilities to the public by providing NTSs are depicted in **Figure 3.4**.



(A) Funding agencies associated with establishment of NTSs across India



(B) Agencies associated with operation and maintenance of NTSs across India

Figure 3.4: Agencies involved for providing funding for establishment and operation and maintenance for various types of NTSs across India

SJB/NN = State Jal Board/ Jal Nigam; M.Cop. = Municipal Corporation; NPP = Nagar Palika Prishad; PHED = Public Health Engineering Department; GOS and GOI = Govt. of State and Govt. of India; WSB = Water and Sewage Board; NRCD = National River Conservation Directorate; UNDP = United Nations Development Programme; EPCO = Environmental Planning & Coordination Organisation; VP = Village Council

The National River Conservation Directorate (NRCD) under the Ministry of Environment and Forests (MOEF), GOI were the executing agencies for the Yamuna Action Plan project with different state agencies including, Uttar Pradesh Jal Nigam (UPJN) in UP, the Public Health Engineering Department (PHED) in Haryana, and the Municipal Corporation of Delhi (MCD) in Delhi, being the chief Project Implementing Agencies (PIAs). Yamuna Action Plan was a centrally sponsored scheme, aimed at reducing pollution load in Yamuna River, which is the main source of water supply in Delhi and some parts of Haryana, by providing sewage treatment plants in twelve towns identified under the scheme.

More importantly, in Ganga Action Plan (GAP), number of wastewater treatment systems based on NTSs as well as mechanized have been funded in order to minimize untreated or improperly treated human wastes disposed into aquatic resources from where the downstream city's water requirements are drawn – which may constitute a big public health hazard in terms of their potential for spreading water borne diseases. Out of 8250 MLD of wastewater generated in the Ganga basin, the treatment facilities are available only for 3500 MLD of wastewater (town-wise treatment capacity is provided. Out of 3500 MLD treatment capacity, 880 MLD is created under the Ganga Action Plan, 720 MLD is created under the Yamuna Action Plan by NRCD, MoEF, Govt of India and about 2189

MLD treatment capacity is created by the Govt. of Delhi for restoration of water quality in Yamuna river (CPCB, New Delhi).

3.3.5 Wastewater treatment train adopted for NTSs

The most of the NTSs consist of a train of individual unit processes set up in a series, with the output (effluent) of one process becoming the input (influent) of the next process. The first stages usually made up of physical processes that take out easily removable pollutants. After this, biological processes generally treat the remaining pollutants further. These may 1) convert dissolved or colloidal impurities into a solid or gaseous form, so that they can be removed physically, or 2) convert them into dissolved materials, which remain in the water, but are not considered as undesirable as the original pollutants. The solids (residuals or sludges) which result from these processes form a side stream, also has to be treated for making fertilizer or for disposal.

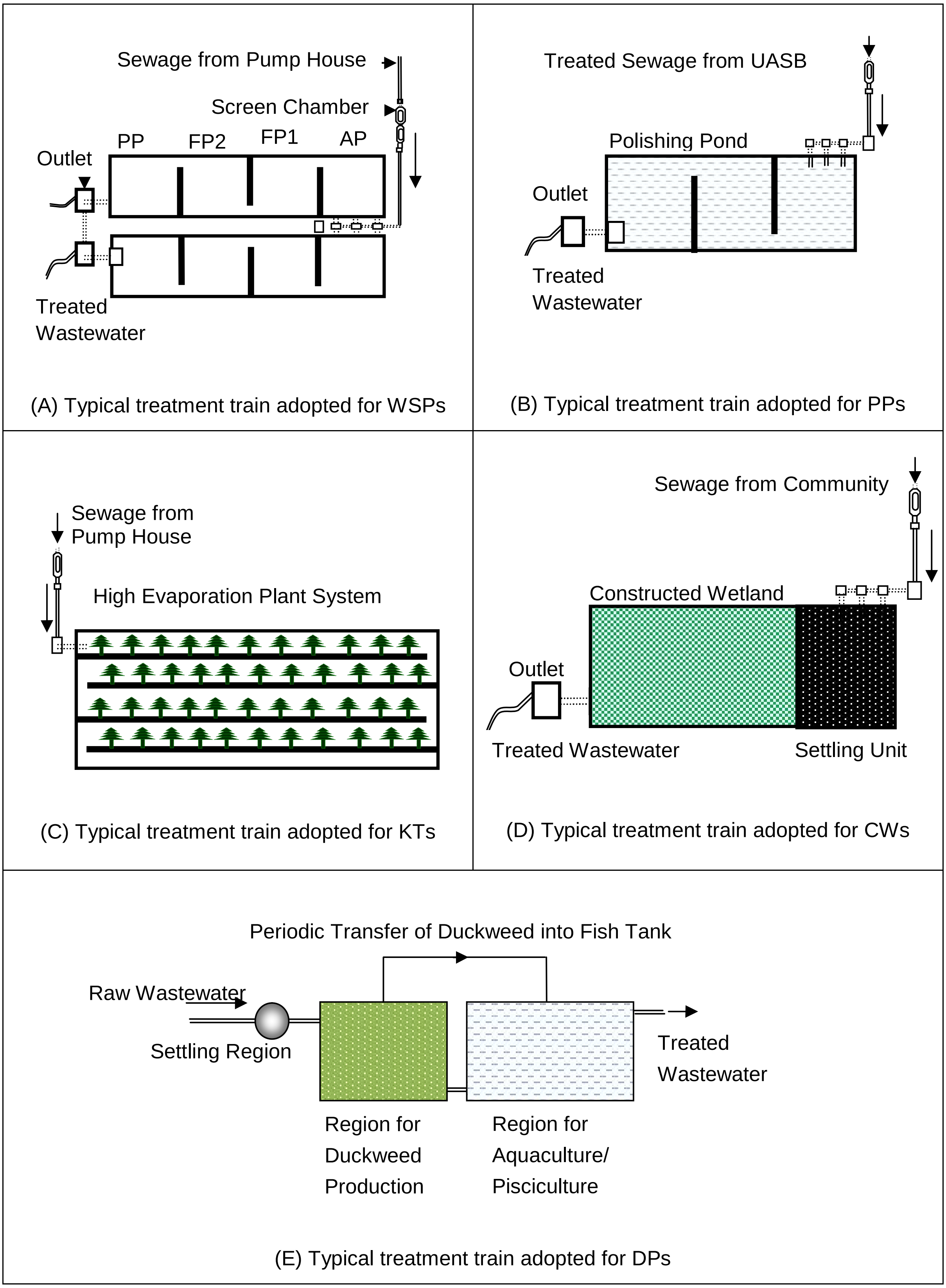
From the field survey, it was observed that at most of the places the same wastewater treatment train is being adopted for particular type of NTSs. Based on biological processes taking place, WSPs treatment units can be classified in three classes: 1) anaerobic, 2) facultative, and 3). Aerobic. On the basis of water depth, ponds can also be classified into two classes: a) shallow ponds and b) deep ponds. Shallow ponds (water depth <2.5 m) include conventional aerobic wastewater treatment ponds and polishing or maturation ponds with marginal facultative conditions near sediments. The deep ponds (water depth >2.5 m) typically include facultative ponds having aerobic, facultative and anaerobic layers. The deep ponds also include anaerobic ponds having 5 - 10 m depth. The generalised treatment trains adopted at most of the WSPs based NTSs are shown in **Figure 3.5.**

Based on the basis of utility of treatment units, DPs treatment units can be classified in three classes: 1) settling unit, 2) duckweed pond, and 3) fish ponds. Duckweed plants can double their mass in about two to three days under ideal conditions of nutrient availability, sunlight and temperature. Therefore size of different treatment units has been decided on the basis of climatic conditions and feasibility of land available. The typical flow sheet for duckweed-fed aquaculture for sewage treatment adopted at most of the places is depicted in **Figure 3.5**.

Polishing ponds are used to improve the quality of effluents from efficient anaerobic sewage treatment plants like UASB reactors, so that the final effluent quality becomes compatible with legal or desired standards. The residual organic material and suspended solids concentrations in the digested sewage are reduced, but often the main objective of polishing ponds is to improve the hygienic quality, measured by the concentration of two indicator organisms: helminth eggs and faecal coliforms (FC). The FC removal is normally the slowest process and for that reason it becomes the main design criterion for a polishing pond. In India depth of UASB polishing pond has been kept 1-1.5 meter and average HRT of 24 hrs. At most of the places this HRT happens to be insufficient to cater the need of pathogen removal. The typical treatment train adopted at most of the PPs across India is shown in **Figure 3.5**.

CWs are installed at most of the places in India as decentralized systems for wastewater treatment. This system is being used most dynamically for treating domestic as well as industrial wastewaters. At some places CWs are being used for improving the quality of secondary treated wastewater from activated sludge process by removing nutrients. CWs require a primary treatment to wastewater before treating in the CWs bed, therefore, a primary treatment unit is installed at most of treatment systems. Horizontal subsurface flow CWs are mostly used for treatment of wastewater in India. At most of the treatment plants, three type of plant species, namely *Canna indica*, *Phragmites karka* and *Typha latifolia* are being used in CWs bed. The generalized treatment train adopted at most of the CWs in India is shown in **Figure 3.5**.

KTs used to generate gross returns from the sale of fuel wood. As the sewage water itself provides nutrients and irrigation ameliorates to the sodic soil by lowering the pH, relatively unfertile wastelands can be used for this purpose. This technology seems to be most appropriate and economical viable proposition for the rural areas as this technology is used to raise forestry, which would aid in re-storing environment and to generate biomass. Though most of the plants are suitable for utilizing the effluents, yet, those tree species which are fast growing can transpire high amounts of water and are able to with stand high moisture content in the root environment are most suitable for such purposes. Eucalyptus is one such species, which has the capacity to transpire large amounts of water, and remains active throughout the year. Raw wastewater is directly applied in furrow on which plant is being planted. The whole wastewater is absorbed in soil and transpires by the high evaporation plant system. The generalized treatment train adopted at most of the KTs across India is depicted in **Figure 3.**5.



(A) Typical treatment train adopted for WSPs

(B) Typical treatment train adopted for PPs

(C) Typical treatment train adopted for KTs

(D) Typical treatment train adopted for CWs

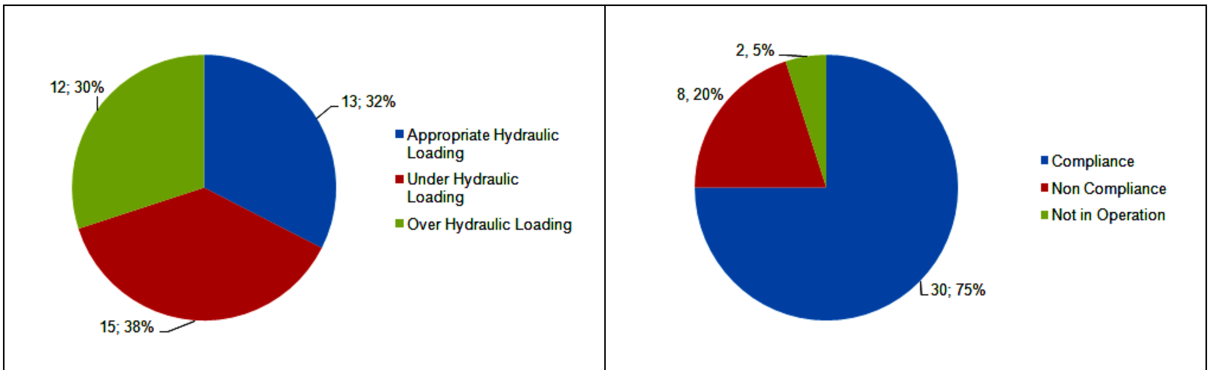
(E) Typical treatment train adopted for DPs

Figure 3.5: Typical treatment train adopted for wastewater treatment at various types of NTSs

AP = Anaerobic Pond; FP1 = Facultative Pond 1; FP2 = Facultative Pond 2; PP = Polishing Pond

3.3.6 Hydraulic loading, compliance status and overall performance of visited NTSs across India

The survey of NTSs across India indicates lots of variation in hydraulic loading at wastewater treatment plants. The sewage treatment plant were found in three type of conditions in context of receiving the amount of wastewater as per their design, 1) appropriate hydraulically loaded 38% (13 No.), 2) under hydraulically loaded 38% (15 No.) and, 3) over hydraulically loaded 30% (12 No.), as depicted in **Figure 3.6**. The NTSs for wastewater treatment are delicately balanced and any fluctuation in hydraulic loading or organic loading as per there design always affect the overall performance of the system. The most easily effected unit in treatment system is anaerobic unit associated with treatment train in most of the NTSs if there are little variations taken place in loading or organic loading. In anaerobic digestion, a delicate balance exists between the primary processes (hydrolysis and acidogenesis) and the conversion of the acid products by acetogenic and methanogenic bacteria into methane and carbon dioxide (Cohen *et al.*, 1982). These slight changes in condition of anaerobic unit directly affect the oxygen level of the forthcoming treatment units, therefore appropriate hydraulic loading as well as organic loading are essential in successful operation and maintenance of treatment plan.



(A) Status of hydraulic loading on NTSs

(B) Compliance status of NTSs

Figure 3.6: Hydraulic loading and compliance status of visited NTSs across India

The compliance status of visited NTSs were identified according to meet the downstream reuse of discharge standards prescribed by CPCB, New Delhi, given in **Table 3.1**. Survey results concludes, 75% (30 No.) compliance, 20% (8 No.) non-compliance and 5% (3 No.) not in operation of total 41 NTSs visited across India. There are many reasons associated with noncompliance of these NTSs, which may include as follows-

- Inappropriate hydraulic/organic loading,
- poor / absence of operation and maintenance by operating agencies,
- fund shortage was observed an important factor in poor operation and maintenance of STPs,
- sludge removal / treatment / handling appears to be the most neglected area in STPs operation,

- lack of alternate power supply for pumping the continuous wastewater into treatment units in most of the cases,
- lack of proper laboratories at site is another area that needs attention and,
- In majority of the cases, contractors look after operation of the NTSs. These contractors generally depute unqualified or less qualified staff at site, which is also an important factor responsible for poor operation of NTSs.

The detailed information on raw wastewater and treated wastewater quality, design details of treatment units installed, organizational structure for operation and maintenance, operational status/problems, any expected health risk, information on downstream use of treated effluent, sludge management etc. were collected for assessment. The detailed information of visited treatment plant for these mentioned parameters have been given in Appendix I. Apart from geographical location, different size of NTSs and there types were taken into account while collecting the onsite data during the field visits. The summary of performance in terms of percentage removal of BOD_5, COD and fecal coliforms of visited NTSs during last twelve months have been given in **Table 3.2**.

Table 3.2: Summary of performance of NTSs across India

S. No	NTSs Site Code	Location (State)	Performance		
			%BOD Removal	%COD Removal	% Fecal coliforms Removal
1	India_DL_1_WSP	New Delhi, (Delhi)	78	79	99.00
2	India_HR_1_WSP	Karnal, (Haryana)	95	92	98.89
3	India_HR_2_PP	Karnal, (Haryana)	56	33	94.50
4	India_HR_3_WSP	Palval, (Haryana)	85	68	94.50
5	India_MH_1_WSP	Aurangabad, (Maharashtra)	50	69	94.50
6	India_MH_2_WSP	Sangli (Maharashtra)	NA	NA	NA
7	India_MH_3_WSP	Miraj, (Maharashtra)	45	NA	NA
8	India_MH_4_WSP	Karad, (Maharashtra)	76	NA	NA
9	India_MP_1_KT	Ujjain, (Maharashtra)	NA	NA	NA
10	India_MP_2_KT	Ujjain, (Madhya Pradesh)	NA	NA	NA
11	India_MP_3_WSP	Ujjain, (Madhya Pradesh)	96	75	90.00

Table 3.2 *continued...*

12	India_MP_4_CW	Ujjain, (Madhya Pradesh)	66	NA	99.00
13	India_MP_5_CW	Bhopal, (Madhya Pradesh)	65	70	99.90
14	India_MP_6_CW	Bhopal, (Madhya Pradesh)	75	78	99.90
15	India_PB_1_PP	Kapoorthala, (Punjab)	51	38	98.75
16	India_PB_2_WSP	Ludhiana, (Punjab)	92	62	99.00
17	India_PB_3_WSP	Ludhiana, (Punjab)	93	65	94.50
18	India_PB_4_PP	Ludhiana, Zone B, (Punjab)	51	46	90.00
19	India_PB_5_WSP	Phillore, (Punjab)	87	66	99.00
20	India_PB_6_CW	Ropar, (Punjab)	93	NA	NA
21	India_PB_7_DP	Ludhiana, (Punjab)	95	NA	99.00
22	India_PB_8_DP	Sandhuan, Roop Nagar, (Punjab)	92	NA	99.00
23	India_PB_9_WSP	Sandhuan, Roop Nagar, (Punjab)	NA	NA	NA
24	India_PB_10_DP	Uncha, Roop Nagar, (Punjab)	89	NA	94.50
25	India_PB_11_WSP	Sultanpur Lodi, (Punjab)	79	80	94.50
26	India_RJ_1_WSP	Jodhpur, (Rajasthan)	78	80	99.00
27	India_RJ_2_WSP	Bikaner, (Rajasthan)	67	53	99.00
28	India_UP_1_WSP	Agra, (Utter Pradesh)	83	72	98.89
29	India_UP_2_WSP	Agra, (Utter Pradesh)	86	78	99.31
30	India_UP_3_PP	Agra, (Utter Pradesh)	63	20	NA
31	India_UP_4_PP	Agra, (Utter Pradesh)	64	43	NA
32	India_UP_5_WSP	Mathura, (Utter Pradesh)	78	73	98.57
33	India_UP_6_WSP	Mathura, (Utter Pradesh)	68	64	98.75
34	India_UP_7_WSP	Vrindavan, (Utter Pradesh)	50	61	99.00
35	India_UP_8_WSP	Vrindavan, (Utter Pradesh)	NA	NA	NA

36	India_UP_9_WSP	Etawah, (Utter Pradesh)	85	74	98
37	India_UP_10_CW	Agra, (Utter Pradesh)	61	64	NA
38	India_UP_11_PP	Saharanpur, (Utter Pradesh)	69	38	NA
39	India_UA_1_WSP	Reshikesh (Uttranchal)	85	74	98
40	India_AP_1_PP	Hyderabad (Andhra Pradesh)	33	17	NA
41	India_TN_1_CW	Auroville, Tamil Naidu	88	90	99.99

DL = Delhi; HR = Haryana; MH = Maharashtra; MP = Madhya Pradesh; PB = Punjab; RJ = Rajasthan; UP = Utter Pradesh; UA = Uttaranchal; AP = Andhra Pradesh; TN = Tamil Naidu; NA = Not Available, WSP = Waste Stabilisation Pond, PP = Polishing Pond, CW = Constructed Wetland

3.3.7 BOD, COD and fecal coliform removal performance NTSs

During the national survey of NTSs, it was observed that mainly three parameters, namely BOD_5, COD and fecal coliforms are the primarily used to assess the performance of treatment systems. All different types of NTs were covered during the performance evaluation. To carry out the assessment of NTSs for BOD_5, COD and fecal coliforms removal by a different NTSs across India, statistical analyses have been performed. The findings of the studies on evaluation of the performance of all visited sewage treatment plants across the country in respect of removal of are depicted in **Figure 3.6**.

Performance of WSPs: The results of BOD_5, COD and fecal coliforms removal by WSPs India are depicted in **(A), (B) and (C) of Figure 3.7,** respectively.

The lowest and highest BOD_5 removal performances were observed 45% and 96%, respectively. The lowest BOD_5 removal (45%) was observed at site code India_MH_3_WSP. This lowest performance of BOD_5 removal was due to over hydraulic loading, poor operation and maintenance of treatment plant. The highest (96%) removal of BOD_5 observed at WSP Ujjain. WSP Karnal also performing the very high removal of BOD_5 (95%). The treatment units of WSP Karnal also used for sewage fed aquaculture. From the results of BOD_5 removal performance, average value of 77.9% was observed with standard deviation and standard error of 14.9 and 3.3, respectively. The range of BOD_5 removals were found between 70.9 to 84.9 at 95% confidence interval.

The lowest and highest COD removal performances were observed 53% and 92% respectively. The lowest COD removal (53%) was observed at site code, India_RJ_2_WSP. This lowest performance of COD removal was because of excessive sludge depositing taken place in the anaerobic treatment units and also mixing of industrial effluent to domestic wastewater. The highest (92%) removal of COD observed at site code India_HR_1_WSP. The treatment units of WSP Karnal also used for sewage fed aquaculture. Results of WSP Karnal indicate the successful treatment to the wastewater. From the results of COD removal performance, average value of 71% was observed with standard deviation and standard error of 9 and 2.1, respectively. The ranges of COD removals were found between 66.9 to 75.9 at 95% confidence interval.

The lowest and highest fecal coliforms removal performances were observed 90% and 99.31% respectively. The lowest fecal coliforms removal (90%) was observed at site code, India_MP_3_WSP. This lowest performance of fecal coliforms removal was because of poor operation and management, which results growing of weeds in treatment units. The highest (99.32%) removal of fecal coliforms observed at site code India_UP_2_WSP. From the results of bacterial fecal coliforms removal performance, average value of 97.36% was observed with standard deviation and standard error of 2.61 and 0.61, respectively. The ranges of fecal coliforms removals were found between 96.06 to .98.65 at 95% confidence interval.

Performance of PPs: The lowest and highest BOD_5 removal performances were observed 33% and 69%, respectively. The lowest BOD_5 removal (33%) was observed at site code India_AP_1_PP. The highest (69%) removal of BOD_5 observed at Site code India_UP_11_PP. From the results of BOD_5 removal performance, average value of 55.43% was observed with standard deviation and standard error of 11.83 and 4.49, respectively. The range of BOD_5 removals were found between 44.45 to 66.41 at 95% confidence interval.

The lowest and highest COD removal performances were observed 17% and 46% respectively. The lowest COD removal (17%) was observed at site code, India_AP_1_PP. The highest (46%) removal of COD observed at site code India_PB_4_PP. From the results of COD removal performance, average value of 33.56% was observed with standard deviation and standard error of 11.09 and 4.18, respectively. The ranges of COD removals were found between 23.31 to 43.82 at 95% confidence interval.

The lowest and highest fecal coliforms removal performances were observed 90% and 99% respectively. The lowest fecal coliforms removal (90%) was observed at site code, India_PB_4_PP. The highest (99) removal of fecal coliforms observed at site code India_UP_4_PP. From the results of fecal coliforms removal performance, average value of 95.6% was observed with standard deviation and standard error of 4.24 and 2.12, respectively.

Performance of CWs: The lowest and highest BOD_5 removal performances were observed 61% and 93%, respectively. The lowest BOD_5 removal (61%) was observed at site code India_UP_10_CW. The highest (93%) removal of BOD_5 observed at Site code India_PB_6_CW. From the results of BOD_5 removal performance, average value of 72% was observed with standard deviation and standard error of 12.8 and 5.7, respectively. The range of BOD_5 removals were found between 56.1 to 87.9 at 95% confidence interval.

The lowest and highest COD removal performances were observed 64% and 78% respectively. The lowest COD removal (64%) was observed at site code, India_UP_10_CW. The highest (78%) removal of COD observed at site code India_MP_5_CW. From the results of COD removal performance, average value of 71% was observed.

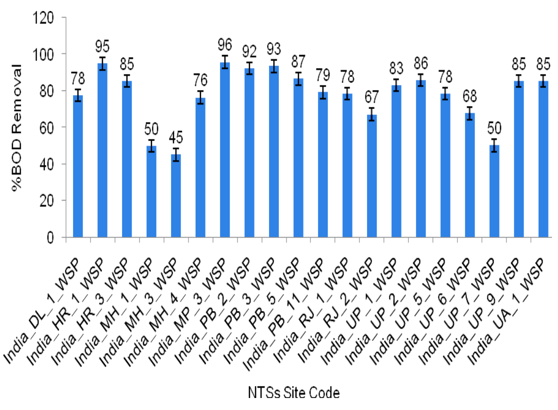
The lowest and highest fecal coliforms removal performances were observed 99% and 99.9% respectively. The lowest fecal coliforms removal (99%) was observed at site code, India_MP_4_CW. The highest (99.9) removal fecal coliforms observed at site code India_MP_6_CW. From the results of fecal coliforms removal performance, average value of 99.6% was observed.

The standard deviation and standard error were not calculated in case of COD and fecal coliforms removal because of smaller sample size.

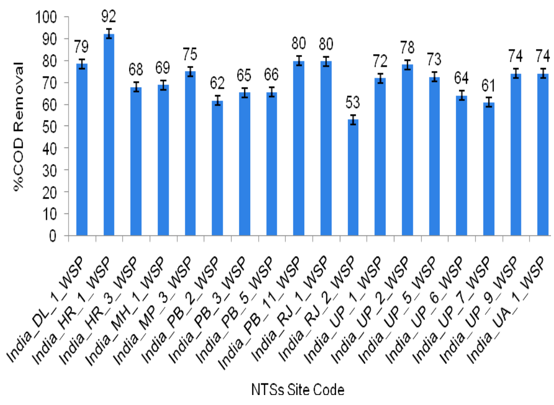
Performance of DPs: The lowest and highest BOD_5 removal performances were observed 89% and 95%, respectively. The lowest BOD_5 removal (89%) was observed at site code India_PP_10_DP. The highest (95%) removal of BOD_5 observed at Site code India_PB_10_DP. From the results of BOD_5 removal performance, average value of 92% was observed.

The lowest and highest fecal coliforms removal performances were observed 94.5% and 99% respectively. The lowest fecal coliforms removal (94.5%) was observed at site code, India_PB_10_DP. The highest (99%) removal of fecal coliforms observed at site code India_PB_8_DP. From the results of fecal coliforms removal performance, average value of 97.5% was observed.

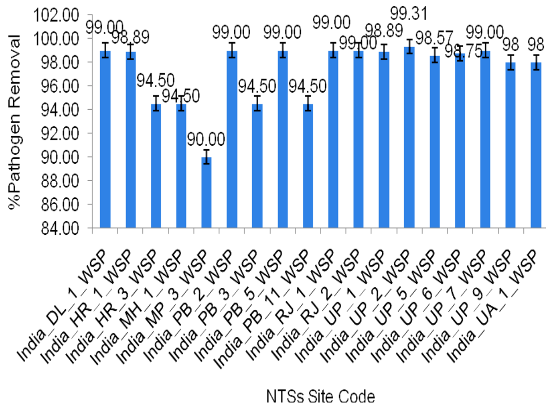
The standard deviation and standard error were not calculated in case of BOD and fecal coliforms removal because of smaller sample size.



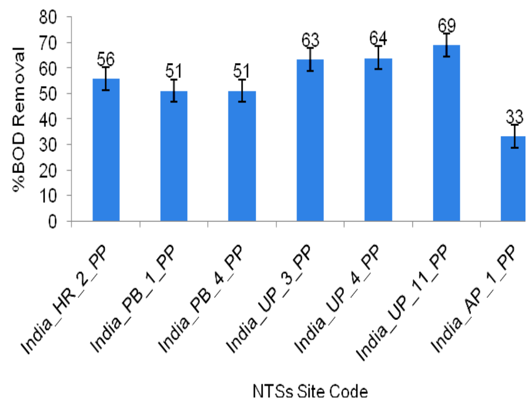
(A) Percentage BOD_5 removal at various WSPs



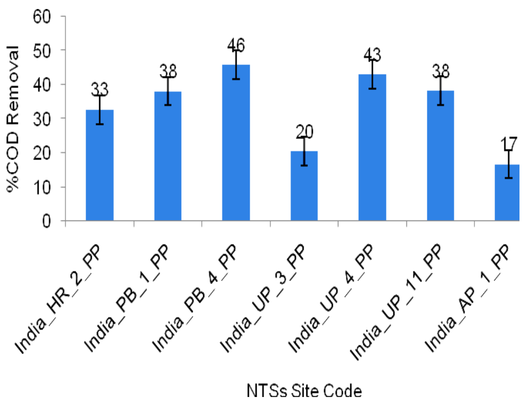
(B) Percentage COD removal at various WSPs



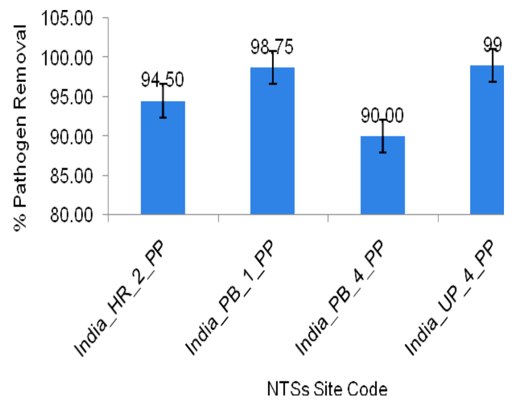
(C) Percentage fecal coliforms removal at various WSPs



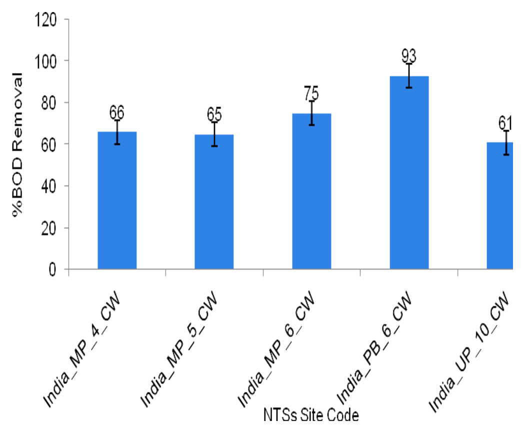
(D) Percentage BOD_5 removal at various PPs



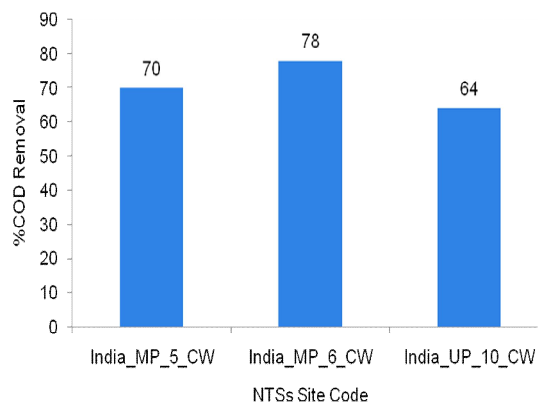
(E) Percentage COD removal at various PPs



(F) Percentage fecal coliforms removal at various PPs

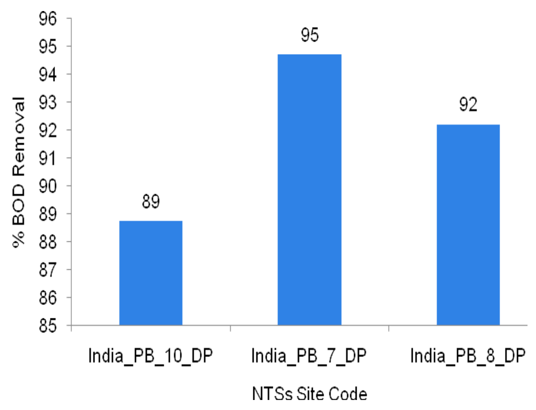


(G) Percentage BOD_5 removal at various CWs

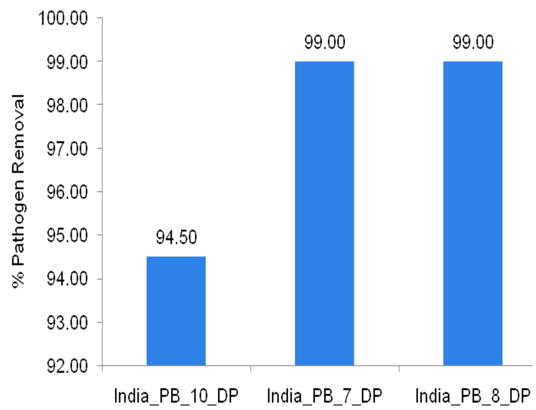


(H) Percentage COD removal at various CWs

(I) Fecal coliforms removal at various CWs



(J) Percentage BOD_5 removal at various DPs



(K) Percentage fecal coliforms removal at various DPs

Figure3.7: (A to K) Performance of BOD_5, COD and fecal coliforms removal by visited NTSs acroses India

3.3.8 Problems associated with successful operation and maintenance of NTSs across India

Results of national survey of CWs and other NTSs across India indicates that at some places NTSs have failed in achieving the design standard of treated wastewater. During the field visits many reasons were identified which were found to be mainly responsible for failures of some systems. Some of the identified reasons found to be responsible for failure of NTSs are summarized below:

Mixing of industrial effluents with domestic wastewater: At some places, the average BOD removal was reported low due the mixing of industrial effluents with domestic wastewater. The toxicity of industrial wastewater affects the NTSs health as was seen in case of KT based treatment plant in Ujjain. This may also reduce the treatment efficiency of NTSs substantially if contrition remains for long period. Some other industrial mixed wastewaters that affect the treatment process at some plants are depicted in **Plate 3.1**.

Picture 3.1: Inlet appearance of Industrially mixed wastewater at site code; India_MP_1_KT

Picture 3.2: Impacts on plant health system of NTSs at site code; India_MP_1_KT

Plate 3.1: Problem associated with mixing of industrial wastewater and associated problem at treatment site

Effluent overload on the STPs: At many places, STPs were found overloaded in terms of hydraulic loading which results in lower BOD removal performance of STPs. This effluent overload on the STPs lowers the HRT of wastewater in the treatment units of STP, which reflects in lower performance.

Operation and maintenance: Poor operation and maintenance were also the main reason that greatly affected the pollutants removal performance of some of the STP visited. They include:

- Lack of regular cleaning of primary treatment units especially influence the performance of anaerobic pond, which results in lowering the overall performance of STP.

- Lack of maintenance of inlet and outlet structures at many places of STPs, which immediately leads to lowering the performance and it may also cause clogging in case of CWs.
- Due the power shutdown at many STPs, irregular pumping of wastewater is being done that impose the shock load in the treatment units. The irregular pumping also affects the hydrodynamics of the treatment units which results in lower removal performance.
- Mostly STPs lack trained work force who are not able to understand small shortcoming of treatment plants and act accordingly.

The various above-mentioned problems associated with operation and maintenance of different types of NTSs is depicted in **Plate 3.2**.

 Picture 3.3: Status of irregular cleaning of primary treatment unit at site code; India_MP_6_CW	 Picture 3. 4: Status of CW bed covered with wild growth of weeds at site code; India_MP_6_CW
 Picture 3.5: Status of lack of cleaning of CW bed at site code; India_MP_4_CW	 Picture 3.6: Status of lack of cleaning of CW bed at site code; India_PB_6_CW

Plate 3.2: Problems associated with operation and maintenance of various CWs across India

The primary treatment unit installed at CW treatment system in Bhopal (site code: India_MP_6_CW) has become totally filled with of settled sludge. This non-functionality of treatment unit leads to the sludge deposited in the CW bed and system become beyond the recovery. The secondary treatment unit of this plant also affected by wild growth of herbs that totally hide the CW vegetation and health of planted vegetation is also greatly affected. The planted species in CW bed have also not been harvested from a long time that has become the habitat of domestic animals which continuously affected the system as depicted in **Plate 3.2**.

 Picture 3.7: Status of poor O&M of primary treatment unit at site code: India_UP_7_WSP	 Picture 3.8: Effects of non-functioning of primary treatment unit in at site code; India_UP_7_WSP
 Picture 3.9: Status of improper cleaning of primary treatment unit at site code; India_UP_6_WSP	 Picture 3.10: Status of lack of cleaning to primary treatment unit at site code; India_MH_3_WSP

Plate 3.3: Problems associated with operation and maintenance of various locations of WSPs

There is no primary treatment unit installed at CW treatment system Ujjain (site code: India_MP_4_CW) and wastewater directly treated in the CW bed. This CW was constructed in open wastewater carrying canal and wastewater directly distributed in bed through distribution box made-up of roubles. Due to over flooding and lack of maintenance, the distribution box become totally clogged which resulted in short circuiting of wastewater channel in CW bed. Some of common problems related with WSPs encounter during our nationalize survey are depicted in **Plate 3.3**.

The primary treatment unit (septic tank) installed at CW treatment system at Ropar (site code: India_PB_6_CW) was almost filled with of settled sludge. The primary settling units has not been cleaned from the date of installation of this system, which results in very poor quality of primary treated wastewater goes into the CW bed. This non-functionality of treatment unit leads to the sludge deposited in the CW bed and system has become beyond the recovery. The secondary treatment units of this system also affected by the pollution of solid waste thrown by nearby community, which results in adverse impacts on growth and multiplication of planted species CW bed. The planted species in bed are also not been harvested from a long time that resulted in CW bed becomes the habitat of animals which continuously affected the system.

 Picture 3.11: Status of lack of cleaning to primary treatment unit at site code; India_PB_10_DP	 Picture 3.12: Status of submerged primary treatment unit at site code; India_PB_8_DP
 Picture 3.13: Absence of primary treatment unit at site code; India_PB_7_DP	 Picture 3.14: Status of poor maintenance to wind protector at site code; India_PB_10_DP

Plate 3.4: Problems associated with operation and maintenance at various DPs

At some WSP, the regular cleaning of primary treatment unit are being avoided which results in silting in anaerobic ponds. This silting affects the performance efficiency of treatment plants that reduces the HRT substantially. At some places like, site code; India_UP_7_WSP, the primary treatment units has become completely breakdown because of corrosion and the incoming wastewater directly enter into the anaerobic pond without any primary treatment. Some of the pictures depicted in **Plate 3.4** clearly indicates that the proper primary treatment to the wastewater are absent at some places.

The primary treatments units that were installed at STPs were found in very critical stage of their function as they become totally clogged. In some treatment plants as depicted in figure, the bamboo which were used to maintain the uniform distribution of duckweeds species has become destroyed which results in non-uniform distribution of grown duckweeds species in the pond. These sorts of problems are most commonly seen during the national survey of NTSs across India.

3.3.9 Practices of integrated wastewater treatment and downstream fate of treated wastewater from NTSs in India

The experience gained from country-wide survey of NTSs across India reveal that the wastewater is not necessarily a pollutant but a nutrient resource that can be recycled through integrating various aquaculture and agriculture practices. The aquaculture practices during wastewater treatment observed were integrated use of duckweed production that being used as fish fodder and sewage-fed aquaculture. At some places of DPs the algae and duckweed are being used to remove nutrients and reduce BOD and COD levels, complemented by fishponds holding ponds for marketing. At some places the aquaculture production during wastewater treatment generates enough amount of revenue for operation and maintenance of treatment system. Traditional practices of recycling effluent through agriculture, horticulture and on land treatment were found at many locations of NTSs. Many places in India, NTSs are being used as resource recovery system through treatment of wastewater through sewage-fed aquaculture, biomass production from CWs and wood production from KTs (on-land treatment). The concept of treating domestic sewage through aquaculture is based on taking advantage of macrophytes to trap nutrients together with the traditional use of wastewater in fish farming, which is being well practiced in India.

The integrated systems for sewage treatment and aquaculture production like DPs in India receive primary-treated sewage after the removal of solids. The inlet BOD levels for the duckweed production unit are in the range of 120-160 mg/L and consequently it treated in an anaerobic unit where the organic load and BOD levels are very high. Duckweed culture, before the fishponds, aids in the removal of excessive nutrient concentration and residues from the primary treated wastewater. The waste from duckweed production unit contains BOD_5 levels of about 80 mg/L after treatment in the system with a total retention period of 4 - 5 days. The overflow of duckweed production unit sent to fish production unit where the final effluent BOD_5 is brought down to 10 - 30 mg/L in, meeting the required CPCB standards for discharge into natural bodies of reuse for irrigation.

The integrated fish and livestock farming are also excellently practiced at some places for recycling of wastewater and optimum production of high-quality protein at low cost. The advantage of presence of nutrients in secondary treated wastewater from WSPs and PPs are excellently taking care of utilising it for irrigation – which directly save ample amount of fertilizers in the used for agricultural fields. Farmers have reported to increase the yield in their farms as well as need of lesser amount fertilizers with use of treated wastewater.

The various ways of reuse and downstream disposal of treated wastewater include irrigation of agricultural fields, gardening and discharge into the river of adjoining water body. Out of 41 NTSs studied across India, the reuse and discharges of treated wastewaters from various systems includes, irrigation (17 No.), river discharge (8 No.), combine irrigation and river discharge (4 No.), fish production (2 No.), gardening (1 No.), combine fish production and irrigation (3 No.), discharged into wastewater drain (2 No.), and on-land treatment for wood production (2 No.). The bifurcation of different types of NTSs engaged in providing various useful resources, treated wastewater for irrigation and discharge into water resources are depicted in **Table 3.3**.

3.3.10 Prevailing practices of post-treatment of treated effluent from NTSs

Through the national survey of NTSs, 108 sites were identified which are being used in wastewater treatment across India. The NTSs have been practiced for more than four decades in India, serving the low cost, less resource intensive and more ecologically sustainable form of wastewater treatment. The most of the NTSs which are properly operated and maintained, they are able to give comparable quality of treated wastewater. The additional benefits of using of NTSs over mechanized treatment systems for wastewater treatment are of uniqueness of giving better quality of treated wastewater in terms of lower bacteriological count. In most of the cases, the properly operated systems of wastewater treatment based on NTSs are able to achieve up-to 3 – 4 log reduction in pathogenic bacterial count. More importantly, the naturally die-off of pathogenic species of bacteria may the best way because it does not have any harmful substances like chlorine into the wastewater as conventional practices being follow for disinfection. The most chemical and physical methods uses to disinfect the wastewater (except chlorine) are found either costly or ineffective for long-term practices, therefore NTSs provide the most appropriate way of reducing the pathogenic count without adding any harmful byproduct in the wastewater.

Table 3.3: Integrated wastewater treatment and aquaculture production practices NTSs in India

S.No.	Type of NTSs	Total No	Capacity	Post-treatment	Agricultural Fields	River Discharge	Agricultural Fields and River Discharge	Fish Pond	Gardening	Fish Pond and Agricultural Fields	Discharge into Wastewater Drain	On-land Traetment
1	WSPs	72	0.5 - 58	None	13	5	3	1	0	0	0	0
2	PPs	15	14 - 152	2 (Cl)	3	3	1	0	0	0	0	0
3	KTs	5	0.75 - 9	None	0	0	0	0	0	0	0	2
4	CWs	10	0.5 - 7.8	None	1	0	0	1	1	0	2	0
5	DPs	4	0.5 - 1	None	0	0	0	0	0	3	0	0
	Total	108		2 (Cl)	17	8	4	2	1	3	2	2

Out of these 108 sites of wastewater treatment based on NTSs, very few (only 2) have a post-treatment facility. **Table 3.4** provides a summary of the available NTSs, post-treatment applied and downstream use of the effluents from different systems (see Appendix II for the details). It was observed that chlorination is the only method which is being practiced in India for post-treatment of effluent coming from NTSs. Typically 1-2 mg/L of chlorine is being added at the outlet before the effluent is being reused for irrigation or gardening or discharged into the water body. The treated effluents from 22 out of 108 NTSs are currently used for irrigation of agricultural fields. In other cases, the effluents from NTSs are directly discharged into the nearby rivers or other water bodies.

There is high potential to use the effluent from NTSs in agriculture because of its low cost and high nutrient content. For that infrastructure should be in place for transfer of the treated effluent from the treatment plants to the field. Furthermore, the farmers should be made aware of the implication of the wastewater reuse in agriculture and potential health effects. Additionally, effluent from NTSs could also be used in some industrial processes after suitable post-treatment. Finally, artificial recharge of the treated effluent from NTSs is another attractive option to polish the effluent quality and to replenish the depleting groundwater reserves in different places of India.

Table 3.4: Practices of Post-treatment of treated wastewater from NTSs

Sr. No.	Type of NTSs	Number of Systems	Range Treatment Capacity (MLD)	Post-treatment	Down streams use of treated effluent		
					Agriculture	River or Lake	Unknown
1	WSPs	72	0.5 - 58	None	13	38	21
2	PPs	15	14 - 152	2 - chlorination	5	4	6
3	KTs	5	0.75 - 9	None		3	2
4	CWs	10	0.5 - 7.8	None		1	9
5	DPs	4	0.5 - 1	None	4		
6	OPs	2	12 - 19	None		2	
Total		**108**			**22**	**48**	**38**

4 Classification of natural treatment systems with an emphasis on reuse and social relevance

This section deals with the outcome of activities related to **Task 3.1.2** entitled: *classification of constructed wetlands and other natural treatment systems with an emphasis on reuse and social relevance*. The prior section (Section 3), dealt primarily with the status of NTSs in India and the relationship of the community with a given NTSs. As described in the section 3, a regress methodology of field survey, interaction with community, collection of responses through structured questionnaire as well as through obtaining secondary and tertiary data published on the NTSs subjected to the scrutiny of NTSs in the national survey conducted by IITB team during M1 to M15.

Let us start with understanding the meaning of word “classification”. It typically refers to as “the action or process of classifying something according to shared qualities or characteristics” as per the *Oxford Dictionary*. The act of classification has also been described by Kwasnik (1999) as a meaningful process of clustering experiences which may be used as a tool for understanding the relationships and representation of entities in structures that reflect knowledge of the domain being classified. Further, the classification facilitates in development of our ability to store and retrieve large amounts of information that have stimulated an interest in new ways to exploit this information for advancing human knowledge.

The process of classification can be used in a formative way and is thus useful during the preliminary stages of inquiry as a heuristic tool in discovery, analysis, and theorizing (Davies, 1989). Michalski and Stepp (1983) observe “An omnipresent problem in science is to construct meaningful classifications of observed objects or situations”. Such classifications facilitate human comprehension of the observations and the subsequent development of a scientific theory. According to Kwasnik (1999), the strengths and limitations of four classificatory approaches (hierarchies, trees, paradigms, and faceted analysis) are described in terms of their ability to reflect, discover, and create new knowledge.

Efforts have been made, in this section, to classify various NTSs studied throughout India during the past 17 months and on the basis of published reports and literature as well as the insights developed by IITB team after philosophizing and theorizing the learnings from published literature.

4.1 Synopsis of prevailing classifications of NTSs

The prior section (Section 3) gives a detailed survey (status report) on NTSs in India. Even prior to that, researchers have studied conventionally employed technologies for treatment of sewages in rural, small urban communities and peri-urban communities at the outskirts of metropolitan habitats in India. In order to summarize the wastewater treatment and management systems based on natural process, many attempts have been made to articulate the classification of NTSs by different researchers who have aspired to construct and make classification schemes more comprehensive.

Thus, every classification process has different goals, schemes and different structural properties as well as different strengths and weaknesses in terms of representation and discovery of knowledge. The different classifications given by several researchers as well as new approaches of classification based on the existing literature are described in this section.

Chaturvedi and Asolekar (2009) have presented a detailed account of a variety of real-life examples of NTSs in India including hyacinth and duckweed ponds, lemna ponds, fish ponds, waste stabilization ponds, oxidation ponds and lagoons and algal-bacterial ponds. In all those situations, the NTSs were deemed to be logical choices by the communities on the basis of relatively low energy consumption and easy for operation and maintenance. Asolekar *et al.* (2013) have broadened the classification framework proposed by Chaturvedi and Asolekar (2009) further by augmenting the case studies and analyses of rejuvenation of Mansagar Lake in Jaipur, India – wherein CWs have been successfully used to render tertiary treatment of 7.8 MLD sewage treated with the help of modern primary and biological secondary wastewater treatment (activated sludge plant). Also, a great deal of discussion on case studies demonstrating successful efforts of rejuvenation of Rivers and Lakes in India was included wherein significance of ecocentric approach of remediation using NTSs was underscored.

4.2 Classification of NTSs based on “eco-technologies for sewage treatment” by Chauturvedi and Asolekar (2009)

As stated earlier, Chaturvedi and Asolekar (2009) have classified aquatic natural systems into two classes: (I) intrinsic and (II) engineered systems. The intrinsic systems were further subdivided into two divisions, *namely*: self-supporting and stressed systems. A self-supporting system typically allows degradation of pollution without altering its own mechanisms and processes; for example, rivers and lakes polishing traces of biodegradable organic matter or treated sewage with the help of plants and microorganisms present in the system.

The engineered systems were further divided into three categories namely, Phyto-remediation, Bio-remediation and Zoo-remediation, based on principally used plants, microorganisms and animals, respectively. Further, each one of three types of system were divided into two categories based on their treatment location i.e. in-situ and ex-situ systems. Thus, the classification of NTSs developed by Chaturvedi and Asolekar (2009) as well as Asolekar *et al.* (2013) appears to address natural and man-made aquatic systems subjected to sewages and can be depicted in a logic diagram as presented in **Figure 4.1**.

Upon minute inspection of the scheme of classification proposed in **Figure 4.1,** it becomes clear that Chaturvedi and Asolekar (2009) as well as Asolekar *et al.* (2013) have emphasized natural and man-made aquatic systems subjected to sewages. Their system of classification did not throw enough light on the fate of intrinsic natural aquatic systems (such as a lake, pond, stretch of a river, beach, creek or estuary) that are subjected to a chronic input of sewages disposed by communities around a given water body.

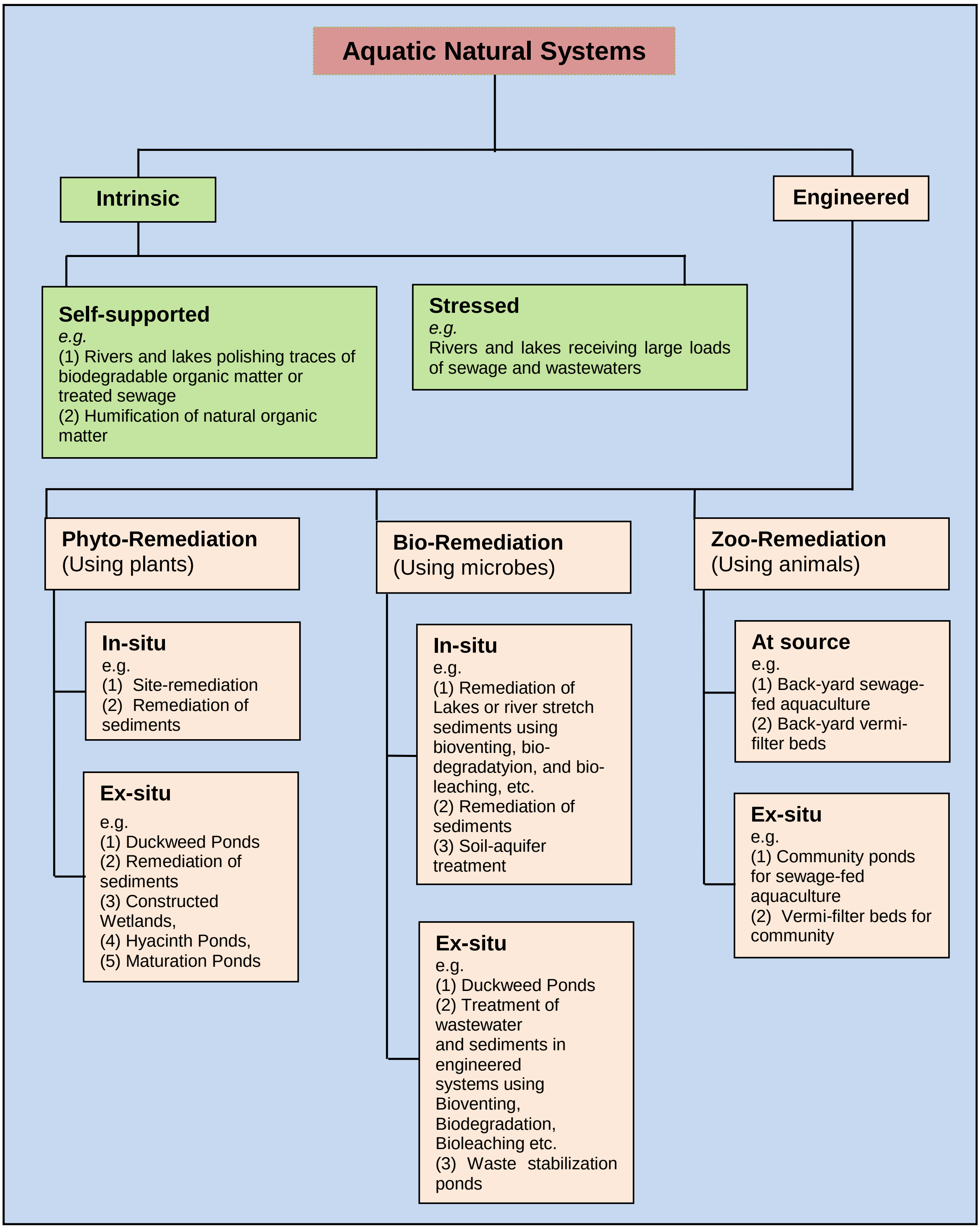


Figure 4.1: Classification of Natural Treatment Systems based on "use of eco-technologies for sewage treatment" (Source: Chaturvedi and Asolekar (2009) and Asolekar *et al.* (2013))

However, the classification system proposed by Chaturvedi and Asolekar (2009) and Asolekar *et al.* (2013) presents probably the most comprehensive and one of its kind classifications of engineered aquatic natural systems employed for treatment of sewages. In any case, one of the most important outcomes of the classifications proposed by Asolekar and co-workers (referred above) has been that it has illustrated the continuum between pristine aquatic natural systems and those aquatic systems that have been engineered for giving treatment to sewages using eco-centric technologies.

4.3 Classification of NTSs by Sharma and co-workers

Sharma and Amy (2010) have published detailed account of a variety of NTSs by collecting secondary data and case studies from existing systems world over. Sharma *et al.* (2012) have published detailed accounts of MAR and SAT – especially significance of these technologies and their roles in rendering water and wastewater treatment before discharging into surface waters or recharging into ground.

As regards to providing classification of NTSs, Sharma and Rousseau (2011) have classified the natural treatment systems broadly into two categories, *namely*: (a) “Terrestrial Systems” and (b) “Aquatic Systems”. The terrestrial systems were further divided into “Water Treatment Systems” and “Wastewater Treatment Systems”. The aquatic systems have been classified into two categories, *namely*: water-based and pond-based systems. These systems were further classified into two categories *namely*: water treatment systems and wastewater treatment systems as depicted in **Table 4.1.**

Table 4.1: Classification of NTSs by Sharma and Rousseau (2011) (personnel communication)

<table>
<tr><th colspan="2"></th><th>Water Treatment</th><th>Wastewater Treatment and Reuse</th></tr>
<tr><td colspan="2">Terrestrial System
(Soil/Aquifer-based)
Managed Aquifer Recharge (MAR)</td><td>1. Bank Filtration
2. Artificial Recharge
3. Sub-surface GW Treatment</td><td>1. Slow Rate Irrigation
2. Overland Flow
3. Soil Aquifer Treatment</td></tr>
<tr><td rowspan="2">Aquatic System</td><td>Vegetation-based (macrophytes)</td><td></td><td>1.Constructed Wetlands
2.Water Hyacinths</td></tr>
<tr><td>Pond-based</td><td>(Storage Reservoirs)</td><td>1. Anaerobic
2. Facultative (Algal ponds)
3. Aerobic
4. Maturation</td></tr>
</table>

It appears that the so-called “terrestrial system” referred to by Sharma and Rousseau (2011) is those installations that are primarily using subsurface and ground water processes to achieve treatment. The “Aquatic system”, as depicted in **Table 4.1**, refers to vegetation based and pond based system, respectively. One of the strengths of the classification proposed by Sharma and Rousseau (2011) happens to be the inclusion of issues related to water as well as wastewater treatment.

Clearly, there is a room for integrating additional points of view while developing classification system including the issues associated with natural *versus* engineered systems as well as effectiveness of systems devised for achieving disposal *versus* reuse *versus* recharge of treated waters and wastewaters.

4.4 Detailed classification of CWs as reported by Vymazal (2010)

According to Mbuligwe *et al.* (2011), wetlands types and classifications are normally discussed on the basis of criteria including hydrologic and hydraulic properties or behaviour, functions, types and characteristics of their media or plants, spatial attributes, and salinity of water. Mbuligwe, *et al.* (2011) reported that generally the wetlands can be either natural or artificial (non-natural). The artificial type of wetland is named as engineered constructed wetland and the so-called created wetland (Kadlec and Knight, 1996; Mitsch and Gosselink, 2000). Further, Kadlec and Knight (1996) have classified the natural wetlands into two categories each with its subcategories.

The main categories are freshwater wetlands and saltwater wetlands. The former category refers to those that are inundated with freshwater (salinities less than 1,000 mg/L). The latter class refers to those that are inundated with brackish or saline water (salinities more than 1,000 mg/L). Furthermore, each category of wetland have classified into two sub categories. The subcategories of freshwater wetlands and salt water wetlands are freshwater marsh, freshwater swamp and salt marsh, forested saltwater or mangrove, respectively (Mbuligwe, *et al.*, 2011).

According to Mbuligwe, *et al.*, (2011), engineered wetland systems (EWS) popularly known as constructed wetlands (CW) are those wetland systems conceived, planned, designed, implemented (constructed) and operated as well as maintained for their specific objective such as wastewater treatment. On the basis of water flow pattern, CW have been broadly classified into categories, *namely* horizontal flow (HF) and vertical flow (VF) wetland systems (Kadlec et al, 2000). Further, each category of wetland has been classified into two sub categories. The subcategories of VF wetland system and VF wetland system are free water surface flow (FWS), Sub-surface flow (SSF) and vertical down flow (VD), vertical upflow (VU), respectively (Mbuligwe, *et al.*, 2011).

Brix (1989) has classified CWs for wastewater treatment according to the life form of the dominating macrophyte into the systems with free-floating, floating leaved, rooted emergent and submerged macrophytes. Further, Vymazal (2008) has classified the Brix (1989) system of CWs classification according to the wetland hydrology (free water surface and subsurface systems) and subsurface flow CWs were further classified according to the flow direction (horizontal and vertical). The collective form of classification of CWs reported by Vymazal (2010) has been depicted in **Figure 4.2**.

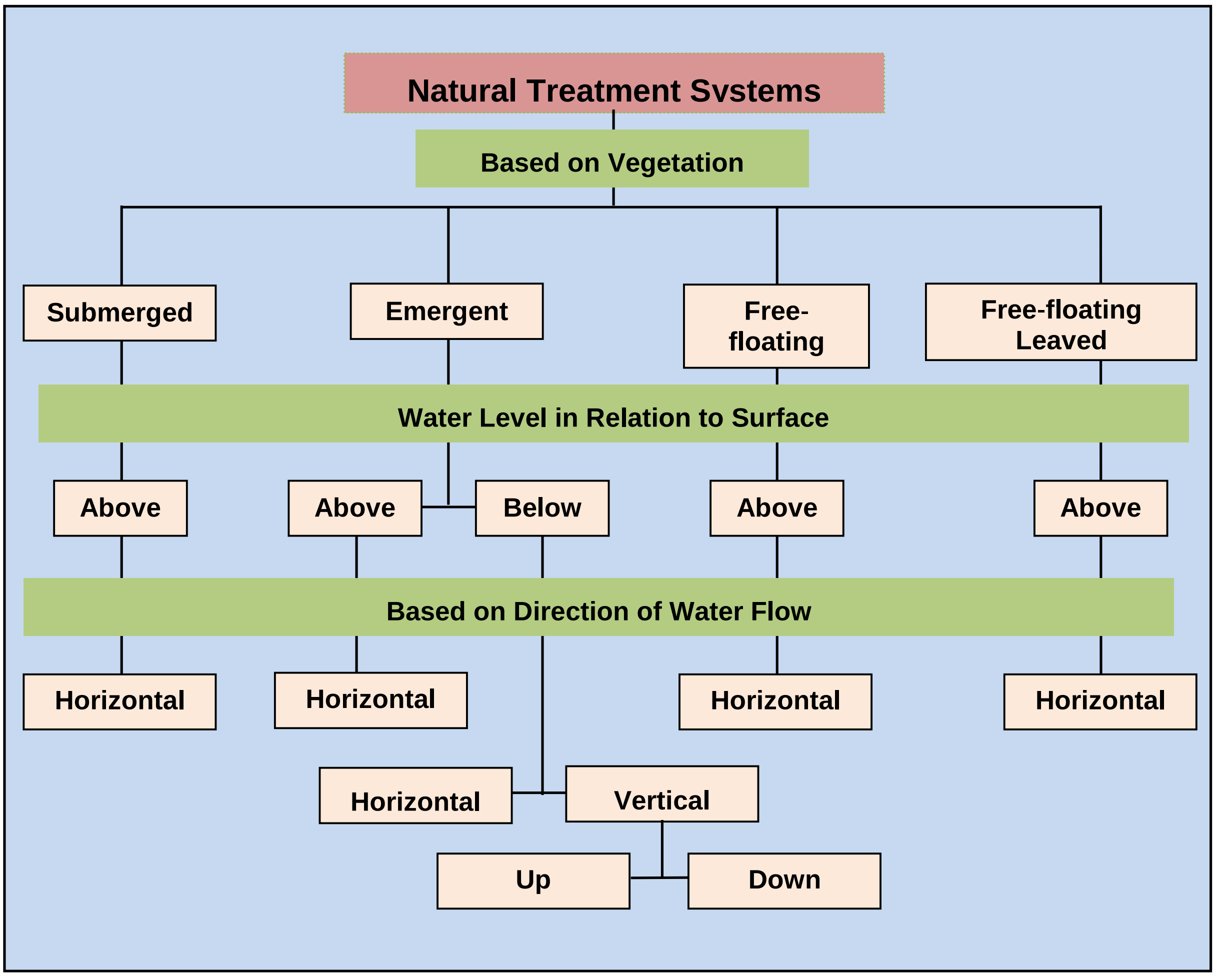


Figure 4.2: Classification of constructed wetlands based on types of vegetation and water flow patterns flow diagramme was constructed based on the information in Vymazal, 2010)

4.5 Other classification systems reported in literature

<u>Classification of NTSs based on infiltration pattern and type of flow</u>

Based on the United Nations Report (2003), the wastewater treatment technologies, the NTSs can be classified under land applications of wastewater as depicted in **Figure 4.3**. Based on this report, NTSs may broadly be classified into four categories based on flow pattern of wastewater during the treatment, which were named as Slow Rate (SR), Rapid Infiltration (RI), Overland Flow (OF) and Constructed Wetlands (CWs). Slow rate systems were further described into two types, Type 1 and Type 2, based on design objectives either wastewater treatment itself, rather than crop production and water reuse for crop production, respectively. In Rapid infiltration relatively high hydraulic and organic loadings are applied intermittently to shallow infiltration or spreading basins technology incorporates wastewater treatment, water reuse, crop utilization of nutrients and wastewater disposal. Overland flow wastewater is treated as it flows down through a network of vegetated sloping terraces. Constructed wetlands have divided into two categories, namely free water surface systems and subsurface flow systems based on the flow pattern of wastewater during the treatment.

The classification of natural treatment systems based on infiltration pattern and type of flow are depicted in **Figure 4.3**.

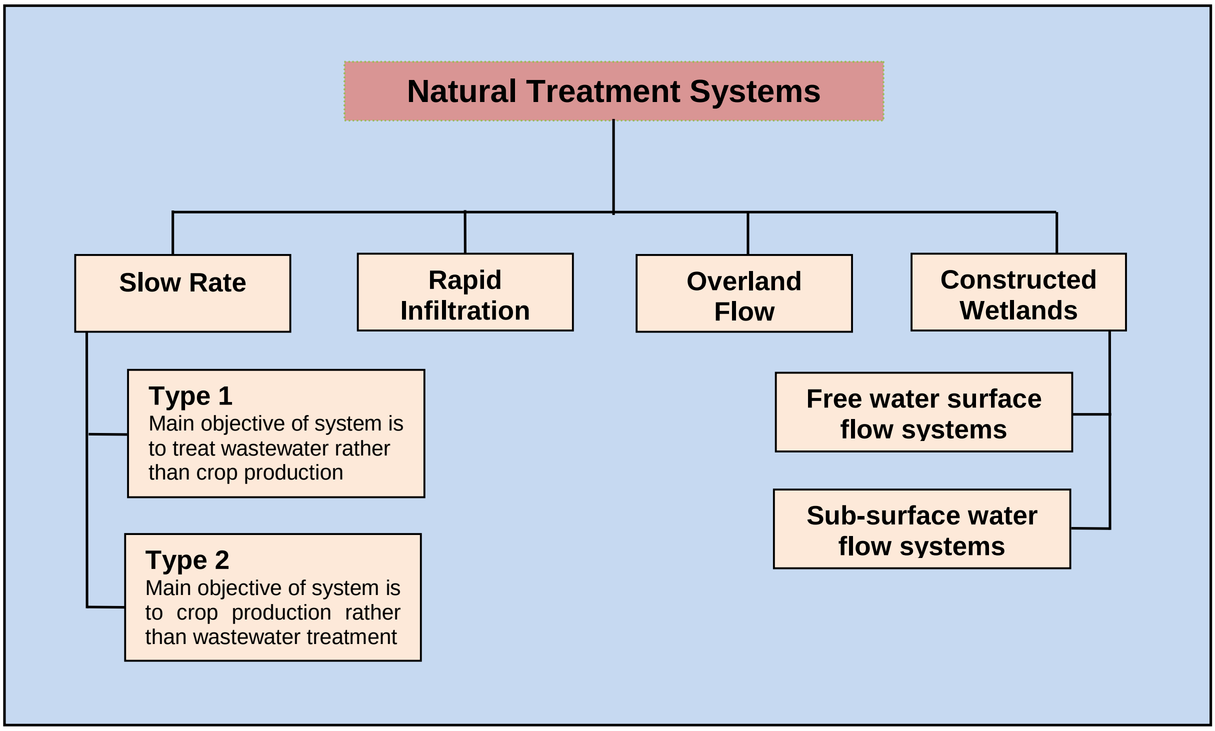


Figure 4.3: Classification of NTSs based on infiltration pattern and type of flow (Information based on United Nations Report, 2003)

<u>Classification of NTSs based on type of treatment system used</u>

The report of working group on rivers, lakes and aquifers in environment and forests for the eleventh five-year plan for India (2007-2012), has described the NTSs under the category of decentralized systems for wastewater. In this report, NTSs have broadly named into two categories, Land Treatment Systems and Aquatic Systems. The Land Treatment and Aquatic Systems further described into Slow Rate, Rapid Infiltration, Overflow Systems and Natural Wetlands, Constructed wetlands, Floating Aquatic Plant Systems, respectively. The NTSs can be broadly classified into two groups based on type of principle system used in treatment i.e. the land treatment systems and aquatic treatment systems, which is depicted in **Figure 4.4**.

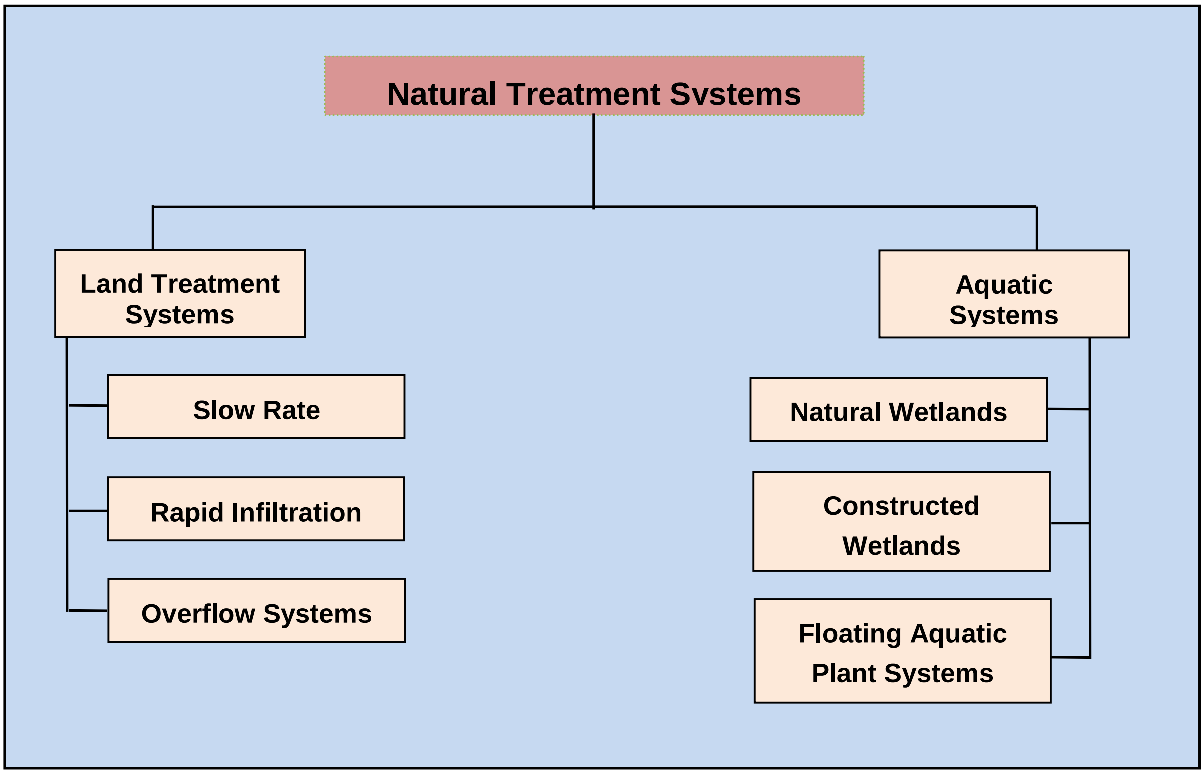


Figure 4.4: Classification of NTSs based on type of treatment system used (Information based on Eleventh Five-Year Plan for India, 2007-2012)

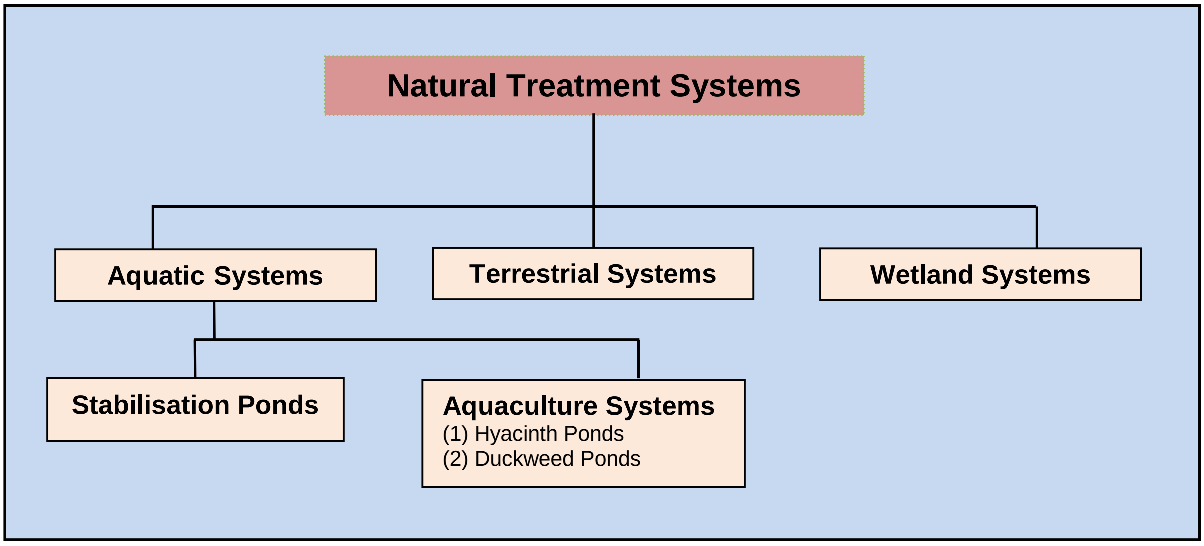


Figure 4.5: Classification of NTSs based on type of treatment system used (Information based on Metcalf, and Eddy, 1991; Reed *et al.*, 1995; Kadlec and Knight, 1996)

Similarly Metcalf, and Eddy, 1991; Reed *et al.*, 1995; Kadlec and Knight, 1996; have described Natural waste treatment systems in three broad categories inspite of two as described in Eleventh Five-Year Plan for India, namely Aquatic, Terrestrial, and Wetland Systems as depicted in **Figure 4.5**. Aquatic treatment systems are mainly Stabilisation

Ponds and Aquaculture Systems. Aquaculture Systems typically include Hyacinth and Duckweed Ponds.

4.6 Proposed system of classification

As discussed above, Chaturvedi and Asolekar (2009) and Asolekar *et al.* (2013) have given the classification of NTSs - by-far the first of its kind published in literature. They sampled as well as examined secondary data on those interventions that were successfully treating sewages at various locations in India and proposed the above mentioned classification scheme of NTSs.

Yet another important classification exercise worthy of discussion was due to Sharma and Rousseau (2011), Sharma and Amy (2010) and Sharma *et al.* (2012). They have published detailed account of a variety of NTSs by collecting secondary data and case studies from existing systems world over; with a specific focus on MAR and SAT – especially significance of these technologies and their roles in rendering water and wastewater treatment before discharging into surface waters or recharging into ground. There is a room for integrating additional points of view with the classification scheme proposed by Sharma and co-workers by incorporating the issues associated with natural versus engineered systems as well as effectiveness of systems devised for achieving disposal versus reuse versus recharge of treated waters and wastewaters.

One more interesting angle related to technology-society interaction has been pursued by Asolekar *et al.* (2013). They have argued that incorporation of societal priorities into all the steps of implementation of NTS-related projects, starting from decision making at the planning level, implementing and apportioning the responsibility to operate and monitor the solution is desirable and possible by involving the respective community.

The Indian democracy has an inbuilt mechanism that enables involvement of community in governance through Panchayati Raj Institutions (PRIs) promulgated in 1992 through the 73rd Amendment of the Honorable Constitution of India. PRIs, thus, can participate in decentralized governance and communities have begun to exercise their rights and responsibilities to solve their own problems. Further, PRIs have a mandate to perform 29 specifically prescribed functions including soil conservation, water management and watershed development. Clearly, involvement of PRIs in the management of natural resources and environmental protection is the path to achieving sustainability in India (Asolekar, *et al.*, 2013).

In summary, on one hand, the classification system, developed by Asolekar and co-workers, essentially addressed the sewage treatment-related applications and in that sense it was important in the context of selecting appropriate NTSs for achieving a given treatment objective. On the other hand, one of the most important outcomes of that classification was that it illustrated the continuum between pristine aquatic natural systems and those aquatic systems that have been engineered for obtaining desire sewage treatment objective. The classification system proposed by Sharma and co-workers specifically focused on MAR and SAT – especially significance of these technologies and their roles in rendering water and wastewater treatment before discharging into surface waters or recharging into ground. Asolekar *et al.* (2013) emphasized the possibility and necessity of balancing social priorities with the technological possibilities while planning, detailing and implementing the sewage treatment projects as well as projects aimed at rehabilitation and rejuvenation of contaminated stretches of rivers, lakes and ground water with the help of NTSs.

It is interesting to note, as described above in sections 4.1 that there have been some efforts for classification of NTSs based on the studies originated from India as well as international groups of researchers. Although, none did recognized the fact that “any” classification system would at least have a tacit basis or purpose/intention – in absence of which it would be rather difficult for the researcher to draw lessons from the field experiences and published literature.

Clearly, the above classification methods are far from being perfect and comprehensive. Therefore, the purpose of proposing “classification of NTSs” in this section is to organize the present literature and insights from field work into a defendable and useful framework for viewing the so-called NTSs as “a category of useful technologies that mimic nature on one hand and transfer benefits to community in a sustainable manner on the other hand”.

These insights from literature have been deemed to be the most fundamental and therefore useful while proposing rational classification of NTSs in the present research project.

Based on the perspective discussed above, the typologies of categories of NTSs have been proposed in **Table 4.2**. It is important to note that the detailing of each category has also been undertaken and listed in **Table 4.3 to 4.7**.

Table 4.2: Typologies of categories of NTSs

Category Code	Category Name
1	Classification based on gainful utilization of runoff and effluents
2	Classification based on goal and intention visualized
3	Classification based on treatment principle
4	Classification based on terrestrial versus aquatic systems
5	Classification based on the preferences of benefactor

Table 4.3: Classification based on gainful utilization of runoff and effluents

Sub-Category Code	Sub-category Description	Technology and Choices (3 to 5 Best Choices)
1.1	Production of water for agriculture or irrigation or gardening	WSP, UASB-PP, DP
1.2	Production of water for pisciculture or aquaculture	SFA, DP, PP, ABP, WSP
1.3	Production of water for recreational facilities	CW, DP, SFA, WSP, PP
1.4	Production of water for industrial applications	CW, DP, WSP, PP
1.5	Production of water for body contact	CW, DP, WSP, PP

CW = Constructed Wetland; WSP = Waste Stablization Pond; PP = Polishing Pond; DP = Duckweed Pond; SFA = Sewage Fed Aquaculture; ABP = Algal Bacterial Pond

Table 4.4: Classification based on goal and intention visualized

Category Code	Sub-category Description	Technology and Choices (3 to 5 Best Choices)
2.1	Economically viable (cost-effective) approaches of treatment	CW, SFA, DP, SAT, WSP
2.2	Resource recovery associated with wastewater treatment	CW, SFA, DP, KT
2.3	Decentralized wastewater treatment	CW, SFA, DP, KT, WSP
2.4	Cost-effective evaporation of wastewaters, especially in land-lock regions	KT, CW

CW = Constructed Wetland; WSP = Waste Stablization Pond; PP = Polishing Pond; DP = Duckweed Pond; SFA = Sewage Fed Aquaculture; SAT = Soil Aquifer Treatment; KT = Karnal Technology

Table 4.5: Classification based on treatment principle

Category Code	Sub-category Description	Technology and Choices (3 to 5 Best Choices)
3.1	Phyto-remediation (using plants)	CW, DP, WHP
3.2	Zoo-remediation (using animals)	SFA, VBF
3.3	Bio-remediation (using microbes)	WSP, PP, ABP, SAT
3.4	Hybrid	CW

CW = Constructed Wetland; WSP = Water Hyacynth Pond; PP = Polishing Pond; DP = Duckweed Pond; SFA = Sewage Fed Aquaculture; ABP = Algal Bacterial Pond; VBF = Vermi Filter Beds

Table 4.6: Classification based on terrestrial versus aquatic systems

Category Code	Sub-category Description	Technology and Choices (3 to 5 Best Choices)
4.1	Slow rate	SF, Trench, Beads
4.2	Overland flow	KT, SF, CW
4.3	Rapid infiltration	MAR
4.4	Sub-surface infiltration	CW, SAT, RBF, UCSS
4.5	Aquatic mechanized systems	Lagoons
4.6	Aquatic non-mechanized systems	DP, WSP, SFA, PP, ABP

CW = Constructed Wetland; SF = Sewage Faming; WSP = Waste Stablization Pond; PP = Polishing Pond; DP = Duckweed Pond; SFA = Sewage Fed Aquaculture; ABP = Algal Bacterial Pond; UCSS = Underground Capillary Seepage System

Table 4.7: Classification based on the preferences of benefactor

Category Code	Sub-category Description	Technology and Choices (3 to 5 Best Choices)
5.1	Compliance driven action State Water Board, State Sewage Board , Municipality, Regional Development Authorities, Workers' Residential Colony or any agency desirous to establish an STP primarily	WSP, DP, SFA

	for fulfillment of regulatory obligations	
5.2	Recycle and reuse of treated sewage State Water Board, State Sewage Board , Municipality, Regional Development Authorities, Workers' Residential Colony or any agency desirous to establish an STP primarily for recycle and reuse of treated sewage	Recycling type 1: Agriculture, Irrigation or Gardening WSP, DP, PP Recycling type 2: Pisciculture or Aquaculture SFA, DP, PP, ABP, WSP Recycling type 3: Recreational facilities CW, DP, SFA, WSP, PP Recycling type 4: Industrial applications CW, DP, WSP, PP Recycling type 5: Body contact or animal drinking CW, DP, WSP, PP

Table 4.3 proposes five sub-categories (i.e. 1.1 to 1.5) of the category entitled: "Classification based on gainful utilization of runoff and effluents". In other words, the Category-1 addresses the potential application of profitable and productive uses of treated effluents by employing sewage treatment systems that primarily draws from the virtues of NTS including production of water for agriculture or irrigation or gardening, pisciculture or aquaculture, recreational facilities, industrial applications and for body contact. These all kinds of sub-category of gainful utilization of runoff and effluents options requires the different quality of water which may be feed for direct utilization in process or may also be require further appropriate treatment. In summary, this category of classification gives a quick look of using an appropriate NTS in achieving the basic quality of treated effluent and runoff for its gainful applications. This system of classification also gives an opportunity to select an appropriate process, depending on the nature of the impurities to be removed and the intended use of the treated water or effluent.

There could be yet another approach to classification, as highlighted in Category-2, wherein classification is based on the visualized goal and intention of the project proponent. The Category-2 proposes four sub-categories (*i.e.* 2.1 to 2.4), as depicted in **Table 4.4**, for articulating the goals and intentions behind the water management project and the potential of NTS during implementation of the proposed project. On the basis of visualized goal and intention, the proposed sub-categories included economically viable (cost-effective) approaches of treatment, resource recovery associated with wastewater treatment, decentralized wastewater treatment and cost-effective evaporation of wastewaters, especially in land-lock regions. Further, the proposed system of classification also gives an opportunity in explicitly supports the process of linking knowledge-items integrated in achieving the overall any system.

The Category-3 entitled “Classification based on treatment principle”, proposes the four sub-categories (*i.e.* 3.1 to 3.4) as depicted in **Table 4.5** primarily based on the involvement of most important treatment entity during the treatment process. The proposed sub-categories include phyto-remediation (using plants), zoo-remediation (using animals), bio-remediation (using microbes) and hybrid systems. This classification is based on the insights of mechanisms involved in different treatment technologies (for example, through plants, animals, microbes or a hybrid process). In all kinds of NTSs, plants, animals and microbes always participate as the integral part of treatment process but one of them could play rather crucial role. Thus, the classification based on principal-live component might help while selecting a suitable NTS technology based on the ecological niche of the micro-environment.

“Classification based on terrestrial versus aquatic systems” (Category-4) proposes the six sub-categories (*i.e.* 4.1 to 4.6) as depicted in **Table 4.6**, illustrate the categorization of NTSs based on the primary medium (soil or water) targeted during the treatment. The put forwarded sub-categories in Category-4 are slow rate, overland flow, rapid infiltration, sub-surface infiltration, aquatic mechanized systems, and aquatic non-mechanized systems. It is hoped that this classification may provide an opportunity to compare terrestrial and aquatic systems. It should be recognized that the appropriate choice of technology in the context of a given geographical and ecological reality will govern the eventual decision because land-based possibilities are distinct when compared with the possibilities offered by adopting technologies involving ponds, stretch of a river, lakes, estuaries and coasts. Yet another dimension of complexity faced by the decision maker happens to be the symbiotic and interdependent web of relationship between vegetation and climate. The Category-5 *entitled* “Classification based on the preferences of benefactor”, proposes the two sub-categories (*i.e.* 5.1 and 5.2) as depicted in **Table 4.7**. It is based on the preferences of benefactor either for accomplishing the compliance with the stipulated minimum regulatory standards or alternately the benefactor would like to go beyond the compliance and get benefited by recycling of treated effluents.

5 In-depth evaluation of selected case studies

Based on the survey results, all NTSs systems were classified, and a few case studies selected for further investigation. These selections of case studies of NTSs for further investigation were based on type, quantity, and special features of reuse of treated wastewater. The basis of selection of case studies for in-depth evaluation were as follows:

- Treatment plant should be located in such a location that can represent the reuse potential of treated wastewater
- The capacity of treatment plant should be much enough to represent the technology for wastewater treatment
- The community surrounding the treatment plant should understand the benefits for treating wastewater

5.1 Selected NTSs for in-depth evaluation

The five treatment plants based on most practiced NTSs (WSPs, CWs, PPs, DPs and sewage-fed aquaculture) in India were selected for in-depth evaluation. The NTSs based on different technology were selected in Agra (Utter Pradesh), Ludhiana (Punjab) and Karnal, (Haryana). Some of these case STPs were with WP-6 (*Saph Pani* project partner) and remaining by IITB alone for reuse potential and other special functions, integrated assessments linking health, environment, society, and institutions. The list of selected case studies for in-depth evaluation studies have given in **Table 5.1**.

Table 5.1: NTSs selected for in-depth evaluation

Sr. No.	Location (State)	Location (State)	Organizations Involved in Assessing the NTSs
1.	India_UP_6_WSP	Mathura (Utter Pradesh)	IITB, CEMDS
2.	India_UP_10_CW	Agra, (Utter Pradesh)	IITB, CEMDS
3.	India_UP_4_PP	Agra, (Utter Pradesh)	IITB
4.	India_PB_7_DP	Ludhiana, (Punjab)	IITB, CEMDS
5.	India_HR_1_WSP/SFA	Karnal, (Haryana)	IITB

The brief description, special reuse potential of treated wastewater as well as integrated assessments linking health, environment, society, and institutions associated with selected NTSs are summarize in this section.

Waste stabilisation pond, Mathura, Utter Pradesh

Location ID: India_UP_6_WSP

Purpose for establishing the treatment plant and technical description: To treat the wastewater of Mathura city, the WSP of 14.5 MLD capacity STP with waste stabilization ponds system was constructed under YAP-I in the year 2000 as the core project under the National River Conservation Plan, Government of India. The system was hand over by Utter Pradesh Jal Nigam to Mathura Municipality for O&M in June, 2006. Due to high anaerobic loading and greater depth during starting of treatment, the first pond remains anaerobic followed by two facultative ponds and one maturation pond. Presently, the treated wastewater is being used for irrigating the agricultural fields. The sewage irrigated filed, community involved in agricultural activities and types of crops cultivated are depicted in **Plate 5.1**.

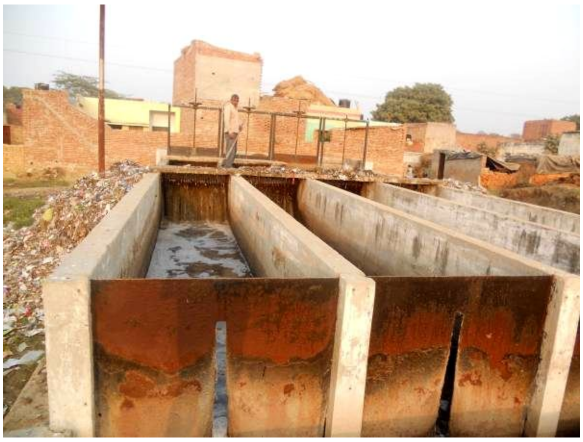
 Picture 5.1: Manually removal of floating objects from bar-screen	 Picture 5.2: Farmers community involved in agriculture activities
 Picture 5.3: Agricultural fields irrigated with treated wastewater	 Picture 5.4: Agriculture produced from the fields

Plate 5.1: Various aspects of treatment and reuse of treated wastewater at WSP, Mathura

Overall evaluation results: This treatment plant has a typical four ponds in series configuration with 1-day detention in anaerobic pond, 4 days in each facultative pond and 5 days in maturation pond. The bar screens installed at sewage pumping station as well as at the STP are manual and are found to be ineffective in removal of plastic bags and small pouches as depicted in **Plate 5.1**.

The floating material is then removed manually from anaerobic pond through an unprepared screen attached to a long bamboo. These features of the plant leads to creation of small heaps which are then burnt after it become dried. Such burnt objects along the perimeter of the ponds and gives unaesthetic looks to the WSPs. The STP is not able to meet the prescribed standards of treated effluent. The influent wastewater represents the high value of COD and TSS which indicate the mixing of industrial wastewaters into the sewage and hence may be the major cause of reduced efficiency of STP.

<u>Reuse of treated wastewater</u>: Some amount of treated wastewater is being reused in agriculture fields adjoin to the treatment plant and remaining discharges into the Yamuna River. In wastewater-irrigated fields, different types of crops are being produced. The most cultivated crops include Brinjal (egg plant), Colocasia, Cucumber, Rice, Wheat, Maize, Millet, Barley, Jute, Cotton, Sugarcane and Oil Seeds *etc*. The treated wastewater is being well accepted by the farmers as it gives additional benefit in economy by using lesser fertilizers in getting the comparable crop yield.

<u>Health risks</u>: The operator is exposed during removal of grits from primary treatment unit. During grit removal operations, operators did not use special equipment for cleaning the screen. Although proper precautions are being taking care of by operators but manual handling of infectious sludge and wastewater may be a cause of concern from their occupation health point of view. As described earlier, the STP also receiving a fraction of industrial wastewaters from the city which may contains the variety of pollutants including heavy metals and fecal coliforms which may potentially harm the farmers who are engaged in irrigation activities.

The use of industrial mixed treated wastewater for irrigation may lead to excessive accumulation of heavy metals in agricultural soils through wastewater irrigation, may not only result in soil contamination, but also lead to elevated heavy metal uptake by crops, and thus affect food quality and safety (Muchuweti *et al.*, 2006). Humans may exposed to the risks through the consumption of food crops contaminated with heavy metals and are one of the important pathways for the entry of toxic substances into the human body. Therefore, the present practices of using treated industrial mixed sewage may cause a serious health impacts if remain continued for a long in future.

<u>Institutional and operational aspects</u>: Jal Nigam, Mathura, Utter Pradesh, is the main agency responsible for operation and maintenance of WSPs. Jal Nigam, Mathura, Utter Pradesh has given the treatment plant to a private company for operation and maintenance. Contracted company has appointed two non-technical persons for operation and maintenance of treatment systems. Jal Nigam, Mathura has also appointed an engineer for technical assistance to different wastewater treatment plant for proper operation. The non-technical persons appointed for operation of treatment plant by the company the local community based on prior experience in the respective area. The persons dealing the operation activities

at treatment plant are well trained and their main tasks are to observe the appropriate flow pattern of wastewater in the treatment units as well as any nuisance and cleaning of bar-screen (shown in **Table 5.2**). Jal Nigam, Mathura and CPCB, New Delhi monitors the treatment performance every month, but the information on the performance is not publically available.

Table 5.2: Manpower directly involved in operation and maintenance WSP

S.No.	Person Designation	Assigned Duties	Number
1.	Sweeper cum watchman	Under the general supervision, to clean the STP boundary platforms, equipment and working area and to guard the WSP.	1
2.	Operator	To observe the appropriate flow pattern of wastewater in the treatment units as well as any nuisance and cleaning of bar-screen	1
Total			2

<u>Economic aspects</u>: Jal Nigam, Mathura, Utter Pradesh are paying INR 7 lakhs per year to the private company for operation of WSP. The each operator receives a salary of around INR 2000 per month. The land next to the WSP is leased to local farmers who can also use the treated water. The treated wastewater is being reused in irrigation of nearby farmers. There is around 100 acres of land that is being irrigated by treated sewage from WSP. The treated wastewater is being well accepted by farmers and it is demanding more distribution network for irrigation of their fields. Farmers have reported two major benefits of using treated wastewater rather than bore-well water, 1) the treated wastewater has far low-priced than bore-well water, and 2) it reduced the fertilizer demands substantially for getting equal amount of agricultural yields. The gross benefit goes to farmers by using the treated wastewater rather bore-well which was calculated based on interviews performed with farmers in their fields. The amounts saved for fertilizer and irrigation water were around INR 1,700 and 3,000 to 4,000, respectively for one acre of cultivated land.

<u>Social aspects</u>: The irrigation of agriculture fields by wastewater plays two important roles; recycling nutrients from wastewater to reduce eutrophication in Yamuna River saving of substantial amounts for getting equal yield from the fields. The treatment plant directly give the benefits for creating employment to the nearby community as more and more persons involved for agriculture activities if the treated wastewater is available for irrigation. It was observed that the communities involving for agricultural activities are poor and not able to afford the bore-well water for irrigating their fields. Therefore, a good operation and maintenance of sewage treatment may become the boon for development of low-income

group communities. It is advisable to restrict the mixing of industrial wastewater to reach at treatment plant which ultimately irrigate the fields and may cause the severe health risks.

Constructed wetland, Agra, Utter Pradesh

Location ID: India_UP_10_CW

Purpose for establishing the treatment plant and technical description: A decentralised wastewater treatment system of capacity 50 KLD at Kachpura slum, Agra, Utter Pradesh based on CW was established in year 2010. The establishment of CW at Kachpura slum is a part of Crosscutting Agra Program (CAP) for low income communities. The system was installed with financial assistance from Water Trust UK and London Metropolitan University and technical support by Vijay Vigyan foundation. The overall aim to establish this system was to improve the sanitation setting in the Kachpura slum areas (depicted in **Plate 5.2**). The system receives wastewater from 5 clusters of slums through a common drain provided by Agra Municipal Corporation. Through the CW, only some amount of wastewater being treated and the remaining untreated wastewater flows through parallel drain into the major drain that connects to the River Yamuna.

Overall evaluation results: The primary treatment comprises of grit chamber, bar-screen and three chambered septic tank. The bar-screen prevents the larger floating solid waste (diameter about 50 mm), which may enter into the septic tank. After primary treatment, the wastewater goes to nine chambered baffled anaerobic reactor which is filled with gravels. The primary treated wastewater from septic enters into the CW bed made of coarse gravels of size around 30 – 50 mm. After secondary treatment the wastewater goes to planted filter bed for root zone treatment. The bed is filled with three different types of filter media (white river pebbles, red stones and gravels) and planted with *Canna indica*. The treated wastewater is reused for horticulture and irrigation purpose by the local community of Kachpura, as shown in Plate 5.3. The overall operation and maintenance of system was found satisfactory.

Reuse of treated wastewater: The treated wastewater is being reused in horticulture fields adjoining to the treatment plant.

Health risks: The local community reported that, before establishment of CW, there was wide canal of wastewater which creates number of problems like mosquito breeding, foul etc, in the community. The system has noticeably improved the sanitation in the community. During the wastewater treatment, the wastewater is not visible because it is coved in primary treatment units and flowing subsurface in CW bed. The only associated health risk observed with the system during wastewater treatment was of manual cleaning of bar-screen for removal of floating objects as well as open grit chamber which may cause nuisance. During grit removal operations, operators did not use any special equipment for cleaning the grit chamber which has to perform after every ten days. Also, operators did not use special equipment for cleaning of floating objects from bar-screen which they have to perform after eight hours. Although proper precautions are being taken care by operators during handling of grit from grit chamber and floating objects from bar-screen but manual handling of infectious sludge and wastewater may be a cause of concern from their occupation health point of view.

Picture 5.5: Open grit chamber for receiving wastewater from main channel

Picture 5.6: Constructed wetland bed for wastewater treatment

Picture 5.7: Treated wastewater collection tank cum pisciculture tank

Picture 5.8: Reused of treated wastewater for gardening behind Taj Mahal

Plate 5.2: Various aspects of CW operated at Kachpura, Agra

Institutional and operational aspects: The Agra Municipal Corporation is mainly responsible for operation and maintenance of treatment systems. Agency has appointed two persons from the local community for operation of treatment plant whose lives near by the treatment plant site. The persons who are dealing with the operational activities at treatment plant are well trained and their main tasks are to observe the appropriate flow pattern of wastewater in the treatment units as well as any nuisance and cleaning of bar-screen after every eight hours. The total operation and maintenance of treatment plant are being continuously informed to junior engineer of Agra Municipal Corporation for the performance of proper operation and maintenance. The manpower directly involved in operation and maintenance CW is depicted in **Table 5.3**.

Table 5.3: Manpower directly involved in operation and maintenance CW

S.No.	Person Designation	Assigned Duties	Number
1.	Sweeper cum watchman	Under the general supervision, to clean the STP boundary platforms, equipment and working area and to guard the WSP	1
2.	Operator	To observe the appropriate flow pattern of wastewater in the treatment units as well as any nuisance and cleaning of bar-screen	1
Total			**2**

Economic aspects: Centre for Urban and Regional Excellence (CURE), Agra Nagar Nigam (ANN) and USAID were implementing decentralised system for wastewater treatment. The overall cost for establishing the system was around INR 11 lakhs. The annual operation and maintenance cost of treatment plant is around INR 80,000. The operation and maintenance cost occurred is mainly goes for salaries to the operators.

Social aspects: The treatment system was found very much socially relevant as it has created a job opportunity to the local people with appropriate treatment of wastewater. During interview of local community it was found that the persons are very happy for establishment of this treatment plant because it has improved the sanitation in the slum. The treated wastewater is well accepted by the communities for horticultural activities nearby the system. The system does not require any mechanized or delicate instrument as well as highly skilled manpower for operation and local people are able to manage very nicely. The community has requested the Agra Municipal Corporation for establishing other such kind of systems because it gives direct benefit to the community in terms of economy, better sanitation and make available treated wastewater for gardening.

Polishing pond, Agra, Utter Pradesh

Location ID: India_UP_3_PP

Purpose for establishing the treatment plant and technical description: UASB process with polishing ponds has been provided to treat 14 MLD wastewater in Cis-Yamuna area under YAP-I in the year 2009 (depicted in **Plate 5.3**)

Picture 5.9: Properly maintained polishing pond

Picture 5.10: Mechanically sludge handling

Picture 5.11: Post-treatment (disinfection) given to treated wastewater

Picture 5.12: Treated wastewater discharge into River

Plate 5.3: Various aspects of operation and maintenance of UASB-Polishing Pond at Jaganpur, Agra

Due to increase of wastewater generation from Agra city, the existing wastewater treatment plant become overloaded and therefore Agra Municipal Corporation were requested to Govt. India to provide the funds for establishing a new wastewater treatment plant. Prior to establishment of this treatment plant, the existing wastewater treatment plant was overloaded and hence new STP based on UASB-PP was established.

Overall evaluation results: The overall performance of sewage treatment plant was found satisfactory and able to achieve the treated wastewater standards for disposal into water body. The operation and maintenance of system was found excellent. The chlorine disinfection unit also installed at the site for giving post-treatment to treated effluent from polishing pond prior to discharge into the Yamuna River. The plant also have well-established laboratory for daily monitoring and assessment of plant performance. The laboratory staff and plant operators are well trained and operating the treatment plant very well.

Reuse of treated wastewater: The treated wastewater after chlorination is being discharged into the Yamuna River. Plant operators reported that the farmers adjoining to the treatment plant have requested to give the treated wastewater to irrigate their field but because of lack of wastewater distribution system, the treated wastewater not being currently reused.

Health risks: It was observed that most of the system operations are mechanically operated, therefore no health risks seems to be found at treatment site. The operators are only engaged for opening and closing of valves for regulating the wastewater flow and decanting of sludge from anaerobic reactor to sludge dry bed. The sludge is being kept for drying and then collected and sent it to nearby farmers to use as fertiliser. The dried sludge is collected manually and seems to be no health because it collected only after sludge becomes completely dried. The disinfection to the treated wastewater also being giving before it discharges into the Yamuna River which may reduce chance of microbiological contamination along the river.

The use of chlorine disinfection is being used for control of pathogen in wastewater on one hand and it generates the carcinogenic compound on other hand. Literature clearly reports the potential adverse toxicological impacts of chlorine chemicals and by-products of chlorination on the aquatic environment (Queensland Department of Environment and Heritage, 1991). High total residual chlorine in discharges to water may lead to an acute response of aquatic organisms, ranging from avoidance to death. Therefore, the post-treatment of wastewater for control of fecal coliforms through chlorination may not be the appropriate means, and hence the natural die-off phenomenon through natural treatment systems should be practice.

Institutional and operational aspects: The Jal Nigam, Agra is mainly responsible for operation and maintenance of treatment systems. Agency has appointed 15 persons from the local community for operation of treatment plant. The persons dealing the operation activities at treatment plant are well trained and their main tasks are depicted in **Table 5.4**. The total operation and maintenance of treatment plant are being continuously informed to Executive engineer of Jal Nigam, Agra for performing proper operation and maintenance.

Economic aspects: Presently, no revenue is being generated from the treated wastewater, but there is adequate scope of reuse of treated wastewater in adjoining agricultural fields if proper wastewater distribution canal reach to the fields. **Table 5.4** shows that ample amount of money goes to work force for their salary, which is total of all kinds of operation needed for entire UASB-PP plant and laboratory analysis. The operation and maintenance cost of PP is very low because it needs no mechanization.

Social aspects: The treatment plant is giving the good quality of treated effluent, which has great potential of reuse in irrigation. At treatment plant, chlorine disinfection is practiced and treated wastewater discharged into the Yamuna River, which may be toxic to river ecosystem, but may be well accepted in agriculture filed, as there is no risk of bacterial fecal coliforms. Therefore, the treated wastewater may be accepted very well (as farmers already requested but no wastewater distribution network) by nearby community. The treatment plant and associated agriculture fields are near to Agra city, therefore the practice of irrigating vegetables that not eaten in raw form may be irrigated after secondary treatment followed by chlorine disinfected.

Table 5.4: Manpower directly involved in operation and maintenance of UASB-PP

S.No.	Person Designation	Assigned Duties	Number
1.	Operator Mechanical	Maintain easements, ensure heavy equipments are safely running, routine maintenance etc.	3
2.	Operator Electrical	Control and maintain auxiliary equipment, such as pumps, fans, compressors, condensers, feed wastewater heaters, filters, and chlorinator, fuel, lubricants, air, and auxiliary power etc.	3
3.	Fitter	Maintains, repairs and installs plumbing and related fixtures and components, maintains and adjusts chemical treatment controls etc.	2
4.	Sweeper cum helper	Under the general supervision, to clean the STP boundary platforms, equipment and working area and to operate other light and heavy equipment as required.	3
5.	Analyst	Extract analysis of wastewater samples, document data, draw sound conclusions, communicate results, provide technical support for operation of STP.	2
6	Lab. Attendant	Collects and preserves varied samples for analysis daily from specific locations according to a predetermined schedule; collects special samples as conditions indicate; storage and laboratory testing.	2
Total			15

Note: The individual manpower requirement has not been calculated because of combined operations. The STP laboratory also engaged in analysis of samples brought from other STPs operated in Agra.

Duckweed pond, Ludhiana, Punjab

Location ID: India_PB_7_DP

Purpose for establishing the treatment plant and technical description: The Duckweed Pond of 0.5 MLD was established in the year 2004 at village Saidpur, Ludhiana, Punjab for addressing the problem of wastewater generated from the village community (depicted in **Plate 5.4**).

Picture 5.13: DP for treatment of wastewater and pond for duckweed production

Picture 5.14: Fishpond for pisciculture

Picture 5.15: Dense fruit plantation on the boundary of treatment plant

Picture 5.16: Agriculture fields irrigated with treated wastewater

Plate 5.4: Various aspects of wastewater treatment, pisciculture and reuse of treated wastewater in agriculture at Ludhiana, Punjab

Prior to establishment of treatment plant, the wastewater generated from the village community had deposited around the village in near low land areas and creates many problems like wastewater logging, smell problem, mosquito and many other unaesthetic issues. To overcome this problem, the Sarpanch village council had requested to Ludhiana Water and Sewage Board. The funds for the project implementation were provided by Govt.

of Punjab. Besides this, the funds from many sources were also dove tailed and activities of the related programmes execute executed.

Punjab government has established wastewater treatment plants at many villages to make better sanitation. The following selection criteria were followed during selection of village for establishing sewage treatment plant-

- Villages facing stagnation of drains and choked ponds, which are in dire need of pond renovation, should be given the preference.
- Village already selected for water supply under Source Water Assessment and Protection (SWAP) mode where Information, Education and Communication (IEC) activity has already been done and water supply @ 70 LPCD is operational/ or being commissioned may be preferred.
- Village where village council and community was pro-active and expresses demand for the pond renovation and show eagerness to participate in the pond renovation work
- All selected villages should get approval from District Water Supply Mission constituted under Total Sanitation Campaign (TSC) project.

Overall evaluation results: The wastewater treatment system is being excellently used for treatment of wastewater treatment as well as generation of revenue, which is being utilized by Village Council for sewage collection, operation and maintenance of treatment system. The treatment of wastewater through duckweed production which utilises nutrients are ultimately increased the treated wastewater quality. The STP is performing satisfactory for achieving the Indian standards for wastewater disposal into the water body or land irrigation.

Reuse of treated wastewater: The treated wastewater is being reused in irrigation. In wastewater-irrigated fields, different types of crops are being produced. The most cultivated crops include Mustard, Rice, Wheat, Maize, Millet, Barley, Jute, Cotton, Sugarcane and Oilseeds etc. The treated wastewater is being well accepted by the farmers as it gives additional benefit in term of economy of fertilizers up to some extent.

Health risks: The major risk associated with this system was observed of manual harvesting and transferring of duckweed from the duckweed pond to associated fishpond, although the best possible precautions are being taking care off. The another associated risk with use of duckweed as fish-feed which may gradually accumulate the persistent contaminants in fish up to the point where it poses a potential health risk to human consumers.

Institutional and operational aspects: The treatment plant is being operated and maintained by village council since the year of establishment. Village sarpanch has appointed two persons for operation and maintenance of treatment plant. The responsibilities of appointed persons (depicted in **Table 5.5**) include regular cleaning of boundaries, harvesting of duckweed and put into the fishpond, cutting the extra branches of the tress etc. The work-force involved for catching the fishes are being hired at momentary basis as the activity start.

Table 5.5: Manpower directly involved in operation and maintenance of DP

S.No.	Person Designation	Assigned Duties	Number
1.	Sweeper cum watchman	Under the general supervision, to clean the STP boundary platforms, equipment and working area and to guard the WSP.	1
2.	Operator	To observe the appropriate flow pattern of wastewater in the treatment units as well as any nuisance and cleaning of bar-screen	1
		Total manpower	**2**

Economic aspects: The treatment plant gives three kinds of benefits to the operators, 1) revenue generated from pisciculture, 2) Orange trees planted on the edge and 3) treated wastewater to the agriculture fields. It was observed that system generating the revenue of about INR 50,000-70,000 per year, which is more than enough for operation and maintenance for the system.

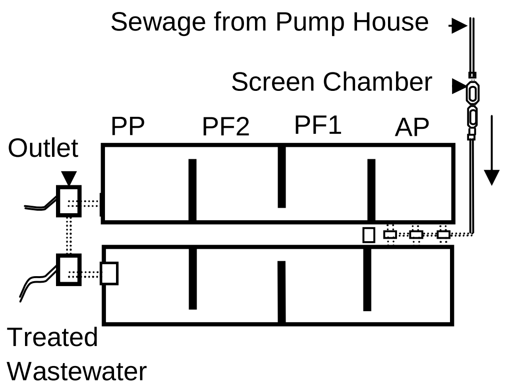
Social aspects: The community were involved while undertaking this project right from planning, designing, execution. The upkeep and maintenance of the project thereafter was also be undertaken by community. At district level, Zila Parishad had powers to undertake the project including selection of village and technology and monitor the progress during course of execution. Zila Parishad has also arranged prior funds from various sources required for the project. At village level, Village Council was nodal agency for the project. The department had act as facilitator / technical advisor at all levels for providing continuous guidance and back up for the project. In order to ensure larger participation of community, IEC activities were under taken by drinking water supply and sanitation committee in the village. Apart from that, community directly benefited is not only getting fishes and fruits at low price but also treated wastewater containing nutrients, benefit to save fertilizers.

Sewage-fed aquaculture, Karnal, (Haryana)

Location ID: India_HR_1_WSP/SFA

Purpose for establishing the treatment plant and technical description: To treat the wastewater of Karnal city, the WSP of 8 MLD constructed (completed in December 1999) under Yamuna Action Plan at a cost of INR 1.06 crore. As there was no appropriate arrangement for discharge of effluent, the low lying area near the plant was filled. The Forest Department as well as the farmers objected to the water being released on their land, therefore the treatment plant was established. Later on the Municipal Corporation of Karnal, Haryana has given the WSP at lease for operation and maintenance. The most important thing for operation and maintains of this treatment plant is that the municipal corporation getting funded through wastewater treatment.

During the sewage treatment, the treatment train followed at the site and status of treatment system are depicted is directed in **Plate 5.5**. Due to high anaerobic loading and greater depth during starting of treatment, the first pond remains anaerobic followed by two facultative ponds and one maturation pond. The facultative and maturation ponds are being used for pisciculture. The overflow of maturation pond (treated wastewater) is being sent for irrigating the agriculture fields.



Scheme of sewage-fed aquaculture

Picture 5.17: Facultative pond 1 (fishpond 1)

Picture 5.18: Facultative pond 2 (fishpond 2)

Picture 5.19: Maturation pond (fishpond 3)

Plate 5.5: Scheme of wastewater treatment and sewage-fed aquaculture activities at WSP Karnal

AP = Anaerobic Pond; FP1 = Facultative Pond 1 (fishpond 1); FP2 = Facultative Pond 2 (fishpond 2); PP = Polishing Pond (fishpond 3)

Overall evaluation results: The wastewater treatment system is being excellently used for treatment of wastewater treatment as well as generation of revenue, which is being utilized by Karnal Municipal Corporation for sewage collection. Sometimes, the WSP received more wastewater as per their design that causes to increase the organic loading in the first facultative pond. The increased organic loading in the first facultative pond results in increase the BOD as well as suspended particles, which causes death of fishes. These types of issues are being taking care of by introducing lime in the first facultative pond for precipitating the suspended matter. The plant operator reported that the fish species, namely Katla has the maximum survival potential of tolerating organic loading in the treatment units. The presence of fishes in the treatment unit has appears to increase the quality of treated wastewater. The STP is performing satisfactory for achieving the Indian standards for wastewater disposal into the water body. Moreover, the survival as well as good production of fishes is being used as indicator for overall performance of treatment plant.

Reuse of treated wastewater: Currently the treated wastewater is being reused in irrigation. In wastewater-irrigated fields, different types of crops are being produced. The most cultivated crops include rice, wheat, maize, millet, barley, Jute, cotton, sugarcane and oil seeds *etc*. The treated wastewater is being well accepted by the farmers as it gives additional benefit in economy of fertilizers up to some extent.

Health risks: During operation of treatment plant operators are exposed to the solids of the screen. The operators are not using the special equipment for cleaning the screen and during fish cultivation, the persons are also directly exposed with wastewater, hence exposed to health risks. Moreover, the use of human waste in aquaculture always remains a potential public health risks concerns from many decades. Martin Strauss, has described the actual public health risks occurring through the use of waste use in aquaculture which may be divided into three main categories; i.e., those affecting consumers of the aquatic products grown in wastewater-fed waters (consumer risk), those affecting the operators of the aquaculture system who might become exposed to treated and/or diluted wastewaters (operators' risk), and those who handle and process the products (e.g. fish) (workers' risk).

Institutional and operational aspects: The salaries of three persons are being paid by the private contractor who is operating the treatment plant. The persons were selected for operation of treatment plant from the local community based on prior experience in the respective areas. The persons dealing the operational activities at treatment plant are well trained and their main tasks are to observe the appropriate flow pattern of wastewater in the treatment units as well as any nuisance in the fishponds (facultative and maturation pond) as depicted in **Table 5.6**. The technical issues related with operation and maintenance of wastewater treatment plant are being taken care by technical supervisor and junior engineer working at Karnal Municipal Corporation. The Karnal Municipal Corporation and the CPCB monitor the treatment performance every month, but the information on the performance is not publically available.

Table 5.6: Manpower directly involved in operation and maintenance of WSP/SFA

S.No.	Person Designation	Assigned Duties	Number
1.	Sweeper cum watchman	Under the general supervision, to clean the STP boundary platforms, equipment and working area and to guard the WSP.	2
2.	Operator	To observe the appropriate flow pattern of wastewater in the treatment units as well as any nuisance and cleaning of bar-screen	1
Total			3

Economic aspects: The costs associated with wastewater collection and maintenance of treatment plant are being afforded by the Karnal Municipal Corporation. Municipal Corporation has given the treatment plant at lease for one year to private contractor for aquaculture activities in the treatment units. The cost for lease for using treatment units for aquaculture was decided on the basis of highest auction cost. In the current lease year, contractor has paid INR 2 lakhs for one year to Municipal Corporation. Contactor has reported to generate the revenue from selling the fish in the market of around INR 6 – 8 Lakhs. The Karnal Municipal Corporation has also earning some revenue by selling treated wastewater to the farmers.

Social aspects: Fish culture in wastewater plays two important roles; recycling nutrients from wastewater to reduce eutrophication and fish production for community welfare. The treatment plant is directly giving the benefits for creating employment to nearby community as well as provide the low-cost fish for poor peoples. The one more benefit from the treatment plant was observed to get better quality of treated wastewater as compared to conventional treatment process because aquaculture significantly contributes in betterment of overall quality of the effluent. The rate of fish survival and production of fish during wastewater treatment gives the direct indication of quality of treated wastewater, as the more organic loading starting in the treatment units, especially in facultative and maturation ponds, fish start to dying in the night. Therefore, a good operation and maintenance of sewage fed aquaculture always gives a positive indication of superior quality of treated wastewater.

Summary

India is facing a grave crisis with respect to water (in urban as well as rural areas) supplied for potable, domestic, agricultural, and industrial purposes while the available water resources are getting polluted due to disposal of partially treated and untreated domestic and industrial effluents. Although, the number of wastewater treatment plants has increased over the years in urban India, this increase is not adequate to keep pace with escalating generation of wastewater. A large volume of wastewater continues to be discharged into natural watercourses leading to pollution of the coastal zones and drinking water reservoirs in India. About 38,254 MLD of sewage is generated from Class I and Class II towns and existing treatment capacity is 2000 MLD, therefore, a large gap exists between sewage generation and treatment in India (CPCB, 2009). Discharge of this untreated sewage into water courses both surface and ground waters is primarily responsible for water pollution in India.

The conventional mechanised systems turn out to be rather expensive in terms of both, the installation as well as operation and maintenance costs. There are number of conventional wastewater treatment plants installed in past few years along with Ganga and Yamuna River under Ganga Action Plan (GAP) and Yamuna Action Plan (YAP) to minimize the pollution from the cities. Many of STPs installed along these rivers are not performing satisfactory because of operation and maintenance failures. NTSs have additional benefits over the conventional treatment systems as they required minimum operational and maintenance cost and also provide effluent quality often close to conventional wastewater treatment systems. It is argued here that the newer solutions should be such that the peri-urban and small communities should be able to own and operate their wastewater treatment plants. The NTSs provide the opportunity to take avoid many practical problems of operation and maintenance occurred using conventional treatment systems and may be the most feasible solution in India.

There are different types of NTSs available and the most practiced include: Constructed Wetlands (CWs), Hyacinth and Duckweed Ponds (DPs), Karnal Technology (KTs) for On-land Disposal of wastewater, Fish Ponds, Waste Stabilization Ponds (WSPs), Polishing Pond (PPs), Oxidation Ponds and Lagoons and, Algal-bacterial Ponds. All wastewater treatment systems based on NTSs have been designed and operated in order to meet the regulatory standards prescribed by CPCB, New Delhi for reuse and discharge into the water body. The major reuses of treated domestic wastewaters from NTSs in India are irrigation of agricultural fields and gardens. Another substantial use has been for disposing into sewage fed aqua-culture ponds. In most of the cases, the treated effluent from NTSs directly reused in agriculture or disposed into nearby river.

To assess the potential of existing NTSs for wastewater treatment and reuse across India - a nationwide survey of identified potential sites of NTSs was carried out. There are numerous sites of NTSs available in India, however, for this study only engineered ones were selected so that the treatment process and kinetics may be simulated in any place if the treatment systems gives the overall better pollutant removal efficiency in relevance with recycle and

reuse. Aiming at understandiing wastewater treatment and management in Indian cities and rural areas, 41 NTSs based STPs across India were visited during last 15 months and secondary data were collected by interviewing the operating staff of the respective STPs as well as by utilizing the literature, log books, and progress reports supplied by the respective personnel. The secondary data obtained during field visits were assessed for their social aspects as well as performance capacity of the engineered NTSs.

The total 41 visited sites of NTSs comprises of WSPs (23 No.), DPs (3 No.), PPs (7 No.), CWs (5 No.) and KT (2 No.). It was found that PPs is the most commonly practiced NTSs in India - which contributes nearly 53% of total wastewater treated by the means of NTSs (total load serviced by NTSs is around 1838 MLD). One of the impressive features of PPs is its versatility. For example, several PPs have been employed for municipal as well as industrial wastewater treatment all over India after UASB units for improving the quality of treated effluents by means of the anaerobic biological reactor. WSPs are also equally practiced and they account for nearly 45% of total wastewater treated by means of NTSs in India. However, KTs for on-land disposal of wastewater, engineered CWs as well as DPs were found to cater lower amounts of wastewater as compared with total load serviced by NTSs, but their number is significant – which is the direct indication that these treatment technologies (KTs, CWs and DPs) are used as decentralised systems for wastewater treatment. Therefore, the NTSs including KTs, CWs and DPs, which are at present treating relatively lower amounts of wastewater, may play a significant role in development of proper wastewater management and treatment in India where low-density communities and varying site conditions prevails.

The duckweed based wastewater treatment system in conjunction with pisciculture is one such technology that has the potential of offering effective wastewater treatment besides providing economic returns as well as generating employment opportunities in the rural areas. The decentralized wastewater treatment and management systems are appropriate and cost-effective solution for such low-density communities where restricted local budgets, lack of local expertise, and lack of funding (USEPA, 2002).

There are various agencies involved directly or indirectly for establishment as well as operation and maintenance of NTSs, that includes, Govt. of States and Govt. of India, State Jal Board/Jal Nigam, Municipal Corporations of respective cities, Nagar Palika Prishad, Public Health Engineering Department (PHED), Water and Sewage Board, National River Conservation Directorate (NRCD), United Nations Development Programme (UNDP), Environmental Planning & Coordination Organisation (EPCO), Village Council *etc*.

At most of the sites of NTSs, the similar wastewater treatment train is being adopted for particular type of NTS. Most of the NTSs consist of a train of individual unit processes set up in series, with the output (effluent) of one process becoming the input (influent) of the next process. The first stage is usually made up of physical processes that take out easily removable pollutants. After physical processes, secondary treatment based on biological processes generally treats the remaining pollutants further. During operation of NTSs lots of variations in hydraulic loading were observed. The survey of 41 NTSs indicates three type of circumstances in context of receiving the amount of wastewater as per their design, a) appropriate hydraulically loaded (13 No.), b) under hydraulically loaded (15 No.) and, c) over hydraulically loaded (12 No.).

The compliance status of visited NTSs was identified according to meet the downstream reuse of discharge standards prescribed by CPCB, New Delhi. Survey results NTSs concludes that 75% (30 No.) compliance, 20% (8 No.) non-compliance and 5% (3 No.) not in operation. The major reasons associated with non-compliance of NTSs includes, inappropriate hydraulic/organic loading, poor of operation and maintenance by operating agencies, fund shortage for operation and maintenance, lack of alternate power supply for pumping wastewater continuously into treatment units, unqualified or less qualified staff at site etc.

In order to assess the performance of NTSs for BOD_5, COD and fecal coliforms removal were analysed statistically and results were represented. In case of WSPs, the average percentage BOD_5, COD and fecal coliforms removal were observed as 77.9, 71 and 97.36, respectively. The average percentage removal of BOD_5, COD and fecal coliforms by PPs were found to be 55.43, 71 and 97.36, respectively. For CWs, the average percentage removal of BOD_5, COD and fecal coliforms were found to be 72, 71 and 99.6, respectively. The average percentage removals of BOD_5, and fecal coliforms for DPs were 92 and 97.5, respectively.

The NTSs at various places were used in integrated manner for wastewater treatment as well as production of useful products like timber, fishes etc. The various applications of treated wastewater from NTSs across India include irrigation of agricultural fields, fish production, gardening, recreation of water bodies, *etc*. The post-treatment of secondary treated effluent *i.e.* disinfection is rather a limited practice and used at only two treatment sites performing namely, 14 MLD STP Kapoorthala (Punjab) and 14 MLD STP Agra (Utter Pradesh). The treated wastewater from NTSs removes fecal coliforms and nutrients significantly besides meeting the biochemical oxygen demand. The quality of treated effluents coming from NTSs based STP which are being properly operated and maintained are equally comparable with mechanized treatment systems in terms of physic-chemical parameters. The additional benefit observed in the treated effluent quality coming from NTSs was of lower count of fecal coliforms as compared to conventional sewage treatment plant – which may give better opportunity to reuse the treated wastewater. Although the treated wastewater from NTSs are still not fit to body contact level because of higher number of coliform bacteria, but it may be reused after disinfection.

The reuse of secondary treated effluent from any kind of treatment technology without any post-treatment may pose the health hazards if community access ground water from nearby treated wastewater reuse or disposal site. On the other hand, chlorination (mostly used and only effective method of disinfection) always leads to creation of carcinogenic by-products in the wastewater and hence NTSs may be the appropriate method if properly designed, operated and maintained in order to achieve the phenomenon of natural die-off. t was observed that there no post-treatments (except disinfection) are being given to the secondary treated effluent of CWs and other NTSs in India. During disinfection, 1-2 ppm of chlorine is dosed at the outlet of secondary treated effluent. Out of 108 operated sites NTSs, only two have the facility of chlorine disinfection. Hence, post-treatment to secondary treated effluent from NTSs is almost absent in India.

During classification of constructed wetlands and other natural treatment systems with an emphasis on reuse and social relevance (Task 3.1.2), efforts have been made to classify various NTSs studied throughout India during the past 17 months and on the basis of published reports and literature as well as the insights developed by IITB team after philosophizing and theorizing the learnings from published literature.

Researchers have studied conventionally employed technologies for treatment of sewages in rural, small urban communities and peri-urban communities at the outskirts of metropolitan habitats in India. In order to summarize the wastewater treatment and management systems based on natural process, many attempts have been made to articulate the classification of NTSs by different researchers who have aspired to construct and make classification schemes more comprehensive. Thus, every classification process has different goals, schemes and different structural properties as well as different strengths and weaknesses in terms of representation and discovery of knowledge.

On one hand, the classification system, developed by Asolekar and co-workers (Chaturvedi and Asolekar, 2009; Asolekar *et al.* 2013), essentially addressed the sewage treatment-related applications and in that sense it was important in the context of selecting appropriate NTSs for achieving a given treatment objective. On the other hand, one of the most important outcomes of that classification was that it illustrated the continuum between pristine aquatic natural systems and those aquatic systems that have been engineered for obtaining desire sewage treatment objective. The classification system proposed by Sharma and co-workers (Sharma and Amy, 2010; Sharma *et al.* 2012; Sharma and Rousseau, 2011) specifically focused on MAR and SAT – especially significance of these technologies and their roles in rendering water and wastewater treatment before discharging into surface waters or recharging into ground. Asolekar *et al.* (2013) emphasized the possibility and necessity of balancing social priorities with the technological possibilities while planning, detailing and implementing the sewage treatment projects as well as projects aimed at rehabilitation and rejuvenation of contaminated stretches of rivers, lakes and ground water with the help of NTSs.

Based on the perspective discussed, the typologies of categories of NTSs have been proposed. The categories of classification include; classification based on gainful utilization of runoff and effluents, classification based on goal and intention visualized, classification based on treatment principle, classification based on terrestrial versus aquatic systems and classification based on the preferences of benefactor. The detailing of each category has also been undertaken and listed during discussion.

During in-depth evaluation of selected case studies, five treatment plants based on most practiced types of NTSs (WSPs, CWs, PPs, DPs and sewage-fed aquaculture) in India were selected for further investigation. In detailed investigations of selected NTSs the major focus was on reuse potential of treated wastewater as well as integrated assessments linking health, environment, society, and institutions. The in-depth evaluation studies of different NTSs indicates that the treated effluent is being well accepted by the community for utilising it in agricultural field, fish production and gardening applications. The adjoining farmers who are presently not getting the treated wastewater are also demanding the treated wastewater because it gives additional benefit in saving of fertilisers during cropping activities. At many places, the revenue generated from either selling treated wastewater or fishes happens to be sufficient for cost occurring during operation and maintenance of NTSs. The farmers are aware with the pathogenicity of treated wastewater and are taking the appropriate measures during irrigation of fields using treated wastewater. The treated effluent in agricultural field mainly utilised for irrigating annual cereal crops, herbaceous fodder crops etc. The vegetable produced from treated wastewater irrigated fields are not being eaten raw.

In addition to the current research activities going on in the work package 3 of *Saph Pani* Project, the work of Identification of strategies for enhancement of the potential of shortlisted constructed wetlands and other natural treatment systems are in progress. The major focuses of these works are the estimation of design parameters from existing plants and elaboration of possible ways to improve the treatment systems. Outcomes of these activities will be feed in the Deleverable D3.3 and D3.4 reports due on M30 and M36 of project reporting.

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Annexures

Annexure A: Brief description of visited engineered natural treatment systems across India

1. Sewage treatment plant, Nehru Vihar, Delhi

Location ID: India_DL_1_WSP

The WSP of capacity 22.7 MLD at Nehru Vihar, Delhi, is performing unsatisfactorily. The apparent reasons for poor performance of STP are due to lack of proper operation and maintenance practices. The treatment units including, facultative and maturation ponds have excessive growth of weeds, which may be the direct indication of negligence. As it stands now, the WSP is seems to be beyond the recovery. Currently STP are performing marginally good in achieving the discharge standards because of receiving only 4 to 5 MLD sewage for treatment (under hydraulic loading condition). The treated effluent from WSP directly discharges into Yamuna River. There are also no means of microbial decontamination available for treated effluent from WSP before discharging into the Yamuna River.

2. Sewage treatment plant, Kathal Road Karnal

Location ID: India_HR_1_WSP

The WSP of capacity 8 MLD is performing satisfactorily in achieving design norms of treated effluent. At this STP, facultative and maturation ponds are being utilized for pisciculture. Sometimes, the fish-kill has been reported in facultative pond due to high organic loading at facultative pond. In the situation of fish killing, plant operators are using lime to precipitate suspended particulate matter in the facultative pond. The pisciculture activities in WSP treatment units during sewage treatment are generating the revenue of about INR 10 Lakh per year. The treated effluent is directly used in irrigation without performing any disinfection process, as there are no means available for microbial decontamination at the treatment site.

3. Sewage treatment plant, Sector 4, Karnal Haryana

Location ID: India_HR_2_PP

The STP was commissioning year 2000 through the funding provided by Yamuna Action Plan (YAP). The treatment plant operated and maintained by Municipal Corporation of Karnal, Haryana. The PP of 40 MLD capacity was installed after Up-flow Anaerobic Sludge Blanket (UASB) unit for up gradation of secondary treated effluent. STP is performing satisfactorily in achieving design norms of treated effluent. Presently, treated water not being reused because the treated wastewater water directly discharges into the Yamuna River. In and around the STP, there is the ample scope of utilising the treated effluent in agriculture fields. The sludge generated from UASB unit is being dried through sludge drying bed by taking appropriate health measures latter on which is being used as fertilizer in associated agricultural fields.

4. Sewage treatment plant, Palval, Haryana

Location ID: India_HR_3_WSP

The WSP of capacity 9 MLD was established under Yamuna Action Plan and being operated and maintained by Municipal Corporation of Palval, Haryana. The treatment plant is overloaded in terms of flow; therefore, performance of the plant is marginally affected. About two years back (2010), the treatment units of STP were being utilized for pisciculture activities but at present used only for wastewater treatment. Some amount of treated wastewater is being reused in agricultural field for irrigation and remaining discharged into the Yamuna River. There are no means available for microbial decontamination or post-treatment at site. Therefore, may be the risk of spread of microorganisms and finally the contamination of receiving water bodies.

5. Sewage treatment plant, JNEC, Aurangabad, Maharashtra

Location ID: India_MH_1_WSP

The WSP of capacity 4 MLD in Aurangabad was found failed in achieving parameters of treated wastewater quality. As it stands now, the WSP is beyond recovery. The reason for failure of treatment plant was observed due the improper functioning of the primary treatment units – which results in siltation of grit as well as excessive weed growth in the treatment units. Presently regulatory authorities are planning to construct a new UASB based wastewater treatment plant of capacity 4 MLD and there is a strategy of utilizing previously constructed structures of WSP pond as polishing pond. The treated wastewater from oxidation pond is being used for maintaining the appropriate water level in Salim Ali Lake. There are no means available for microbial decontamination at the treatment site. Therefore, may be the risk of spread of microorganisms and finally the contamination of receiving water body.

6. Sewage treatment plant, Sangli, Maharashtra

Location ID: India_MH_2_WSP

Sangali Miarj Kupwda Municipal Corporation has established the WSP of capacity 12.5 MLD in miraj in the year 1969. Sangali Miarj Kupwda Municipal Corporation is also taking the operation and maintenance of STP. STP has served the wastewater treatment from a long time and treated wastewater has been reused for irrigation. Presently, Municipal Corporation has decided to shutdown the treatment at present location and willing to shift to another location because of residential development taken place around the STP. Therefore, only small amount flow is coming to the treatment plant and STP is not in proper operation.

7. Sewage treatment plant, Miraj, Maharashtra

Location ID: India_MH_3_WSP

Sangali Miarj Kupwda Municipal Corporation has established the WSP of capacity 9.2 MLD in miraj in the year 1969-71. The WSP is performing close to satisfactorily in achieving design norms of treated effluent. The performance of STP is being affected due to poor operation and maintenance by plant operators. The treated effluent is directly being reused in irrigation without performing any disinfection process because there are no means available for microbial decontamination at the treatment site.

8. Sewage treatment plant, Karad, Maharashtra

Location ID: India_MH_4_WSP

Miraj Nagar Palika Parishad has established the WSP of capacity 7.5 MLD in Karad in the year 1974 for treatment of domestic wastewater from Karad city. The wastewater collection cost is being contributed by Karad Nagar Palika Parishad and operation and maintenance cost is being afforded by Miraj Nagar Palika Parishad. Miraj Nagar Palika Parishad incurred the revenue of about INR 70,000-80,000 per month from farmers. The STP were designed in order to achieve the treated wastewater effluent that may fit for discharge into water body, but due to the unsatisfactory performance, the treated wastewater is being reused in irrigation. The apparent reasons for poor performance of STP are due to lack of proper operation and maintenance practices. The treatment units including, facultative and maturation ponds have excessive growth of weeds, which may be the direct indication of negligence. As it stands now, the WSP is seems to be beyond the recovery. There are no means of microbial decontamination available for treated effluent from WSP before use in agricultural activities.

9. Sewage treatment plant, Barogarh, Ujjain, Madhya Pradesh

Location ID: India_MP_1_KT

1.67 MLD Sewage Treatment Plant, Barogarh, Ujjain, Madhya Predesh, situated at the bank of Shipra River is based on Karnal Technology (KT). The treatment plant was established in year 2002 through funding provided by National River Conservation Directorate (NRCD) for saving the Shipra River. The treatment system involves growing tree on ridges, 1 m wide and 50cm high wand disposing of the untreated sewage in furrows. The total daily sewage treatment (consumption) capacity of this plant is 1.67 MLD. At treatment plant, eucalyptus plants species has been used for treatment (evapotranspiration) of wastewater. Due to lack of inconsistency in flow rate of effluent, as well as mixed nature of domestic and industrial effluent, plant system are suffering from water logging and toxic effect, which results in dying of some plants.

10. Sewage treatment plant, Barogarh, Ujjain, Madhya Pradesh

Location ID: India_MP_2_KT

1.79 MLD Sewage Treatment Plant, Barogarh, Ujjain, Madhya Predesh, situated at the bank of Shipra River is based on Karnal Technology (KT). The treatment plant was established in year 2002 through funding provided by National River Conservation Directorate (NRCD) for saving the Shipra River. The total daily sewage treatment (consumption) capacity is around 1.79 MLD. The treatment plant receives only domestic wastewater and applied wastewater completely absorb into the soil-plant-bed. Treatment plant performing well in terms of wastewater absorption that is being daily applied. The growth and health of planted trees are well as there was no indication of death of any trees. The trees are seems to be mature and regulatory body are planning for harvesting.

11. Sewage treatment plant, Ujjain, Madhya Pradesh

Location ID: India_MP_3_WSP

The WSP of capacity 52.74 MLD in Ujjain, Madhya Pradesh, was established in year 2002 through funding provided by National River Conservation Directorate (NRCD) for saving the Shipra River. The WSP is performing satisfactorily in achieving design norms of treated effluent. The treated effluent is directly used in irrigation without performing any disinfection process because there are no means available for microbial decontamination at the treatment site. STP is suffering by negligence of operating agencies and excessive growth of weeds has grown in facultative and maturation ponds. The WSP is situated 20 km away from the Ujjain city and operating agencies complaining for insufficiency of funds to pump the city wastewater to treatment site.

12. Sewage treatment plant, RTO Thana, Ujjain, Madhya Pradesh

Location ID: India_MP_4_CW

A horizontal flow CWs of capacity 80 KL (size: 17m × 85m ×0.7m) was constructed and commissioned in year 2002 for treating the domestic wastewater of urban community. Capital cost for establishing this treatment plant was provided by UNEDP. The CWs bed was constructed in wastewater carrying nallah. Wastewater without any primary treatment is being passed through the CWs bed. During construction of bed, river sand was used as a constructed material for CWs bed and Phragmites karka planted. Treatment plant is greatly suffered with lack of maintenance - which resulted in clogging of bed as well as development of residence for domestic animals (e.g., Pig). Clogging in the bed is also results of lack of primary treatment of domestic wastewater before entering into the bed. During the rainy season, bed also become over flooded which also the main cause of reduced performance and clogging of bed.

13. Sewage treatment plant, Panchseel Colony, Bhopal

Location ID: India_MP_5_CW

A horizontal flow CWs of capacity 150 KLD was constructed in year 1997 for treating the domestic wastewater of urban community. The system performing satisfactorily in achieving design norms of treated effluent. In treatment train, septic tank was installed for giving primary treatment to the raw wastewater. The primary treated wastewater from septic tank further goes for secondary treatment through CW. The CW bed was constructed by using river sand with the emergent plant species of Phragmites karka. The treated effluent from CW bed is being discharged into the adjacent wastewater carrying nallah. Presently, STP is under stress as the clear sign of clogging in the bed reflected from first sight. The problem of bed clogging arises because of improper functioning to the primary treatment unit. The improper functioning of septic tank arises due to negligence of operating agencies, as de-slugging from septic tank has not been regularly. Due to the improper functioning of settling unit, the floating sludge from septic tank is continue to enter into the CW bed which results in clogging. The system may become beyond the recovery if proper attention not being given, especially immediate cleaning of septic tank.

14. Sewage treatment plant, Ekant Park, Bhopal

Location ID: India_MP_6_CW

A horizontal flow CW of capacity 70 KLD (750 m2) has been constructed in year 2002 for treating the domestic wastewater of urban community. Capital cost of 14.10 Lakhs for establishing this treatment plant was provided by UNEDP, Bhopal. In treatment train, screen and grit removal units were installed for giving primary treatment to the raw wastewater. The primary treated wastewater further goes for secondary treatment through CW. The CW bed was constructed by using river sand with the emergent plant species of Phragmites karka. Treatment plant is greatly suffered with lack of maintenance which results in clogging of bed. Clogging in the bed also results failure of primary treatment of domestic wastewater before entering into the bed. During the rainy season, bed also become over flooded which is also the main cause of reduced performance and clogging of bed. The treated water is being reused for gardening in the community park.

15. Sewage treatment plant, Kapoorthala, Punjab

Location ID: India_PB_1_PP

The STP was established by Kapoorthala water and sewerage board, Punjab. The treatment plant also operated and maintained by Kapoorthala water and sewerage board, Punjab. The PP of capacity 25 MLD installed after UASB unit for up gradation of secondary treated effluent. STP is performing satisfactorily in achieving design norms of treated effluent. The treated effluent from polishing pond is being disinfected (chlorination) before reuse in irrigation. The sludge generated from UASB unit is being dried through sludge drying bed by taking appropriate health measures. The dried sludge is being reused as fertilizer in associated agricultural fields.

16. Sewage treatment plant, Bais, Ludhiana, Punjab

Location ID: India_PB_2_WSP

The WSP of capacity 0.5 MLD has been constructed in year 2008 for treating the domestic wastewater of village community. The raw wastewater passes through primary treatment units *i.e.* screen and grit chamber. The STP is being operated and maintained by village panchayat. The wastewater treated in a chain of anaerobic pond followed by facultative and maturation pond. The system is not being properly taken care by operating authorities for their operation and maintenance. The system is performing well in terms of reuse standard for disposal on the land or irrigation. The one of the most important drawback of this system is the lack of concrete lining in the treatment ponds which may impose the risk of water contamination nearby area of treatment plant. The treated effluent is directly being reused for irrigation without performing any disinfection process, as there are no means available for microbial decontamination at the treatment site.

17. Sewage treatment plant, Dedwal, Ludhiana, Punjab

Location ID: India_PB_3_WSP

The WSP of capacity 0.5 MLD has been constructed in year 2008 for treating the domestic wastewater of village community. In the treatment train there is no primary treatment given to wastewater before entering into the anaerobic pond. The wastewater treated in a chain of anaerobic pond followed by facultative and maturation pond. The system is being properly taken care by operating authorities for their operation and maintenance. The system is performing well in terms of reuse standard of disposal on land and irrigation. One of the most important drawbacks of this system is the lack of concrete lining in the treatment ponds which may impose the risk of water contamination nearby the treatment plant. The treated effluent is directly being reused for irrigation without performing any disinfection process, as there are no means available for microbial decontamination at the treatment site.

18. Sewage treatment plant, Ludhiana, Zone B, Punjab

Location ID: India_PB_4_PP

The STP of capacity 111 MLD was commissioning year 2005 for treating domestic wastewater of Kapurthala Township, Punjab. The treatment plant is being operated and maintained by Kapurthala sewerage board, Punjab. The PP was installed after UASB unit for up gradation of secondary treated effluent. STP is performing satisfactorily in achieving design norms of treated effluent. The treated effluent is not being disinfected prior to reuse in agriculture activities. The sludge generated from UASB unit is being dried through sludge drying bed by taking appropriate health measures. The dried sludge is being used as fertilizer in associated agricultural fields.

19. Sewage treatment plant, Phillore, Punjab

Location ID: India_PB_5_WSP

The WSP of capacity 2.56 MLD was established for treating the domestic wastewater of Phillore Township, Punjab. The raw wastewater passes through primary treatment units *i.e.* screen and grit chamber. The wastewater treated in a chain of anaerobic pond followed by facultative and maturation pond. The system is being properly taken care by operating authorities for their operation and maintenance. The system is performing well in terms of reuse standard of disposal into the water body. The treated effluent is directly being discharged into the Satluz River without performing any disinfection process, as there are no means available for microbial decontamination at the treatment site.

20. Sewage treatment plant at Pipar Majra, Ropar, Punjab

Location ID: India_PB_6_CW

The CWs of capacity 0.5 MLD has been constructed in year 2006 for treating the domestic wastewater of village community. The system performing satisfactorily in achieving design norms of treated effluent. In treatment train, septic tank was installed for giving primary treatment to the raw wastewater. The primary treated wastewater from the septic tank further goes for secondary treatment through CW. The CW bed was constructed by using river sand with the emergent plant species of *Typha latifolia* (Common Cattail). The treated effluent from CW bed is being discharged into the adjacent fish pond where pisciculture is being done. Presently, STP is under stress as the clear sign of clogging in the bed reflected from first sight. The problem of bed clogging arises because of improper functioning of the primary treatment unit. The improper functioning of septic tank arises due to negligence of operating agencies, as de-slugging of septic tank has not been done regularly. Due to the improper functioning of settling unit, the floating sludge from septic tank is continue to enter into the CW bed which results in clogging. The system may become beyond the recovery if proper attention is not given, especially immediate cleaning of septic tank.

21. Sewage treatment plant at Village Saidpur, Ludhiana, Punjab

Location ID: India_PB_7_DP

The DP of capacity 0.5 MLD was established in year 2004 for treating the domestic wastewater of village community. In the treatment train there is no primary treatment given to wastewater before entering into the duckweed pond. The wastewater first treated in DP and overflow goes into fishpond. The system is performing well in terms of reuse standard of disposal on land and irrigation. The pisciculture activities during sewage treatment are generating the revenue of about INR 50,000-70,000 per year – which utilizes for operation and maintenance of treatment plant by Village Council . The treated effluent is directly being reused for irrigation without performing any disinfection process, as there are no means available for microbial decontamination at the treatment site.

22. Sewage treatment plant, Sandhuan, Roop Nagar, Punjab

Location ID: India_PB_8_DP

The DP of capacity 0.5 MLD was established in year 1998 for treating the domestic wastewater of village community. In the treatment train, the wastewater first primarily treated by screen and grit before entering into the duckweed pond. The treated wastewater by DP goes into fishpond. Presently, the pisciculture activities in fishpond are discontinued because of some Village council disputes. The system is performing well in terms of reuse standard of disposal on land and irrigation. Previously, pisciculture activities during sewage treatment were generating the revenue of about INR 50,000-70,000 per year – which was utilizes for operation and maintenance of treatment plant by Village Council. The treated effluent is directly being reused for irrigation without performing any disinfection process, as there are no means available for microbial decontamination at the treatment site.

23. Sewage treatment plant at Village Sandhuan, Roop Nagar, Punjab

Location ID: India_PB_9_WSP

The WSP of capacity 0.5 MLD has been constructed for treating the domestic wastewater of urban community. The treatment plant is going to be commissioned very soon. The raw wastewater will pass through primary treatment units *i.e.* screen and grit chamber. The wastewater will treated in a chain of anaerobic pond followed by facultative and maturation pond.

24. Sewage treatment plant, Uncha, Roop Nagar, Punjab

Location ID: India_PB_10_DP

The DP of capacity 1 MLD was established in year the 2008 for treating the domestic wastewater of village community. In the treatment train there is no primary treatment given to wastewater before entering into the duckweed pond. The wastewater treated in a DP followed fishpond. The system is not being properly taken care by operating authorities for their operation and maintenance. The system is performing well in terms of reuse standard of disposal on land and irrigation. One of the most important drawbacks of this system is the lack of concrete lining in the treatment ponds, which may impose the risk of water contamination nearby the treatment plant. The treated effluent is directly used for irrigation without performing any disinfection process, as there are no means available for microbial decontamination at the treatment site.

25. Sewage treatment plant at Sultanpur Lodi, Punjab

Location ID: India_PB_11_WSP

The WSP of capacity 2.6 MLD was established for treating the domestic wastewater of urban community. The system found overloaded in terms of wastewater flow and therefore not able to achieve treated wastewater standard into water body. The operating agencies have decided to reuse the treated effluent for agriculture activities instead of dispose into water body, as system is not able to meet water body discharge standards. The system is performing well in terms of reuse standard of disposal onto the land or irrigation. The treated effluent is directly being reused in the agriculture activities without performing any disinfection process, as there are no means available for microbial decontamination at the treatment site.

26. Sewage treatment plant at Village Nanded, Jodhpur, Rajasthan

Location ID: India_RJ_1_WSP

RUIDP, Rajasthan established the WSP of capacity 20 MLD for treating the domestic wastewater of urban community of Jodhpur city in year 2007. The system was designed for disposal onto the land or agriculture. The system receives concentrated wastewater in terms of pollution load like BOD, COD etc. The system is under loaded in terms of wastewater flow. The system performing well in terms of reuse standard of disposal onto the land or irrigation. The treated effluent is being directly reused in the agriculture activities without performing any disinfection process, as there are no means available for microbial decontamination at the treatment site.

27. Sewage treatment plant, Vallabh Garden Bikaner, Rajasthan

Location ID: India_RJ_2_WSP

RUIDP, Rajasthan established the WSP of capacity 20 MLD for treating the domestic wastewater of urban community of Bikaner city in year 2007. The system is being properly taken care by operating authorities for their operation and maintenance. The system receives concentrated wastewater in terms of pollution load like BOD, COD etc., which are affecting the treatment performance of the system. The system is under loaded in terms of wastewater flow. The treated effluent is directly used in the agriculture activities without performing any disinfection process, as there are no means available for microbial decontamination at the treatment site.

28. Sewage treatment plant at Bhuri Ka Nagla, Agra, Utter Pradesh

Location ID: India_UP_1_WSP

The WSP of capacity 2.25 MLD is not performing satisfactorily in achieving design norms of treated effluent. The plant is receiving higher amount of flow as of its design capacity, which results in lowering the performance. Highly concentrated wastewater in terms of COD indicates the mixing of industrial effluent, which may also be the major reason for reducing the STP performance. Some amount of treated wastewater is being reused in agricultural field for irrigation and remaining discharged into the Yamuna River. There are no means available for microbial decontamination or post-treatment available at the treatment site.

29. Sewage treatment plant at Peela Khar, Agra, Utter Pradesh

Location ID: India_UP_2_WSP

The WSP of capacity 10 MLD at Peela Khar, Agra was established under Yamuna Action Plan for treating domestic wastewater of Agra city. The Jal Nigam Agra, Utter Pradesh is the agency responsible for operation and maintenance of the STP since it was established. The STP is performing satisfactorily in achieving design norms of treated effluent. Some amount of treated wastewater is being reused in agricultural field for irrigation and remaining discharged into the Yamuna River. There are no means available for microbial decontamination or post-treatment available at the treatment site.

30. Sewage treatment plant, Jaganpur, Dayal Bag, Agra, Utter Pradesh

Location ID: India_UP_3_PP

The UASB-PP of capacity 14 MLD at Jaganpur, Dayal Bag, Agra was established under Yamuna Action Plan II, for treating domestic wastewater of Agra city. The PP was installed after UASB unit for up gradation of secondary treated effluent. The STP is performing satisfactorily in achieving design norms of treated effluent. The treated effluent from polishing pond is being disinfected before it discharges into the Yamuna River. The sludge generated from UASB unit is dried through sludge drying bed by taking appropriate health measures. The dried sludge is being used as fertilizer in associated agricultural fields. The sludge generated from UASB unit is dried through sludge drying bed by taking appropriate health measures. In addition, the appropriate health measures are also taken for handling of the sludge.

31. Sewage treatment plant, Dhandpur, Agra, Utter Pradesh

Location ID: India_UP_4_PP

The UASB-PP of capacity 78 MLD at Dhandpur, Agra, was established under Yamuna Action Plan II, for treating domestic wastewater of Agra city. The PP was installed after UASB unit for up gradation of secondary treated effluent. The STP is performing satisfactorily in achieving design norms of treated effluent. The treated effluent is directly used in irrigation without performing any disinfection process, as there are no means available for microbial decontamination at the treatment site. The sludge generated from UASB unit is being dried through sludge drying bed by taking appropriate health measures. The dried sludge is being used as fertilizer in associated agricultural fields.

32. Sewage treatment plant, Masani, Mathura, Utter Pradesh

Location ID: India_UP_5_WSP

The WSP of capacity 15.59 MLD at Masani, Mathura, was established in year 2001 under Yamuna Action Plan, for treating domestic wastewater of Mathura city. The Jal Nigam Mathura, Utter Pradesh, is the agency responsible for operation and maintenance of the STP since it was established. STP is not able to meet the prescribed standards because plant is overloaded in terms of flow. Some amount of treated wastewater is being reused in agricultural field for irrigation and remaining discharged into the Yamuna River. There are no means available for microbial decontamination or post-treatment available at the treatment site.

33. Sewage Treatment Plant, Bangali Ghat, , Mathura, Utter Pradesh

Location ID: India_UP_6_WSP

The WSP of capacity 14.5 MLD at Masani, Mathura, was established in year 2001 under Yamuna Action Plan, for treating domestic wastewater of Mathura city. The Jal Nigam Mathura, Utter Pradesh, is the agency responsible for operation and maintenance of the STP since it was established. STP is not able to meet the prescribed standards of treated effluent. In raw wastewater, high value of COD and TSS are being reported which indicate the mixing of industrial wastewaters into the sewage and hence may be the major cause of reduced efficiency of STP. The treated effluent is directly discharges into Yamuna River and also used in irrigation without performing any disinfection process because there are no means available for microbial decontamination at the treatment site. Moreover, no appropriate measures are being taken in handling of sludge from primary treatment units, which may pose the health risk to the workers.

34. Sewage treatment plant, Vrindavan, Utter Pradesh

Location ID: India_UP_7_WSP

The WSP of capacity 14.5 MLD at Vrindavan, Mathura, was established under NRCD, Govt. of India, for treating domestic wastewater of Vrindavan township. The Jal Nigam Mathura, Utter Pradesh, is the agency responsible for operation and maintenance of the STP since it was established. The WSP not performing satisfactorily in achieving design norms of treated effluent. The system performance affected because proper care for operation and maintenance not been given from a long time. Some amount of treated wastewater is being reused in agricultural field for irrigation and remaining discharged into the Yamuna River. There are no means available for microbial decontamination or post-treatment available at the treatment site.

35. Sewage Treatment Plant Kali Deh, Vrindavan, Utter Pradesh

Location ID: India_UP_8_WSP

The WSP of capacity 0.5 MLD failed at Vrindavan. As it stands now, the WSP is beyond recovery. Presently, the STP has destroyed and constructed a new UASB based wastewater treatment plant and there is a strategy of utilizing previously constructed structures of WSP pond as polishing pond.

36. Sewage treatment plant, Etawah, Utter Pradesh

Location ID: India_UP_9_WSP

The WSP of capacity 10.445 MLD in Etawah, was established under NRCD, Govt. of India, for treating domestic wastewater of Etawah township. The Jal Nigam Etawah, Utter Pradesh, is the agency responsible for operation and maintenance of the STP since it was established. The WSP performing satisfactorily in achieving design norms of treated discharge standard into the water body. The treated effluent is directly being discharged into Yamuna River without performing any disinfection process, as there was no means available for microbial decontamination at the treatment site.

37. Sewage treatment plant, Kachpura, Agra

Location ID: India_UP_10_CW

The Decentralised wastewater treatment system at Kachpura slum as a part of Cross cutting Agra Program (CAP) for low-income communities. The system was installed in year 2002 with financial assistance from Water Trust UK and London Metropolitan University and technical support by Vijay Vigyan foundation. The capital cost for establishing the system was of INR 10-11 lakhs and per year operation and maintenance cost was around INR 70,000. The aim of the programme was to improve the sanitation conditions in the slum areas. The system treats approximately 50 KLD of the total wastewater which it receives from 5 clusters of slums through a common drain. The remaining untreated wastewater flows through parallel drain into the major drain that connects to the River Yamuna.

The system comprises of screen chamber which prevents the solid waste entering into the system. The wastewater then enters into three chambered septic tank. After primary treatment, it goes to nine-chambered baffled anaerobic reactor filled with gravels. After primary treatment, the wastewater goes to planted filter bed for root zone treatment. The bed filled with three different types of filter media (white river pebbles, red stones and gravels) and planted with *Canna indica*. The performance of the system happens to be satisfactory in terms of pollution removal. The treatment system is being properly operated and maintained by local people appointed for O&M. The local community of Kachpura without any disinfection reuses the treated wastewater for horticulture and irrigation purpose.

38. Sewage treatment plant Saharanpur, Utter Pradesh

<u>Location ID</u>: India_UP_11_PP

The UASB-PP of capacity 38 MLD in Saharanpur was established in year 2001 under Yamuna Action Plan, for treating domestic wastewater of Saharanpur city. The Nagar Nigam, Saharanpur, Utter Pradesh, is the agency responsible for operation and maintenance of the STP since it was established. STP is performing satisfactorily in achieving design norms of treated effluent. The treated effluent is directly drained into the Yamuna River without performing any disinfection process, as there are no means available for microbial decontamination at the treatment site. The sludge generated from UASB unit is dried through sludge drying bed by taking appropriate health measures. The dried sludge is used as fertilizer in associated agricultural fields.

39. Sewage treatment plant, Lakkad Ghat, Reshikesh, Uttrakhand

<u>Location ID</u>: India_UA_1_WSP

The WSP of capacity 6 MLD in Reshikesh, was established in the year 1985 under NRCD, Govt. of India, for treating domestic wastewater of Reshikesh township. The Gharwal Jal Sansthan, Uttrakhand, Utter Pradesh, is the agency responsible for operation and maintenance of the STP. The WSP performing satisfactorily in achieving design norms of treated discharge standard into the water body. The system is properly taken care by operating authorities. The one of the most important drawback of this system is the lack of concrete lining in the treatment ponds, which may impose the risk of water contamination in nearby the treatment plant. The treated effluent is directly discharges into the Gnga River and used in irrigation without performing any disinfection process, as there was no means available for microbial decontamination at the treatment site.

40. Sewage treatment plant, Nallacheruvu, Hyderabad, Andhra Pradesh

Location ID: India_AP_1_PP

The UASB-PP of capacity 30 MLD in Nallacheruvu, Hyderabad was for treating domestic wastewater of Hyderabad city. The HMWSSB Hyderabad, Andhra Pradesh, is the agency responsible for operation and maintenance of the STP since it was established. The treatment performance of polishing pond is good and able to achieve the design parameters. Some amount of treated wastewater is being reused in agricultural field for irrigation and remaining discharged into the River. There is no means available for microbial decontamination or post-treatment available at the treatment site.

41. Sewage Treatment Plant, Auroville, Tamil Naidu

Location ID: India_TN_1_CW

The constructed wetland with a capacity of 10m^3 per day is in good condition. The system is implemented for a residential complex with 57 persons. The system is not well maintained as there is no assigned operating staff. The effluent is used for gardening purposes without prior disinfection. As the performance results show, the plant is able to reduce E.coli by 2-5 log. This constructed wetland is a good example of how treatment systems can be integrated in the landscape.

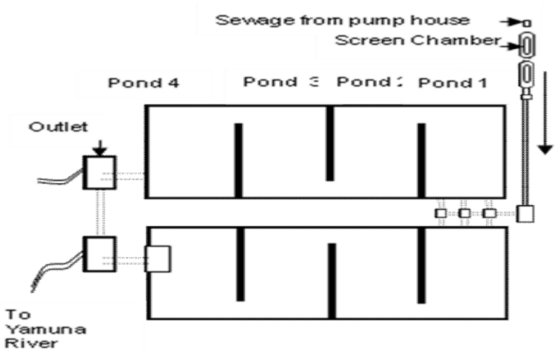
Annexure B: Detailed survey of visited engineered natural treatment systems across India

22.7 MLD, Sewage Treatment Plant, Nehru Vihar, Delhi (Location ID: India_DL_1_WSP)		
1. General Information		
1.1	Location ID	India_DL_1_WSP
1.2	Name and address of STP	22.7 MLD, sewage treatment plant, Nehru Vihar, Delhi
1.3	Contact person	R. P. Singh, Executive Engineer, Delhi Jal Board
1.4	Phone number	+91-9650061222
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Delhi Jal Board
1.8	Type of wastewater treated	Domestic wastewater of Delhi
1.9	Mode of conveyance	Delhi Jal Board sewer line
1.1	Commissioning year the STP	November 1979
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant / fish species	NA
1.14	Downstream reuse of treated wastewater	Treated water uses in irrigation and some quantity also discharge to Yamuna River.
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Delhi Jal Board
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Delhi Jal Board
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber

3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2; Unit Size: NA
3.3	Grit chamber	Unit size: NA; nos. of units: 2; HRT: 3-4 minutes
3.4	Secondary treatment units	Anaerobic Pond, 2 nos.; Facultative Pond, 4 nos.; Maturation Pond, 2 nos.
3.5	Unit 1 (LxBxD)	NA
3.6	Unit 2 (LxBxD)	NA
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	22.7
4.2	Inflow volume at the time of commissioning (MLD)	NA
4.3	Current inflow volume (MLD)	6
4.4	HRT (Days)	Total: 20 days; Unit 1: one day; Unit 2: four –five days; Unit 3: five days; Unit 4: nine days
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 160; COD (mg/L): 864; *p*H: 6.9; TP (mg/L): 0.5; Ammonia (mg/L): 55; TSS (mg/L): 248; TDS (mg/L): 490; Conductivity (µs): 984; Dissolved Oxygen (mg/L); Chloride (mg/L): 248; Total Coliform Count/100ml: 10^6; Fecal Coliform Count/100ml: NA
5.2	Treated Sewage	BOD_5 (mg/L): 36; COD (mg/L): 184; *p*H: 7.2; TP (mg/L): 0.35; Ammonia (mg/L): 18; TSS (mg/L): 48; TDS (mg/L): 490; Conductivity (µs): 860; Dissolved Oxygen (mg/L): 1.6; Chloride: 212; Total Coliform Count/ 100 ml: 10^4; Fecal Coliform Count/100ml: NA
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment available
6.2	Water quality before post treatment	NA

6.3	Cost of post treatment/m^3	NA
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater is being reused in agricultural field and some of treated Wastewater discharge in to Yamuna River.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no associated risk
7.3	Is there any risk for people involved in the disposal handling?	There is no associated risk
7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the WSP because system is far away from residential area as well treatment plant surrounded by a RCC wall.
7.5	For which purposes is the water used?	Treated wastewater is being reused in agricultural field and some of wastewater discharge in to Yamuna River.
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops like, Wheat, Maize, Egg Plant *etc.*
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	Still not assessed
7.13	Additional remarks	Operation and maintenance of treatment plant is being avoided by plant operators, which results in excessive growth of weeds in treatment units.
8. Flow Sheet of the STP		

9. Photo Gallery



Flow Sheet of STP

(A) Primary Treatment Unit

(B) Anaerobic Pond

(C) Facultative Pond 1

(D) Facultative Pond 2

(E) Maturation Pond

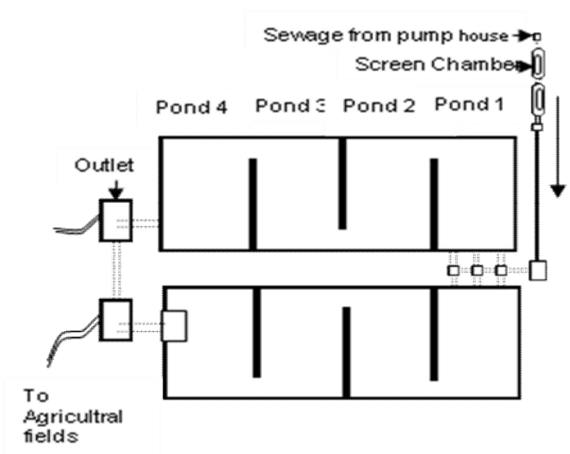
8 MLD, Sewage Treatment Plant, Kathal Road Karnal (Location ID: India_HR_1_WSP/SFA)		
1. General Information		
1.1	Location ID	India_HR_1_WSP
1.2	Name and address of STP	8 MLD, sewage treatment plant, Kathal Road Karnal
1.3	Contact person	Mr. Sanjeev Singh, Junior Engineer
1.4	Phone number	+91-7206036370
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Karnal Municipal Corporation, Haryana
1.8	Type of wastewater treated	Domestic wastewater of Karnal
1.9	Mode of conveyance	Karnal Municipal Corporation sewer line
1.1	Commissioning year the STP's	2000
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant / fish species	Magus
1.14	Downstream reuse of treated wastewater	Treated water uses in irrigation of agricultural fields
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Karnal Municipal Corporation, Haryana
2.4	Revenue generated per month	Around 5,00,00 / month
2.5	Agency bearing wastewater collection costs	Karnal Municipal Corporation, Karnal, Haryana
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2; Unit Size: NA
3.3	Grit chamber	Unit size: NA; Nos. of units: 2; HRT: 3-3.5 minutes
3.4	Secondary treatment units	Anaerobic Pond, 2 nos.; Facultative Pond, 2 nos.; Maturation Pond, 2 nos.
3.5	Unit 1 (LxBxD)	Anaerobic Pond, 2 nos.: (48×33×4m)

3.6	Unit 2 (LxBxD)	Facultative Pond, 2 nos.: (165×102×1.25m)
3.7	Unit 3 (LxBxD)	Maturation Pond, 2 nos.: (165×102×1.25m)
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	8
4.2	Inflow volume at the time of commissioning (MLD)	NA
4.3	Current inflow volume (MLD)	8
4.4	HRT (Days)	Total: 20 days; Unit 1: one day; Unit 2: four –five days; Unit 3: five days; Unit 4: nine days
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 198; COD (mg/L): 680; *p*H: 7.4; TP (mg/L): 7.3; Ammonia (mg/L): NA; TSS (mg/L): 524; TDS (mg/L): NA; Conductivity (µs): NA; Dissolved Oxygen (mg/L): 0; Chloride: NA; Total Coliform Count /100ml: 18×10^6; Fecal Coliform Count /100ml: 9×10^5
5.2	Treated Sewage	BOD_5 (mg/L): 10; COD (mg/L): 52; pH: 8.0; TP (mg/L): 6.24; Ammonia (mg/L): NA; TSS (mg/L): 48; TDS (mg/L): NA; Conductivity (µs): NA; Dissolved Oxygen (mg/L): 2.6; Chloride: NA; Total Coliform Count/ 100 ml: 10^5; Fecal Coliform Count /100ml: 10^4
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment available
6.2	Water quality before post treatment	No post treatment given
6.3	Cost of post treatment/m^3	No post treatment given
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater is being reused in agricultural field.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no associated risk
7.3	Is there any risk for people involved in the disposal handling?	There is no associated risk

7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the WSP because system is far away from residential area as well treatment plant surrounded by the wall.
7.5	For which purposes is the water used?	Treated wastewater is being reused in agricultural field
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal as well as annual crops.
7.7	If vegetables are planted, are the eaten raw?	Seasonal crops include wheat, rice, sorghum *etc.* and annual crops like sugarcane.
7.8	How many people are exposed to the wastewater before treatment and after treatment?	Raw vegetables are not been eaten.
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	Still not assessed
7.13	Additional remarks	The overall performance of the treatment plant is good. The treatment units including facultative and aerobic are being used for pisciculture.

8. Flow Sheet of the STP

9. Photo Gallery



Flow Sheet of STP

(A) Primary Treatment Unit

 (B) Anaerobic Pond	 (C) Facultative Pond 1
 (D) Facultative Pond 2	 (E) Maturation Pond

40 MLD, Sewage Treatment Plant, Sector 4, Karnal Haryana (Location ID: India_HR_2_PP)		
1. General Information		
1.1	Location ID	India_HR_2_PP
1.2	Name and address of STP	40 MLD, sewage treatment plant, near sector 4, Karnal Haryana
1.3	Contact person	Mr. Hariyom Sharma, Plant chemist
1.4	Phone number	+91-9812631166
1.5	Fax number	NA
1.6	E-mail address	Hariom21oct82@yahoo.co.in
1.7	Legal status	Yamuna Action Plan

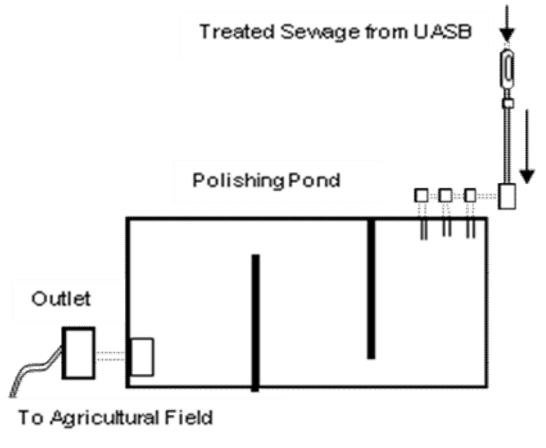
1.8	Type of wastewater treated	Domestic wastewater of Karnal
1.9	Mode of conveyance	Karnal Municipal Corporation sewer line
1.1	Commissioning year the STP's	2000
1.11	Treatment technology	UASB followed by Polishing Pond
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber-UASB-Polishing Pond
1.13	Type of plant/fish species	No plant or fish
1.14	Downstream reuse of treated wastewater	Discharge into Yamuna River.
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA, STP has been constructed under Yamuna Action Plan
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	PHED, Karnal, Haryana
2.4	Revenue generated per month	No Revenue being generated
2.5	Agency bearing wastewater collection costs	PHED, Karnal, Haryana
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2; Unit Size: NA
3.3	Grit chamber	Unit size: NA; Nos. of units: 2; HRT: 3-3.5 minutes
3.4	Secondary treatment units	UASB
3.5	Unit 1 (LxBxD)	Polishing Pond, 1 nos.: (245×145×1.5 m)
3.6	Unit 2 (LxBxD)	Sludge Drying Bed, 20 nos.: (20×20 ft)
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	40
4.2	Inflow volume at the time of commissioning (MLD)	NA

4.3	Current inflow volume (MLD)	40
4.4	HRT (Days)	24 Hrs in Polishing Pond
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 60; COD (mg/L): 200-230; *p*H: 6.9; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 250; TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count /100ml: 10^7
5.2	Treated Sewage	BOD_5 (mg/L): 25-28; COD (mg/L): 130-160; *p*H: 7.03-7.30; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 80; TDS (mg/L): NA; Dissolved Oxygen (mg/L): 1.55; Total Coliform Count /100ml: NA; Fecal Coliform Count /100ml: 10^5-10^6
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment given
6.2	Water quality before post treatment	No post treatment given
6.3	Cost of post treatment/m^3	No post treatment given
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater may be used in agricultural fields
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken.
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken.
7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the WSP because system is far away from residential area as well treatment plant surrounded by the boundary wall.
7.5	For which purposes is the water used?	Presently, treated water not being reused because the treated wastewater water

		directly discharges into the Yamuna River.
7.6	If water is used for irrigation, what plants are irrigated?	NA
7.7	If vegetables are planted, are the eaten raw?	NA
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	The overall performance of the plant is good.

8. Flow Sheet of the STP

9. Photo Gallery



Flow Sheet of STP

(A) UASB Unit

(B) Outlet of UASB

(C) Inlet of Polishing Pond

(D) Polishing Pond

(E) Sludge Drying Beds

9 MLD, Sewage Treatment Plant, Palval, Haryana (Location ID: India_HR_3_WSP)		
1. General Information		
1.1	Location ID	India_HR_3_WSP
1.2	Name and address of STP	9 MLD sewage treatment plant, Palval, Haryana
1.3	Contact person	Mr. Surender Singh, Junior Engineer
1.4	Phone number	+91-9812350623
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Yamuna Action Plan

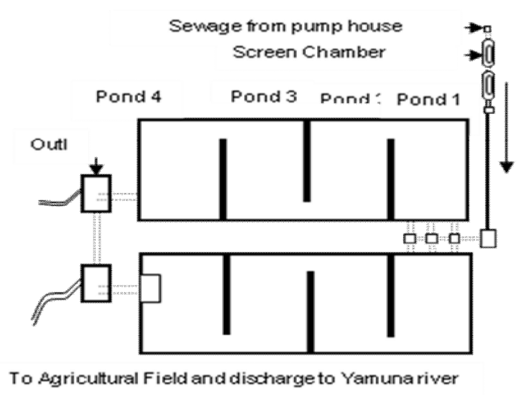
1.8	Type of wastewater treated	Domestic wastewater of Palval, Haryana
1.9	Mode of conveyance	Sewer line of Palval Municipal Corporation
1.1	Commissioning year the STP's	2003
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant / fish species	No plant or fish currently used
1.14	Downstream reuse of treated wastewater	Treated wastewater discharges into Yamuna River.
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA, STP has been constructed under Yamuna Action Plan.
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Municipal corporation, Palval, Haryana
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Municipal corporation, Palval, Haryana
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2; Unit Size: NA
3.3	Grit chamber	Unit size: NA; Nos. of units: 2; HRT: 3-3.5 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	NA
3.6	Unit 2 (LxBxD)	NA
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	9

4.2	Inflow volume at the time of commissioning (MLD)	NA
4.3	Current inflow volume (MLD)	10
4.4	HRT (Days)	Total: 20 days; Unit 1: one day; Unit 2: four - five days; Unit 3: five days; Unit 4: nine days
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 190-220; COD (mg/L): 480-550; *p*H: 6.9; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 350; TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count /100ml: 10^6-10^7
5.2	Treated Sewage	BOD_5 (mg/L): 25-35; COD(mg/L): 145-185; *p*H: 7.30; TP(mg/L): NA; Ammonia(mg/L): NA; TSS (mg/L): 90; TDS (mg/L): NA; Dissolved Oxygen(mg/L): NA; Total Coliform Count /100ml: NA; Fecal Coliform Count /100ml: 1×10^5
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment given
6.2	Water quality before post treatment	No post treatment given
6.3	Cost of post treatment/m^3	No post treatment given
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	No post treatment given
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions have been taken during different operations.
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions have been taken during different operations.

7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the WSP because system is far away from residential area.
7.5	For which purposes is the water used?	Some of treated wastewater is being used in agricultural field and some of wastewater discharge in to Yamuna River.
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops include wheat, rice, sorghum *etc.* and annual crops like sugarcane.
7.7	If vegetables are planted, are the eaten raw?	Raw vegetables are not been eaten.
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	Plant is overloaded in terms of flow; therefore, performance of the plant is slightly affected.

8. Flow Sheet of the STP

9. Photo Gallery



Flow Sheet of STP

(A) Primary Treatment Unit

 (B) Anaerobic Pond	 (C) Facultative Pond 1
 (D) Facultative Pond 2	 (E) Maturation Pond

5 MLD, Sewage Treatment Plant, JNEC, Aurangabad, Maharashtra (Location ID: India_MH_1_WSP)		
1. General Information		
1.1	Location ID	India_MS_1_WSP
1.2	Name and address of STP	5 MLD Sewage Treatment Plant, JNEC, Aurangabad, Maharashtra
1.3	Contact person	Mr. Tanpure, Junior Engineer, Municipal Corporation
1.4	Phone number	+91-9649995992
1.5	Fax number	NA
1.6	E-mail address	NA

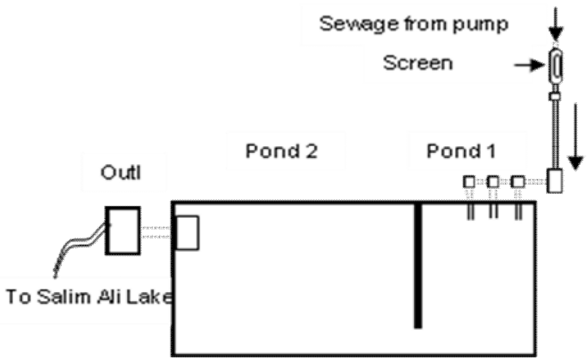
1.7	Legal status	Aurangabad Municipal Corporation
1.8	Type of wastewater treated	Domestic wastewater of Aurangabad township, Maharashtra
1.9	Mode of conveyance	Sewer line of Aurangabad Municipal Corporation
1.1	Commissioning year the STP's	NA
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant / fish species	Water weeds
1.14	Downstream reuse of treated wastewater	Treated wastewater discharges Salim Ali Lake for its rejuvenation
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Municipal corporation, Aurangabad, Maharashtra
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Municipal corporation, Aurangabad, Maharashtra
3. Design Details		
3.1	Primary treatment units	Screen chamber
3.2	Screen chamber:	Type: Coarse; Number of Screens: 2
3.3	Grit chamber	No grit chamber available
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	NA
3.6	Unit 2 (LxBxD)	NA
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	5

4.2	Inflow volume at the time of commissioning (MLD)	NA
4.3	Current inflow volume (MLD)	6
4.4	HRT (Days)	NA
4.5	Design Performance	NA
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 250; COD (mg/L): 300-350; *p*H: 6.5-7.5; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 350; TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count /100ml: 10^6
5.2	Treated Sewage	BOD_5 (mg/L): ≤125; COD (mg/L): 75-130; *p*H: 7.30; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): ≤100; TDS (mg/L): NA; Dissolved Oxygen (mg/L): NA; Total Coliform Count /100ml: NA; Fecal Coliform Count /100ml: 1×10^5
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment given
6.2	Water quality before post treatment	No post treatment given
6.3	Cost of post treatment/m^3	No post treatment given
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater is the major source of water in Salim Ali Sarovar
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions have been taken.
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken during operation and maintains.
7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the WSP is surrounded by a well-defined boundary.

7.5	For which purposes is the water used?	Treated wastewater is being reused for maintaining the appropriate water level in Salim Ali Sarovar of Aurangabad.
7.6	If water is used for irrigation, what plants are irrigated?	Treated wastewater is being reused for maintaining the water level in Salim Ali Sarovar.
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	WSP is severally suffered with the problem of siltation as well as excessive weed growth. Therefore, Municipal Corporation of Aurangabad is setting-up the UASB of 5 MLD capacity before WSP in order to improve the performance.

8. Flow Sheet of the STP

9. Photo Gallery



Flow Sheet of STP

(A) Primary Treatment Unit

(B) Anaerobic Pond

(C) Maturation Pond 1

(D) Salim Ali Lake

(E) Salim Ali Lake

12.5 MLD Sewage Treatment Plant, Sangli, Maharashtra (Location ID: India_MH_2_WSP)		
1. General Information		
1.1	Location ID	India_MH_2_WSP
1.2	Name and address of STP	12.5 MLD sewage treatment plant, Sangli, Maharashtra
1.3	Contact person	Prashant D. Bhamare (Executive Engineer), Sangli, Miraj and Kupwda Municipal Corporation (SKMC), Sangli
1.4	Phone number	+91-9850986425
1.5	Fax number	0233-2323907
1.6	E-mail address	prashant_bhamare2000@rediffmail.com

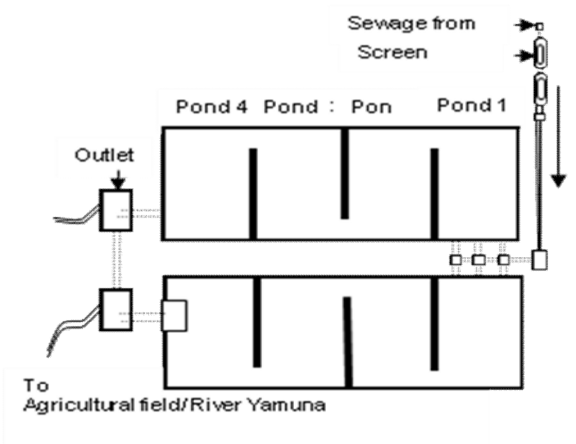
1.7	Legal status	Sangali Miarj Kupwda Municipal Corporation
1.8	Type of wastewater treated	Domestic wastewater of Sangli
1.9	Mode of conveyance	SKMC sever line
1.1	Commissioning year the STP's	1969
1.11	Treatment technology	WSP
1.12	Treatment chain/ mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant/fish species	NA
1.14	Downstream reuse of treated wastewater	Treated wastewater used in irrigation
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA
2.2	Cost of treatment (O&M Cost /month)	NA
2.3	Funding agency for wastewater treatment cost	Sangali Miarj Kupwda Municipal Corporation
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Sangali Miarj Kupwda Municipal Corporation
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2; Unit Size: NA
3.3	Grit chamber	Unit size: NA; Nos. of units: 2; HRT: 3-3.5 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	NA
3.6	Unit 2 (LxBxD)	NA
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		

4.1	Design flow (MLD)	12.5
4.2	Inflow volume at the time of commissioning (MLD)	NA
4.3	Current inflow volume (MLD)	STP is not in operation
4.4	HRT (Days)	STP is not in operation
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	STP is not in operation
5.2	Treated Sewage	STP is not in operation
6. Post Treatment		
6.1	Type of Post Treatment	STP is not in operation
6.2	Water quality before post treatment	STP is not in operation
6.3	Cost of post treatment/m^3	STP is not in operation
6.4	If effluent not being reused now, is there any potential for reuse? If yes, for which purpose	STP is not in operation
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	STP is not in operation
7.3	Is there any risk for people involved in the disposal handling?	STP is not in operation
7.4	Is there any risk for people living in the surrounding area of the system?	STP is not in operation
7.5	For which purposes is the water used?	STP is not in operation
7.6	If water is used for irrigation, what plants are irrigated?	STP is not in operation
7.7	If vegetables are planted, are the eaten raw?	NA
7.8	How many people are exposed to the	NA

	wastewater before treatment and after treatment?	
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	Due to change in land-use pattern around STP, authorities willing to shutdown and shifted the STP to another place for wastewater treatment.

8. Flow Sheet of the STP

9. Photo Gallery



Flow Sheet of STP

(A) Primary Treatment Unit

(B) Anaerobic Pond

(C) Facultative Pond 1

	
(D) Facultative Pond 2	**(E) Maturation Pond**

9.2 MLD, Sewage Treatment Plant, Miraj, Maharashtra (Location ID: India_MH_3_WSP)		
1. General Information		
1.1	Location ID	India_MH_3_WSP
1.2	Name and address of STP	9.2 MLD, sewage treatment plant, Miraj, Maharashtra
1.3	Contact person	R.D. Surya Vanshi (Drainage Engineer) Municipal Corporation, Miraj
1.4	Phone number	+91-9822185964
1.5	Fax number	0233-2323907
1.6	E-mail address	prashant_bhamare2000@rediffmail.com
1.7	Legal status	Sangali Miarj Kupwda Municipal Corporation (SKMC)
1.8	Type of wastewater treated	Domestic wastewater of Miraj City
1.9	Mode of conveyance	SKMC sever line
1.1	Commissioning year the STP's	1969-71
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant / fish	NA

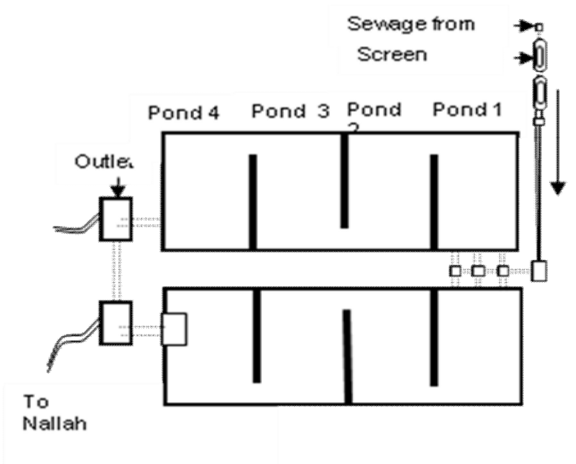
	species	
1.14	Downstream reuse of treated wastewater	Treated wastewater used in irrigation
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	INR. 35 Lakh at Establish of WSP Plant in 1969
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Sangali Miarj Kupwda Municipal Corporation
2.4	Revenue generated per month	2010-11, 18,691/- 2011-2012, 9,075/-
2.5	Agency bearing wastewater collection costs	Sangali Miarj Kupwda Municipal Corporation
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse; Number of Screens: 2 nos.; Unit Size: NA
3.3	Grit chamber	Unit size: NA; 2 Nos.
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Anaerobic Pond, 2 nos.; Size: NA
3.6	Unit 2 (LxBxD)	Facultative Pond, 4 nos.; Size: NA
3.7	Unit 3 (LxBxD)	Maturation Pond, 2 nos.; Size: NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	9.2
4.2	Inflow volume at the time of commissioning (MLD)	NA
4.3	Current inflow volume (MLD)	7.5
4.4	HRT (Days)	15

4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 200-220; COD (mg/L): NA; *p*H: 7.5; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 350-400; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count NA
5.2	Treated Sewage	BOD_5 (mg/L): 110-120; COD (mg/L): NA; *p*H: 7.7; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): NA; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): NA; Total Coliform Count /100ml: NA; Fecal Coliform Count NA
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m^3	No post treatment has been given
6.4	If effluent not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater is being reused in agriculture field
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precaution has been taken
7.3	Is there any risk for people involved in the disposal handling?	STP is not in operation
7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the STP because system is far away from residential.
7.5	For which purposes is the water used?	Treated wastewater is being reused in agriculture field
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops include wheat, sugarcane, maize *etc.*
7.7	If vegetables are planted, are the eaten raw?	NA

7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	STP is able to meet the prescribed standards of treated effluent. Most of the treated wastewater is being used agriculture fields.

8. Flow Sheet of the STP

9. Photo Gallery



Flow Sheet of STP

(A) Primary Treatment Unit

(B) Anaerobic Pond

(C) Facultative Pond 1

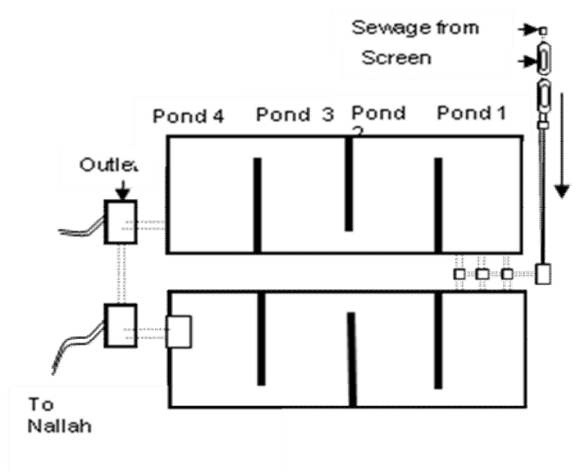
	
(D) Facultative Pond 2	**(E) Maturation Pond**

7.5 MLD, Sewage Treatment Plant, Karad, Maharashtra (Location ID: India_MH_4_WSP)		
1. General Information		
1.1	Location ID	India_MH_4_WSP
1.2	Name and address of STP	7.5 MLD, sewage treatment plant, karad, Maharashtra
1.3	Contact person	Vijay Jagan nath Tevare (Water Suply and Senitration Engineer) nagar palika parishad Karad
1.4	Phone number	+91-9420488032
1.5	Fax number	NA
1.6	E-mail address	vtevare@rediffmail.com
1.7	Legal status	Nagar palika parishad karad
1.8	Type of wastewater treated	Domestic wastewater of Karad city
1.9	Mode of conveyance	Sever line of Nagar palika parishad karard
1.1	Commissioning year the STP's	NA
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Anaerobic Pond, Facultative Pond, Maturation Pond
1.13	Type of plant / fish species	NA

1.14	Downstream reuse of treated wastewater	Treated water uses in irrigation
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	44 Lacks at Establish of WSP Plant in 1974
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Miraj nagar palika parishad
2.4	Revenue generated per month	about 70,000-80,000/-
2.5	Agency bearing wastewater collection costs	Karad nagar palika parishad
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse; Number of Screens: 2 nos.; Unit Size: NA
3.3	Grit chamber	Unit size: NA; 2 Nos.
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Anaerobic Pond, 2 nos.; Size: NA
3.6	Unit 2 (LxBxD)	Facultative Pond, 4 nos.; Size: NA
3.7	Unit 3 (LxBxD)	Maturation Pond, 2 nos.; Size: NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	7.5
4.2	Inflow volume at the time of commissioning (MLD)	NA
4.3	Current inflow volume (MLD)	8.5
4.4	HRT (Days)	20
4.5	Design Performance	BOD_5 (mg/L): 10-20; COD (mg/L): NA; *p*H: 5.5-9; TSS (mg/L): ≥10; TDS (mg/L): NA
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 200-220; COD (mg/L): NA; *p*H: 7.5; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 350-

		400; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count NA
5.2	Treated Sewage	BOD_5 (mg/L): 40-60; COD (mg/L): NA; *p*H: 7.7; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 20-40; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): NA; Total Coliform Count /100ml: NA; Fecal Coliform Count NA
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m^3	No post treatment has been given
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater is being reused in agriculture field
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken
7.4	Is there any risk for people living in the surrounding area of the system?	Associated risk to residents surrounding has not been assessed
7.5	For which purposes is the water used?	Treated wastewater may be used in fish pond.
7.6	If water is used for irrigation, what plants are irrigated?	NA
7.7	If vegetables are planted, are the eaten raw?	NA
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area	NA

	where the treated water is reused?	
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	Operation and maintenance of treatment plant is avoided by plant operators which results in excessive growth of weeds in treatment units.
8. Flow Sheet of the STP		
9. Photo Gallery		



Flow Sheet of STP

(A) Primary Treatment Unit

(B) Anaerobic Pond

(C) Facultative Pond 1

	
(D) Facultative Pond 2	**(E) Maturation Pond**

1.67 MLD, Sewage Treatment Plant, Barogarh, Ujjain, Madhya Pradesh (Location ID: India_MP_1_KT)		
1. General Information		
1.1	Location ID	1.67 MLD, sewage treatment plant, Barogarh, Ujjain, Madhya Pradesh
1.2	Name and address of STP	Ujjain
1.3	Contact person	+91-9406801052
1.4	Phone number	NA
1.5	Fax number	NA
1.6	E-mail address	
1.7	Legal status	PHED Ujjain, Madhya Pradesh
1.8	Type of wastewater treated	Domestic wastewater of Ujjain township, Madhya Pradesh Sewer line of Ujjain
1.9	Mode of conveyance	Municipal Corporation
1.1	Commissioning year the STP's	2002
1.11	Treatment technology	Karnal Technology
1.12	Treatment chain / mode of operation	Evapo-transpiration and percolation to ground
1.13	Type of plant / fish species	Sewage has been totally absorbed by high evaporation Eucalyptus plant system

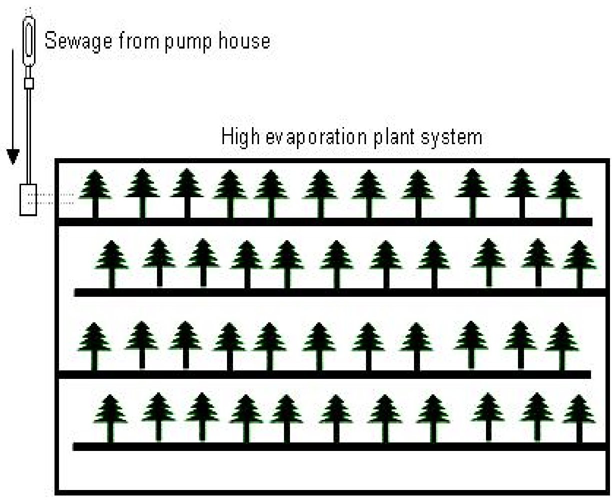
1.14	Downstream reuse of treated wastewater	1.67 MLD Sewage Treatment Plant, Barogarh, Ujjain, Madhya Pradesh
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA, NRCD has funded for establishing of this system
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	PHED Ujjain, Madhya Pradesh
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	PHED Ujjain, Madhya Pradesh
3. Design Details		
3.1	Primary treatment units	Screen chamber
3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2; Unit Size: NA
3.3	Grit chamber	NA
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Total area of high evaporation Eucalyptus plant system: 4 acre
3.6	Unit 2 (LxBxD)	NA
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	1.67
4.2	Inflow volume at the time of commissioning (MLD)	NA
4.3	Current inflow volume (MLD)	1.5
4.4	HRT (Days)	After every 24 Hrs wastewater has been filled in the furrow of high evaporation Eucalyptus plant system.
4.5	Design Performance	NA
5. Actual Performance		

5.1	Raw Sewage	BOD_5 (mg/L): 220-250; COD (mg/L): 300-350; *p*H: 6.5-7.8; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 340; TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count /100ml: 10^6
5.2	Treated Sewage	Sewage has been totally absorbed by high evaporation Eucalyptus plant system.
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment required because sewage totally absorbed by high evaporation Eucalyptus plant system.
6.2	Water quality before post treatment	Sewage has been totally absorbed by high evaporation Eucalyptus plant system.
6.3	Cost of post treatment/m^3	Sewage has been totally absorbed by high evaporation Eucalyptus plant system.
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater is not being left after treatment because sewage totally absorbed by high evaporation Eucalyptus plant system.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken
7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding treatment plant because system is far away from residential area.
7.5	For which purposes is the water used?	Treated wastewater is not being left after treatment because sewage totally absorbed by high evaporation Eucalyptus plant system.
7.6	If water is used for irrigation, what plants are irrigated?	Treated wastewater is not being left after treatment because sewage totally

		absorbed by high evaporation Eucalyptus plant system.
7.7	If vegetables are planted, are the eaten raw?	No wastewater
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	Due to lack of inconsistency in flow rate of effluent, as well as mixed nature of domestic and industrial effluent, plant system are suffering from water logging and toxic effect, which results in dying of some plants.

8. Flow Sheet of the STP

9. Photo Gallery



Flow Sheet of STP

(A) Raw wastewater

	
(B) Pump House	**(C) Plant system**
	
(D) Plant system	**(E) Plant System**

1.79 MLD, Sewage Treatment Plant, Barogarh, Ujjain, Madhya Pradesh (Location ID: India_MP_2_KT)		
1. General Information		
1.1	Location ID	India_MP_2_KT
1.2	Name and address of STP	1.79 MLD, sewage treatment plant, Barogarh, Ujjain, Madhya Pradesh
1.3	Contact person	Mr. Sakhle, PHED, Ujjain
1.4	Phone number	+91-9406801052
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	PHED Ujjain, Madhya Pradesh

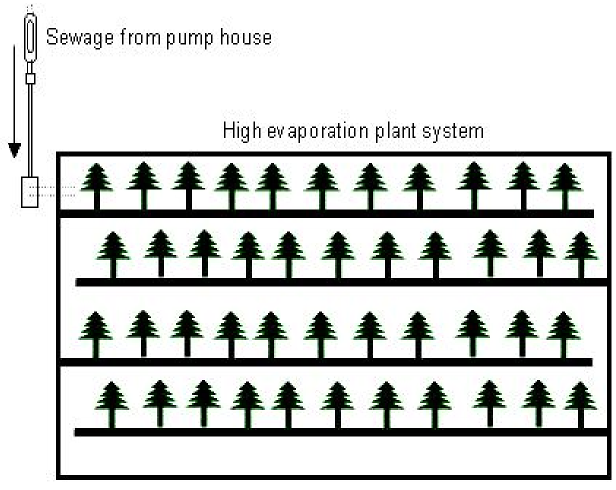
1.8	Type of wastewater treated	Domestic wastewater of Ujjain township, Madhya Pradesh
1.9	Mode of conveyance	Sewer line of Ujjain Municipal Corporation
1.1	Commissioning year the STP's	2002
1.11	Treatment technology	Karnal Technology
1.12	Treatment chain / mode of operation	Evapotranspiration and percolation to ground,
1.13	Type of plant / fish species	Eucalyptus
1.14	Downstream reuse of treated wastewater	Sewage has been totally absorbed by high evaporation Eucalyptus plant system
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA, NRCD has funded for establishing of this system
2.2	Cost of treatment (O&M Cost /month)	NA
2.3	Funding agency for wastewater treatment cost	PHED Ujjain, Madhya Pradesh
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	PHED Ujjain, Madhya Pradesh
3. Design Details		
3.1	Primary treatment units	Screen chamber
3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2; Unit Size: NA
3.3	Grit chamber	NA
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Total area of high evaporation Eucalyptus plant system: 4 acre
3.6	Unit 2 (LxBxD)	NA
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	1.79

4.2	Inflow volume at the time of commissioning (MLD)	NA
4.3	Current inflow volume (MLD)	1.79
4.4	HRT (Days)	After every 24 Hrs wastewater has been filled in the furrow of high evaporation Eucalyptus plant system
4.5	Design Performance	NA
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 220-250; COD (mg/L): 300-350; *p*H: 6.5-7.8; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 340; TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count /100ml: 10^6
5.2	Treated Sewage	Sewage has been totally absorbed by high evaporation Eucalyptus plant system
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment required because sewage totally absorbed by high evaporation Eucalyptus plant system
6.2	Water quality before post treatment	Sewage has been totally absorbed by high evaporation Eucalyptus plant system
6.3	Cost of post treatment/m^3	Sewage has been totally absorbed by high evaporation Eucalyptus plant system
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater is not being left after treatment because sewage totally absorbed by high evaporation Eucalyptus plant system
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken

7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the WSP because system is far away from residential area.
7.5	For which purposes is the water used?	Treated wastewater is not being left after treatment because sewage totally absorbed by high evaporation Eucalyptus plant system
7.6	If water is used for irrigation, what plants are irrigated?	Treated wastewater is not being left after treatment because sewage totally absorbed by high evaporation Eucalyptus plant system
7.7	If vegetables are planted, are the eaten raw?	No wastewater
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	The plant system is properly growing and maintained.

8. Flow Sheet of the STP

9. Photo Gallery



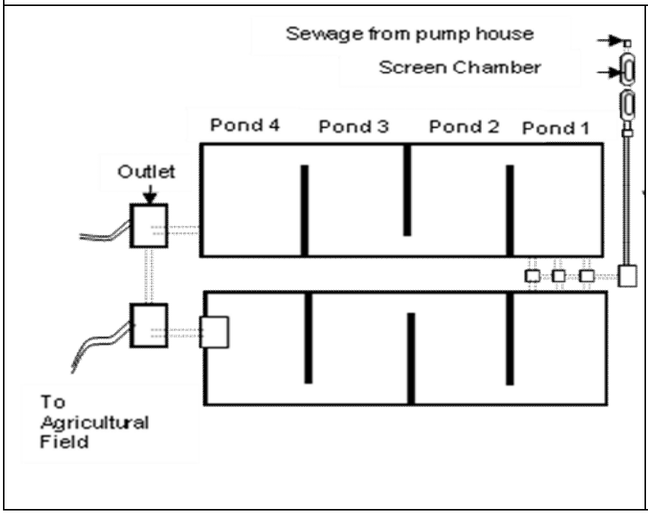
Flow Sheet of STP	(A) Raw wastewater
 (B) Plant system	 (C) Plant system
 (D) Plant system	 (E) Plant System

52.74 MLD, Sewage Treatment Plant, Ujjain, Madhya Pradesh (Location ID: India_MP_3_WSP)		
1. General Information		
1.1	Location ID	India_MP_3_WSP
1.2	Name and address of STP	52.74 MLD sewage treatment plant, Ujjain, Madhya Predesh
1.3	Contact person	Mr. Sakhle, PHED, Ujjain
1.4	Phone number	+91-9406801052
1.5	Fax number	NA
1.6	E-mail address	NA

1.7	Legal status	PHED, Ujjain, Madhya Pradesh
1.8	Type of wastewater treated	Domestic wastewater of Ujjain township, Madhya Pradesh
1.9	Mode of conveyance	Sewer line of Ujjain Municipal Corporation
1.1	Commissioning year the STP's	2002
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant / fish species	No plant or fish species used in system
1.14	Downstream reuse of treated wastewater	Treated wastewater uses in irrigation of agricultural fields
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	221.74 lacks, NRCD has funded for establishing of this WSP
2.2	Cost of treatment (O&M Cost /month)	NA
2.3	Funding agency for wastewater treatment cost	PHED, Ujjain, Madhya Pradesh
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	PHED, Ujjain, Madhya Pradesh
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2; Unit Size: NA
3.3	Grit chamber	Unit size: NA; Nos. of units: 2; HRT: 3-3.5 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Anaerobic Pond, 2 nos.: (143×130×4m)
3.6	Unit 2 (LxBxD)	Facultative Pond, 2 nos.: NA
3.7	Unit 3 (LxBxD)	Maturation Pond, 2 nos.: (690×240×1.25m)
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		

4.1	Design flow (MLD)	52.74
4.2	Inflow volume at the time of commissioning (MLD)	NA
4.3	Current inflow volume (MLD)	58-60
4.4	HRT (Days)	Total: 20 days; Unit 1: one day; Unit 2: four-five days; Unit 3: five days; Unit 4: nine days
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 220-250; COD (mg/L): 300-350; *p*H: 6.5-7.8; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 340; TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count /100ml: 10^6
5.2	Treated Sewage	BOD_5 (mg/L): ≤10; COD (mg/L): ≤80; *p*H: 7.30; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): ≤100; TDS (mg/L): NA; Dissolved Oxygen (mg/L): 2.1; Total Coliform Count /100ml: NA; Fecal Coliform Count /100ml: 1×10^5
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment given
6.2	Water quality before post treatment	No post treatment given
6.3	Cost of post treatment/m^3	No post treatment given
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater is being reused in agricultural field.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken

7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the WSP because system is far away from residential area.
7.5	For which purposes is the water used?	Treated wastewater is being reused in agricultural field.
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops include wheat, rice, sorghum *etc.* and annual crops like sugarcane.
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	The treatment performance of WSP is good and able to achieve the design parameters. But plant suffered by negligence of operating agencies. As the plant is situated far away (20km) from Ujjain city and there is the frequent problem associated with pumping of city effluent to treatment site.
8. Flow Sheet of the STP		
9. Photo Gallery		



Flow Sheet of STP	(A) Primary Treatment Unit
	
(B) Anaerobic Pond	(C) Facultative Pond 1
	
(D) Facultative Pond 2	(E) Maturation Pond

80 KLD Sewage Treatment Plant, RTO Thana, Ujjain, Madhya Pradesh (Location ID: India_MP_4_CW)		
1. General Information		
1.1	Location ID	India_MP_4_CW
1.2	Name and address of STP	80 KLD sewage treatment plant, RTO Thana, Ujjain, Madhya Pradesh
1.3	Contact person	Ujjain Municipal Corporation
1.4	Phone number	NA
1.5	Fax number	NA
1.6	E-mail address	NA

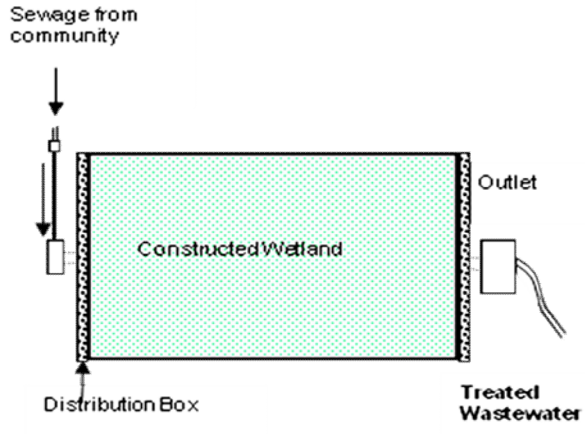
1.7	Legal status	Ujjain Municipal Corporation
1.8	Type of wastewater treated	Domestic wastewater of Ujjain township, Madhya Pradesh
1.9	Mode of conveyance	Sewer line of Ujjain Municipal Corporation
1.1	Commissioning year the STP's	2002
1.11	Treatment technology	CW
1.12	Treatment chain / mode of operation	Raw wastewater directly goes into CW
1.13	Type of plant / fish species	Phragmites karka
1.14	Downstream reuse of treated wastewater	Treated wastewater discharged into wastewater drain
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA (Funded by UNEDP)
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Ujjain municipal Corporation
2.4	Revenue generated per month	No Revenue generated
2.5	Agency bearing wastewater collection costs	Ujjain Municipal Corporation
3. Design Details		
3.1	Primary treatment units	No primary treatment has been given
3.2	Screen chamber:	No primary treatment has been given
3.3	Grit chamber	No primary treatment has been given
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Constructed Wetland Bed, 1 nos.: (85×17×0.7m)
3.6	Unit 2 (LxBxD)	NA
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	80 KLD
4.2	Inflow volume at the time of	70 KLD

	commissioning (MLD)	
4.3	Current inflow volume (MLD)	120 KLD
4.4	HRT (Days)	2 Days
4.5	Design Performance	NA
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 200-220; COD (mg/L): 45-500; *p*H: 6.5-7.0; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 450; TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count /100ml: 10^7
5.2	Treated Sewage	% Removal: BOD_5 = 57-78%; COD = NA; Organic-N = NA; TSS = 70-80.2%; TDS = NA; TKN = NA; Nitrate-N = NA; Coliform 99% /100ml: 1×10^5
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment given
6.2	Water quality before post treatment	No post treatment given
6.3	Cost of post treatment/m^3	No post treatment given
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater may be reused in irrigation
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken
7.4	Is there any risk for people living in the surrounding area of the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.5	For which purposes is the water used?	Treated wastewater has been discharged into the nearby wastewater drain
7.6	If water is used for irrigation, what	Treated wastewater has been discharged

	plants are irrigated?	into the nearby wastewater drain
7.7	If vegetables are planted, are the eaten raw?	NA
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	No
7.11	Are there any wells near the area where the treated water is reused?	No
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	Treatment plant is greatly suffered with lack of maintenance, which results in clogging of bed as well as development of residence domestic animals (*e.g.* Pig). Clogging in the bed is also results of lack of primary treatment of domestic wastewater before entering into the bed.

8. Flow Sheet of the STP

9. Photo Gallery



Flow Sheet of STP

(A) Primary Treatment Unit

(B) Constructed Wetland

(C) Constructed Wetland

(D) Constructed wetland

(E) Constructed wetland

150 KLD, Sewage Treatment Plant, Panchseel Colony, Bhopal (Location ID: India_MP_5_CW)		
1. General Information		
1.1	Location ID	India_MP_5_CW
1.2	Name and address of STP	150 KLD, sewage treatment plant, Panchseel Colony, Bhopal
1.3	Contact person	R. K. Trivedi (Assistant Engineer), Bhopal Municipal Corporation
1.4	Phone number	NA
1.5	Fax number	NA
1.6	E-mail address	NA

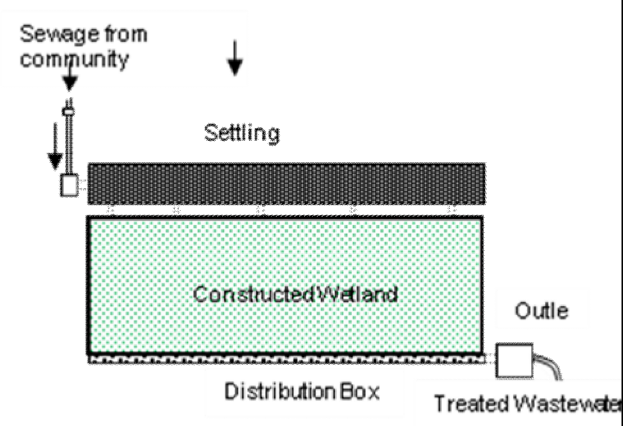
1.7	Legal status	Bhopal Municipal Corporation
1.8	Type of wastewater treated	Domestic wastewater of Bhopal township, Madhya Pradesh
1.9	Mode of conveyance	Sewer line of Bhopal Municipal Corporation
1.1	Commissioning year the STP's	1997
1.11	Treatment technology	CW
1.12	Treatment chain / mode of operation	Septic tank followed by CW
1.13	Type of plant / fish species	Phragmites *karka*
1.14	Downstream reuse of treated wastewater	Treated wastewater discharged into wastewater drain
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA (Funded by UNEDP)
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Bhopal Municipal Corporation
2.4	Revenue generated per month	No Revenue generated
2.5	Agency bearing wastewater collection costs	Bhopal Municipal Corporation
3. Design Details		
3.1	Primary treatment units	No primary treatment has been given
3.2	Screen chamber:	No primary treatment has been given
3.3	Grit chamber	No primary treatment has been given
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Constructed Wetland Bed, 1 nos.: (85×17×0.7m)
3.6	Unit 2 (LxBxD)	NA
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	150 KLD

4.2	Inflow volume at the time of commissioning (MLD)	80 KLD
4.3	Current inflow volume (MLD)	120 KLD
4.4	HRT (Days)	2 5 Days
4.5	Design Performance	NA
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 190-220; COD (mg/L): 400-500; *p*H: 6.5-7.8; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 400; TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count /100ml: 106
5.2	Treated Sewage	% Removal: BOD_5 = 60-70%; COD = 60-80%; Organic-N = 90-95%; TSS = 70-80.2%; TDS = NA; TKN = 60-70%; Nitrate-N = 50-60; Coliform 99.9%
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment given
6.2	Water quality before post treatment	No post treatment given
6.3	Cost of post treatment/m^3	No post treatment given
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	Treated water may be reused in gardening of nearby community
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken
7.4	Is there any risk for people living in the surrounding area of the system?	There is no such kind of associated risk to because system has proper boundary.
7.5	For which purposes is the water	Treated wastewater has been discharged

	used?	into the nearby wastewater drain
7.6	If water is used for irrigation, what plants are irrigated?	Treated wastewater has been discharged into the nearby wastewater drain
7.7	If vegetables are planted, are the eaten raw?	Treated wastewater has been discharged into the nearby wastewater drain
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	No
7.11	Are there any wells near the area where the treated water is reused?	No
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	Operation and maintenance of treatment plant is avoided by operating agencies. The activities of cleaning the septic tank as well as cutting of vegetation have not been done since last three years. Due to inappropriate operation and maintenance, the systems performance is being affected.

8. Flow Sheet of the STP

9. Photo Gallery



Flow Sheet of STP

(A) Primary Treatment Unit

(B) Constructed Wetland

(C) Constructed Wetland

(D) Constructed Wetland

(E) Constructed Wetland

70 KLD, Sewage Treatment Plant, Ekant Park, Bhopal (Location ID: India_MP_6_CW)		
1. General Information		
1.1	Location ID	India_MP_6_CW
1.2	Name and address of STP	70 KLD, sewage treatment plant, Ekant Park, Bhopal
1.3	Contact person	IEMPS, Vikram University, Ujjain
1.4	Phone number	NA
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	EPCO, Bhopal

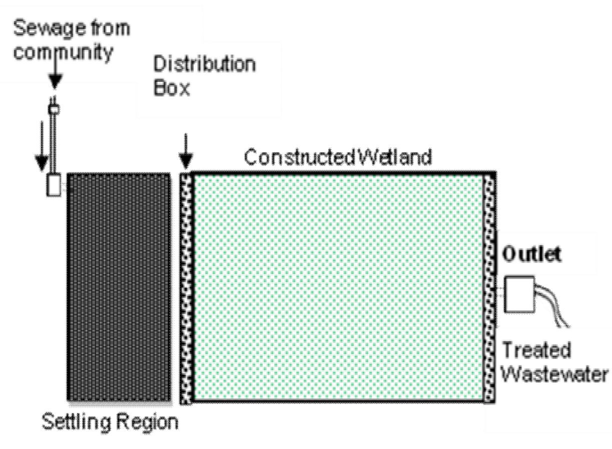
1.8	Type of wastewater treated	Domestic wastewater of Bhopal township, Madhya Pradesh
1.9	Mode of conveyance	Sewer line of Bhopal Municipal Corporation
1.1	Commissioning year the STP's	2002
1.11	Treatment technology	CW
1.12	Treatment chain / mode of operation	Grit chamber followed by CW
1.13	Type of plant / fish species	Phragmites *karka*
1.14	Downstream reuse of treated wastewater	Treated wastewater uses in gardening
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	14.10 Lakhs (Fundefd by EPCO, Bhopal)
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Bhopal Municipal Corporation
2.4	Revenue generated per month	No Revenue generated
2.5	Agency bearing wastewater collection costs	Bhopal Municipal Corporation
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse ; Number of Screens: 1; Unit Size: 3×1m
3.3	Grit chamber	Unit size: 3×10m; Nos. of units: 1; HRT: 3-3.5 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Constructed Wetland Bed, 1 nos.: (17×85×0.7m)
3.6	Unit 2 (LxBxD)	NA
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	70 KLD

4.2	Inflow volume at the time of commissioning (MLD)	35 KLD
4.3	Current inflow volume (MLD)	70 KLD
4.4	HRT (Days)	2.5 Days
4.5	Design Performance	NA
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 190-220; COD (mg/L): 400-500; *p*H: 6.5-7.8; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 400; TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count /100ml: 106
5.2	Treated Sewage	% Removal: BOD_5 = 65-85%; COD = 78%; Organic-N = 98.7%; TSS = 71.2%; TDS = 77.8%; TKN = 65,7%; Nitrate-N = 53.3; Coliform 99.9%
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment given
6.2	Water quality before post treatment	No post treatment given
6.3	Cost of post treatment/m^3	No post treatment given
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater is being reused in gardening.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken
7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the system because it is far away from residential area.
7.5	For which purposes is the water	Treated wastewater is being reused in

	used?	gardening.
7.6	If water is used for irrigation, what plants are irrigated?	Treated wastewater is being reused in gardening.
7.7	If vegetables are planted, are the eaten raw?	Treated wastewater is being reused in gardening.
7.8	How many people are exposed to the wastewater before treatment and after treatment?	Treated wastewater is being reused in gardening.
7.9	Are there any wells near the area where the treated water is reused?	No
7.11	Are there any wells near the area where the treated water is reused?	No
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	Operation and maintenance of treatment plant is avoided by operation agencies and systems has severely affected.

8. Flow Sheet of the STP

9. Photo Gallery



Flow Sheet of STP

(A) Raw Sewage

	
(B) Primary Treatment Unit	**(C) Constructed Wetland**
	
(D) Constructed Wetland	**(E) Treated Effluent**

25 MLD, Sewage Treatment Plant, Kapoorthala, Punjab (Location ID: India_PB_1_PP)		
1. General Information		
1.1	Location ID	India_PB_1_PP
1.2	Name and address of STP	25 MLD, sewage treatment plant, Kapoorthala, Punjab
1.3	Contact person	Mr. B. Singh, Junior Engineer, Kapoorthala water and sewerage board
1.4	Phone number	NA
1.5	Fax number	NA
1.6	E-mail address	NA

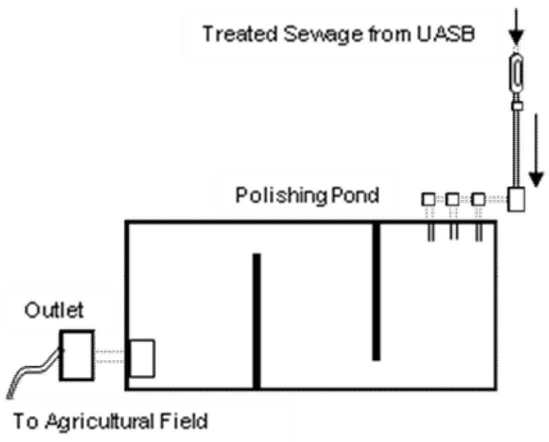
1.7	Legal status	Kapoorthala water and sewerage board
1.8	Type of wastewater treated	Domestic wastewater of Kapoorthala township, Punjab
1.9	Mode of conveyance	Sewer line of Kapoorthala, Punjab
1.1	Commissioning year the STP's	NA
1.11	Treatment technology	UASB followed by Polishing Pond
1.12	Treatment chain / mode of operation	UASB followed by Polishing Pond
1.13	Type of plant/fish species	No plant or fish species used in system
1.14	Downstream reuse of treated wastewater	Treated wastewater uses in irrigation of agricultural fields
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Kapoorthala water and sewerage board, Punjab
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Kapoorthala water and sewerage board, Punjab
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2; Unit Size: 50 mm and 20mm
3.3	Grit chamber	Grit chamber 4 nos.: (10.4×2.5×0.7 m); HRT: 3-3.5 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Polishing Pond 1 nos.: (95×62×1.5 m)
3.6	Unit 2 (LxBxD)	Sludge Drying Bed 20 nos.: (20×20 ft)
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		

4.1	Design flow (MLD)	25
4.2	Inflow volume at the time of commissioning (MLD)	15
4.3	Current inflow volume (MLD)	20
4.4	HRT (Days)	24 Hrs in Polishing Pond
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 55- 60; COD (mg/L): 120-140; *p*H: 7.09; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 150; TDS (mg/L): 990; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count /100ml: $8×10^6$
5.2	Treated Sewage	BOD_5 (mg/L): 28; COD (mg/L): 80; *p*H: 7.30; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 52; TDS (mg/L): 880; Dissolved Oxygen (mg/L):NA; Total Coliform Count /100ml: NA; Fecal Coliform Count /100ml: $1×10^5$
6. Post Treatment		
6.1	Type of Post Treatment	1-2 ppm of chlorine dose has been given
6.2	Water quality before post treatment	BOD_5 (mg/L): 28; COD (mg/L): 112; *p*H: 7.30; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 52; TDS (mg/L): 880; Dissolved Oxygen (mg/L):NA; Total Coliform Count /100ml: NA; Fecal Coliform Count /100ml: $1×10^5$
6.3	Cost of post treatment/m^3	NA
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater is being reused in agricultural field.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has

		been taken
7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the system because system is surrounded by the boundary wall.
7.5	For which purposes is the water used?	Treated wastewater is being reused in agricultural field.
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops include wheat, rice, sorghum *etc.* and annual crops like sugarcane.
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	The treatment performance of PP is good and able to achieve the design parameters.

8. Flow Sheet of the STP

9. Photo Gallery



Flow Sheet of STP

(A) USAB Unit

 **(B) Polishing Pond**	 **(C) Outlet of Polishing Pond**
 **(D) Chlorination Unit**	 **(E) Sludge Drying Beds**

0.5 MLD, Sewage Treatment Plant, Bais, Ludhiana, Punjab (Location ID: India_PB_2_WSP)		
1. General Information		
1.1	Location ID	India_PB_2_WSP
1.2	Name and address of STP	0.5 MLD, sewage treatment plant, Bais, Ludhiana, Punjab
1.3	Contact person	Er Mohd Ishfaq, Executive Engineer, DPMC Ludhiana and Mr. Sudhagar Singh, Village Sarpanch
1.4	Phone number	+91-9915433786
1.5	Fax number	NA

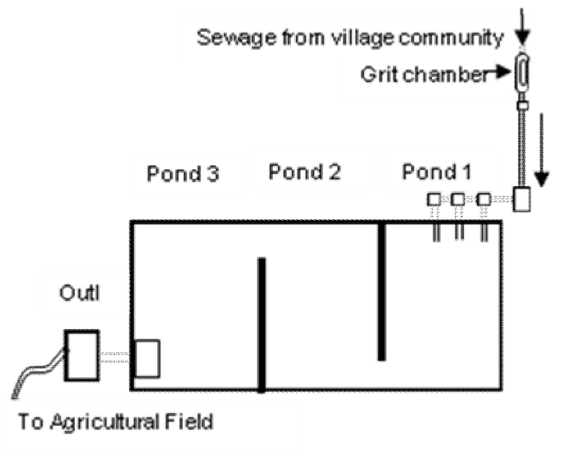
1.6	E-mail address	NA
1.7	Legal status	DPMC Ludhiana
1.8	Type of wastewater treated	Domestic wastewater of village community, Population around 2000
1.9	Mode of conveyance	Sewer line of village community
1.1	Commissioning year the STP's	2008
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Grit Chamber Anaerobic pond followed by Facultative and Maturation pond
1.13	Type of plant / fish species	No plant or fish species used in system
1.14	Downstream reuse of treated wastewater	Treated wastewater used in agricultural field
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Govt. of Punjab and Govt. of India
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Village Panchayat
3. Design Details		
3.1	Primary treatment units	Grit chamber
3.2	Screen chamber:	NA
3.3	Grit chamber	Grit chamber 1nos; HRT: 3-3.5 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	NA
3.6	Unit 2 (LxBxD)	NA
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	0.5

4.2	Inflow volume at the time of commissioning (MLD)	0.4
4.3	Current inflow volume (MLD)	0.5
4.4	HRT (Days)	25-30
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 180- 200; COD (mg/L): 300-350; *p*H: 6.9-7.2; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): NA; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: 10^7; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD_5 (mg/L):10- 20; COD (mg/L): 100-150; *p*H: 7.2-7.5; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): NA; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: 10^5; Fecal Coliform Count: NA
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m^3	No post treatment has been given
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater has been used in agricultural field.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken
7.4	Is there any risk for people living in the surrounding area of the system?	At present there is no evidence or no assessment has been done

7.5	For which purposes is the water used?	Treated wastewater has been used in agricultural field.
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops include wheat, rice, sorghum *etc.* and annual crops like sugarcane.
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	The operation and maintenance of system is avoided by plant operates and hence weed growth in treatment units taken place.

8. Flow Sheet of the STP

9. Photo Gallery



Flow Sheet of STP

(A) Anaerobic Pond

(B) Facultative Pond

(C) Facultative Pond

(D) Maturation Pond

(E) Agriculture field

0.5 MLD, Sewage Treatment Plant, Dedwal, Ludhiana, Punjab (Location ID: India_PB_3_WSP)		
1. General Information		
1.1	Location ID	India_PB_3_WSP
1.2	Name and address of STP	0.5 MLD, sewage treatment plant, Dedwal, Ludhiana, Punjab
1.3	Contact person	Er. Mohd Ishfaq, Executive Engineer, DPMC Ludhiana
1.4	Phone number	+91-9915433786
1.5	Fax number	NA
1.6	E-mail address	NA

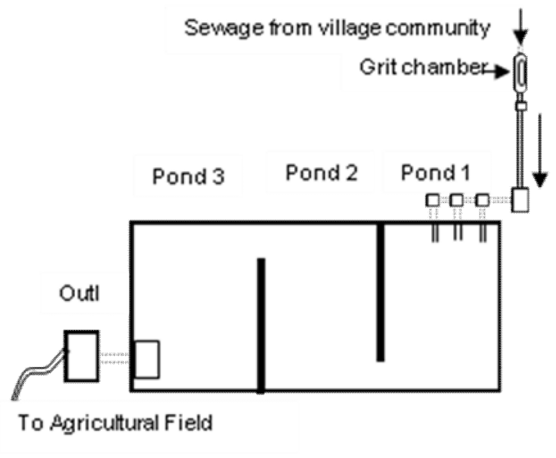
1.7	Legal status	DPMC Ludhiana
1.8	Type of wastewater treated	Domestic wastewater of village community, Population
1.9	Mode of conveyance	Sewer line of village community
1.1	Commissioning year the STP's	NA
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant / fish species	No plant or fish species used in system
1.14	Downstream reuse of treated wastewater	Treated wastewater used in agricultural field
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Govt. of Punjab and Govt. of India
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Village Panchayat
3. Design Details		
3.1	Primary treatment units	NA
3.2	Screen chamber:	NA
3.3	Grit chamber	NA
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	NA
3.6	Unit 2 (LxBxD)	NA
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	0.5

4.2	Inflow volume at the time of commissioning (MLD)	0.35
4.3	Current inflow volume (MLD)	0.4
4.4	HRT (Days)	30-32
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 180-200; COD (mg/L): 300-350; *p*H: 6.9-7.2; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): NA; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: 10^7; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD_5 (mg/L): 10-15; COD (mg/L): 100-125; *p*H: 7.2-7.5; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): NA; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: 10^5; Fecal Coliform Count: NA
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m^3	No post treatment has been given
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater has been used in agricultural field.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken
7.4	Is there any risk for people living in the surrounding area of the system?	At present there is no evidence or no assessment has been done

7.5	For which purposes is the water used?	Treated wastewater has been used in agricultural field.
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops include wheat, rice, sorghum *etc.* and annual crops like sugarcane.
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	The treatment performance of WSP is good.

8. Flow Sheet of the STP

9. Photo Gallery



Flow Sheet of STP

(A) Anaerobic Pond

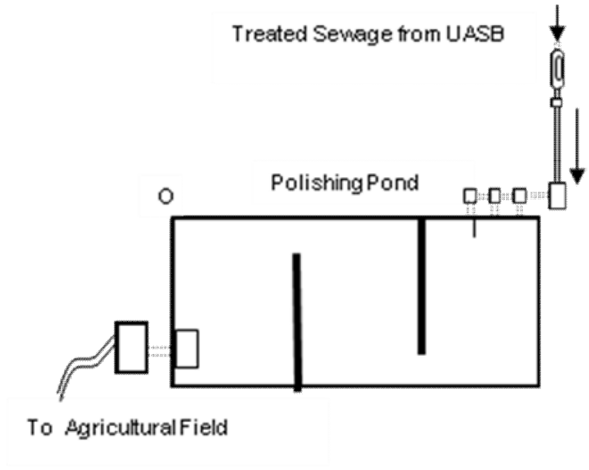
	
(B) Facultative Pond	**(C) Facultative Pond**
	
(D) Maturation Pond	**(E) Agriculture field**

111 MLD, Sewage Treatment Plant, Ludhiana, Zone B, Punjab (Location ID: India_PB_4_PP)		
1. General Information		
1.1	Location ID	India_PB_4_PP
1.2	Name and address of STP	111 MLD sewage treatment plant, Ludhiana, Zone B, Punjab
1.3	Contact person	Mr. B. Singh, Junior Engineer, Kapoorthala Water and Sewerage Board
1.4	Phone number	NA
1.5	Fax number	NA
1.6	E-mail address	NA

1.7	Legal status	Kapoorthala water and sewerage board
1.8	Type of wastewater treated	Domestic wastewater of Kapurthala township, Punjab
1.9	Mode of conveyance	Sewer line of Kapurthala sewerage board, Punjab
1.1	Commissioning year the STP's	2005
1.11	Treatment technology	UASB followed by Polishing Pond
1.12	Treatment chain / mode of operation	UASB followed by Polishing Pond
1.13	Type of plant / fish species	No plant or fish species used in system
1.14	Downstream reuse of treated wastewater	Treated wastewater uses in irrigation of agricultural fields
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Kapurthala water and sewerage board, Punjab
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Kapurthala water and sewerage board, Punjab
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2; Unit Size: 50 mm and 20mm
3.3	Grit chamber	Grit chamber, 4 nos.: (10.4×2.5×0.7m); HRT: 2-3 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Polishing Pond, 1 nos.: (95×62×1.5m)
3.6	Unit 2 (LxBxD)	Sludge Drying Bed, 20 nos.: (20×20 ft)
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA

4. Design Performance		
4.1	Design flow (MLD)	25
4.2	Inflow volume at the time of commissioning (MLD)	20
4.3	Current inflow volume (MLD)	25
4.4	HRT (Days)	24 Hrs in Polishing Pond
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 55-60; COD (mg/L): 120-140; *p*H: 7.09; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 150; TDS (mg/L): 990; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count /100ml: 10^6
5.2	Treated Sewage	BOD_5 (mg/L): 28; COD (mg/L): 70; *p*H: 7.30; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 52; TDS (mg/L): 880; Dissolved Oxygen (mg/L): NA; Total Coliform Count /100ml: NA; Fecal Coliform Count/100ml: $1×10^5$
6. Post Treatment		
6.1	Type of Post Treatment	5 ppm of chlorine dose has been given
6.2	Water quality before post treatment	BOD_5 (mg/L): 28; COD (mg/L): 112; *p*H: 7.30; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 52; TDS (mg/L): 880; Dissolved Oxygen (mg/L): NA; Total Coliform Count /100ml: NA; Fecal Coliform Count/100ml: $1×10^5$
6.3	Cost of post treatment/m3	NA
6.4	If effluent not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater has been used in agricultural field.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person	There is no such kind of associated risk to

	operating the system?	operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no associated risk to residents surrounding the system because it is far away from residential area as well as surrounded by boundary wall.
7.4	Is there any risk for people living in the surrounding area of the system?	NA
7.5	For which purposes is the water used?	Treated wastewater has been used in agricultural field.
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops include wheat, rice, sorghum *etc.* and annual crops like sugarcane.
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	The overall treatment performance system is good.
8. Flow Sheet of the STP		
9. Photo Gallery		



Flow Sheet of STP

(A) USAB Unit

(B) UASB Outlet

(C) Polishing Pond

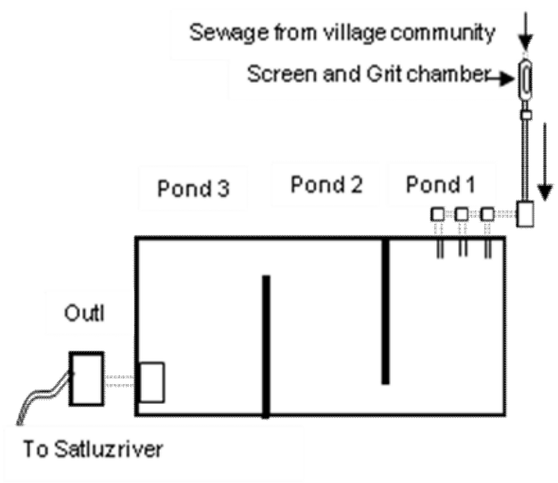
(D) Polishing Pond

(E) Sludge Drying Beds

2.56 MLD, Sewage Treatment Plant, Phillore, Punjab (Location ID: India_PB_5_WSP)		
1. General Information		
1.1	Location ID	India_PB_5_WSP
1.2	Name and address of STP	2.56 MLD sewage treatment plant at Phillore, Punjab
1.3	Contact person	NA
1.4	Phone number	NA
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Phillore water and sewage Board, Punjab
1.8	Type of wastewater treated	Domestic wastewater of Phillore township, Punjab
1.9	Mode of conveyance	Sewer line of Phillore Municipal Corporation
1.1	Commissioning year the STP's	NA
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant / fish species	No plant or fish species cultured in the system
1.14	Downstream reuse of treated wastewater	Treated wastewater discharges into River Satluz.
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Govt. of Punjab and Govt. of India
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Phillore water and sewage board, Punjab
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2; Unit Size: NA

3.3	Grit chamber	Grit chamber, Unit size: NA; Nos. of units: 2; HRT: 3-3.5 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Anaerobic Pond, 1 nos.: (72×30×3 m)
3.6	Unit 2 (LxBxD)	Facultative Pond, 1 nos.: (72×30×1.5 m)
3.7	Unit 3 (LxBxD)	Maturation Pond, 1 nos.: 972×30×1.5 m)
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	2.56
4.2	Inflow volume at the time of commissioning (MLD)	1.5
4.3	Current inflow volume (MLD)	2.5
4.4	HRT (Days)	15
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 120-140; COD (mg/L): 280-300; *p*H: 6.9-7.2; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 280-300; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: 10^7; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD_5 (mg/L): 15-20; COD (mg/L): 80-120; *p*H: 7-7.5; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 280-300; VSS: NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): NA; Total Coliform Count /100ml: 10^5; Fecal Coliform Count: NA
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m^3	No post treatment has been given
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater may be used in agricultural field.

7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken.
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken.
7.4	Is there any risk for people living in the surrounding area of the system?	At present there is no evidence or no assessment has been done
7.5	For which purposes is the water used?	Treated wastewater discharges into River Satluz..
7.6	If water is used for irrigation, what plants are irrigated?	Treated wastewater has been discharge into River Satluz.
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	The treatment performance of WSP is good.
8. Flow Sheet of the STP		
9. Photo Gallery		



Flow Sheet of STP

(A) Distribution Channel

(B) Overview

(C) Facultative Pond

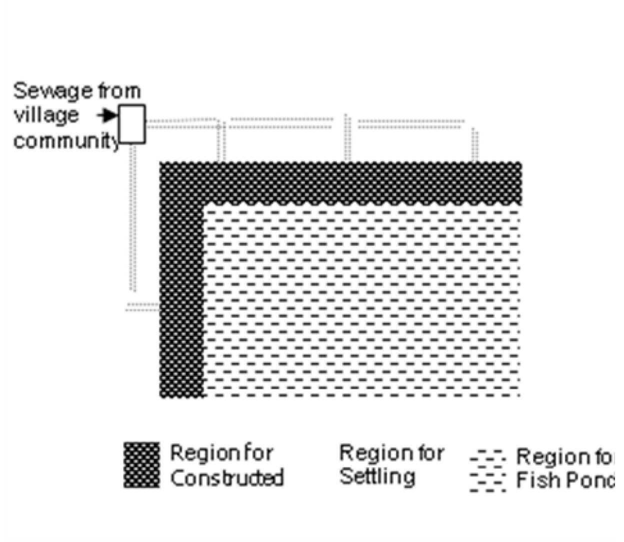
(D) Facultative Pond

(E) Maturation Pond

0.5 MLD Sewage Treatment Plant at Pipar Majra, Ropar, Punjab (Location ID: India_PB_6_CW)		
1. General Information		
1.1	Location ID	India_PB_6_CW
1.2	Name and address of STP	0.5 MLD sewage treatment plant at Pipar Majra, Ropar, Punjab
1.3	Contact person	NA
1.4	Phone number	NA
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Village Panchayat
1.8	Type of wastewater treated	Domestic wastewater of village community
1.9	Mode of conveyance	Sewer line of village community
1.1	Commissioning year the STP's	2006
1.11	Treatment technology	CW
1.12	Treatment chain / mode of operation	Septic Tank-Constructed Wetland-Fish Pond
1.13	Type of plant / fish species	Plant species: Typha *latifolia*
1.14	Downstream reuse of treated wastewater	Treated wastewater is discharges into fish pond
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA (Govt. of Punjab and Govt. of India)
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Village Panchayat
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Village Panchayat
3. Design Details		
3.1	Primary treatment units	Grit chamber
3.2	Screen chamber:	NA
3.3	Grit chamber	Unit size: NA; 3 nos.; HRT: 3-3.5 Hrs

3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Constructed Wetland Size: NA
3.6	Unit 2 (LxBxD)	Fish pond, Size: NA
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	0.5
4.2	Inflow volume at the time of commissioning (MLD)	0.4
4.3	Current inflow volume (MLD)	0.5
4.4	HRT (Days)	NA
4.5	Design Performance	BOD_5 (mg/L): 10-20; COD (mg/L): NA; *p*H: 5.5-9; TSS (mg/L): ≥10; TDS (mg/L): NA
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 200-220; COD (mg/L): NA; *p*H: 7.5; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 350-400; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD_5 (mg/L): 10-20; COD (mg/L): NA; *p*H: 7.7; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 20-40; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): NA; Total Coliform Count /100ml: NA; Fecal Coliform Count: NA
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m^3	No post treatment has been given
6.4	If effluent not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater may be used in fish pond.
7. Health and Environmental Risks		
7.1	Are there any incidences of source	NA

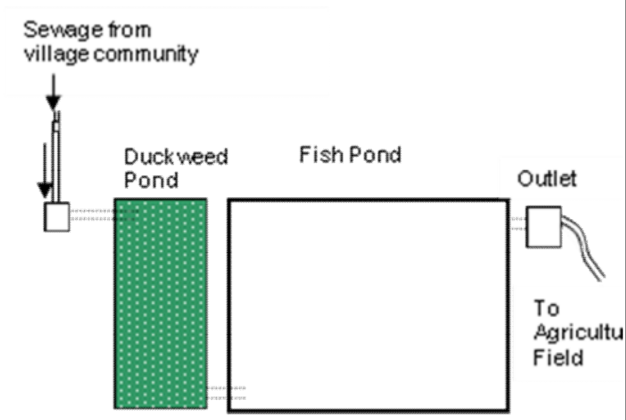
	pollution which occurred in the past?	
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken.
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken.
7.4	Is there any risk for people living in the surrounding area of the system?	Associated risk to residents surrounding has not been assessed
7.5	For which purposes is the water used?	Treated wastewater may be used in fish pond.
7.6	If water is used for irrigation, what plants are irrigated?	Treated wastewater may be used in fish pond.
7.7	If vegetables are planted, are the eaten raw?	Treated wastewater may be used in fish pond.
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	STP meeting the prescribed standards of treated effluent but some wastewater is overflowing on the surface of constructed wetland which indicates the clogging inside the bed. The possible reason of clogging in Constructed Wetland bed is the poor maintenance of settling units.
8. Flow Sheet of the STP		
9. Photo Gallery		

 **Flow Sheet of STP**	 **(A) Primary Treatment Unit**
 **(B) Constructed Wetland**	 **(C) Constructed Wetland**
 **(D) Constructed Wetland**	 **(E) Fish Pond**

0.5 MLD Sewage Treatment Plant at Village Saidpur, Ludhiana, Punjab (Location ID: India_PB_7_DP)		
1. General Information		
1.1	Location ID	India_PB_7_DP
1.2	Name and address of STP	0.5 MLD sewage treatment plant at village Saidpur, Ludhiana, Punjab
1.3	Contact person	Mr. Amric Singh, Sarpanch
1.4	Phone number	NA
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Village Panchayat, Govt. of Punjab
1.8	Type of wastewater treated	Domestic wastewater of village community
1.9	Mode of conveyance	Sewer line of village community
1.1	Commissioning year the STP's	2004
1.11	Treatment technology	DP
1.12	Treatment chain / mode of operation	Duckweed pond followed by fish pond
1.13	Type of plant / fish species	Fish species: Rahu, Katla, Grass
1.14	Downstream reuse of treated wastewater	Treated wastewater from fish pond used in agricultural field
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA
2.2	Cost of treatment (O&M Cost /month)	NA
2.3	Funding agency for wastewater treatment cost	Govt. of Punjab and Govt. of India
2.4	Revenue generated per year	INR 50,000-70,000
2.5	Agency bearing wastewater collection costs	Village Panchayat
3. Design Details		
3.1	Primary treatment units	NA
3.2	Screen chamber:	NA

3.3	Grit chamber	NA
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Duckweed Pond: Unit size: NA; HRT: 7days
3.6	Unit 2 (LxBxD)	Fish Pond: Unit size: NA; HRT: 20-25
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	0.5
4.2	Inflow volume at the time of commissioning (MLD)	0.25
4.3	Current inflow volume (MLD)	0.3
4.4	HRT (Days)	35
4.5	Design Performance	BOD_5 (mg/L): ≤20; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 180-200; COD (mg/L): NA; *p*H: 7.5; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 350-400; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: 10^7; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD_5 (mg/L): ≤10; COD (mg/L): NA; *p*H: 7.7; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 20-40; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): NA; Total Coliform Count /100ml: 10^4
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given.
6.2	Water quality before post treatment	No post treatment has been given.
6.3	Cost of post treatment/m^3	No post treatment has been given.
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater has been used in agricultural field.
7. Health and Environmental Risks		

7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	NA
7.3	Is there any risk for people involved in the disposal handling?	NA
7.4	Is there any risk for people living in the surrounding area of the system?	NA
7.5	For which purposes is the water used?	Treated wastewater has been used for pisciculture and overflow goes to agricultural fields.
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops include wheat, rice, sorghum *etc.* and annual crops like sugarcane.
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	The overall performance of system is good. System also generating the revenue of about INR 50,000-70,000 per year.
8. Flow Sheet of the STP		
9. Photo Gallery		



Flow Sheet of STP

(A) Duckweed Pond

(B) Duckweed Pond

(C) Fish Pond

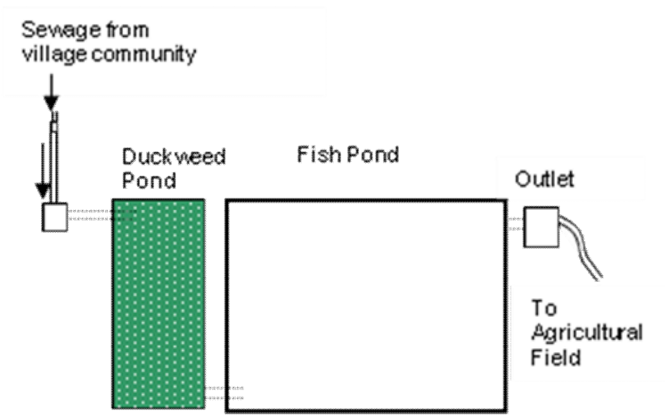
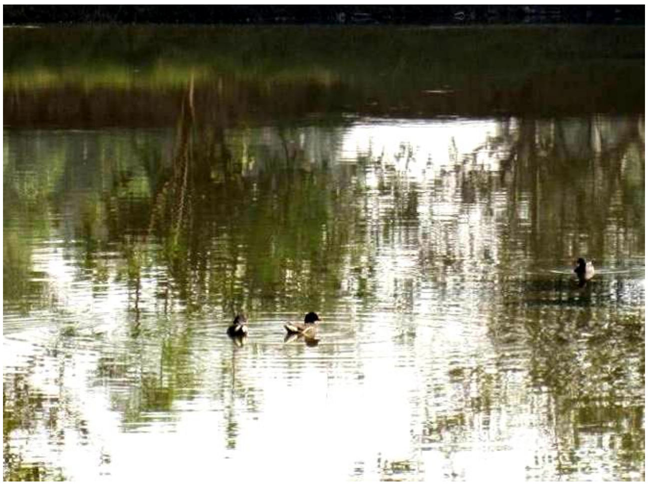
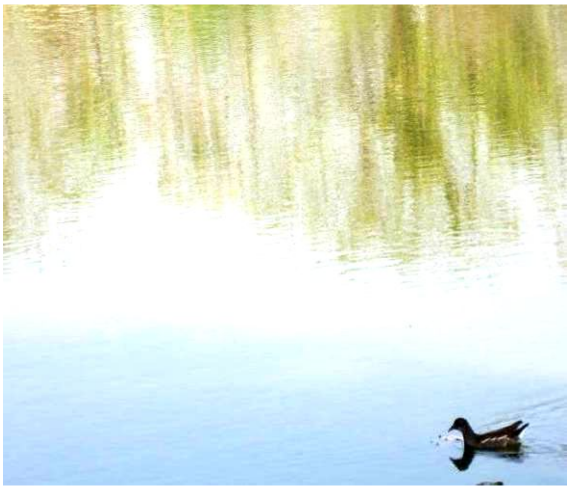
(D) Fish Pond

(E) Agriculture field

0.5 MLD, Sewage Treatment Plant, Sandhuan, Roop Nagar, Punjab (Location ID: India_PB_8_DP)		
1. General Information		
1.1	Location ID	India_PB_8_DP
1.2	Name and address of STP	0.5 MLD sewage treatment plant at village Sandhuan, Roop Nagar, Punjab
1.3	Contact person	Sarpanch
1.4	Phone number	NA
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Village Panchayat, Govt. of Punjab
1.8	Type of wastewater treated	Domestic wastewater of village community
1.9	Mode of conveyance	Sewer line of village community
1.1	Commissioning year the STP's	1998
1.11	Treatment technology	DP
1.12	Treatment chain / mode of operation	Grit Chamber-Duckweed Pond-Fish Pond
1.13	Type of plant / fish species	Fish species: Rahu, Katla, Grass
1.14	Downstream reuse of treated wastewater	Treated wastewater from fish pond used in agricultural field
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Govt. of Punjab and Govt. of India
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Village Panchayat
3. Design Details		
3.1	Primary treatment units	NA
3.2	Screen chamber:	NA
3.3	Grit chamber	NA

3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Duckweed Pond: Unit size: NA; HRT: 7 days
3.6	Unit 2 (LxBxD)	Fish Pond: Unit size: NA; HRT: 20-25
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	0.5
4.2	Inflow volume at the time of commissioning (MLD)	0.25
4.3	Current inflow volume (MLD)	0.56
4.4	HRT (Days)	25-28
4.5	Design Performance	BOD_5 (mg/L): ≤20; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 180-200; COD (mg/L): NA; *p*H: 7.5; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 350-400; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: 10^7; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD_5 (mg/L): 10-20; COD (mg/L): NA; *p*H: 7.7; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 40-60; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): NA; Total Coliform Count /100ml: 10^5; Fecal Coliform Count: NA
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m^3	No post treatment has been given
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater has been used in agricultural field.

7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	NA
7.3	Is there any risk for people involved in the disposal handling?	NA
7.4	Is there any risk for people living in the surrounding area of the system?	NA
7.5	For which purposes is the water used?	Treated wastewater has been used in agricultural field.
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops include wheat, rice, sorghum *etc.* and annual crops like sugarcane.
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	STP performing well in terms of treated effluent standards. System is slightly overloaded in terms of flow as well as it is not maintained properly. .
8. Flow Sheet of the STP		
9. Photo Gallery		

 **Flow Sheet of STP**	 **(A) Duckweed Pond**
 **(B) Duckweed Pond**	 **(C) View of Duck**
 **(D) Fish Pond**	 **(E) Fish Pond**

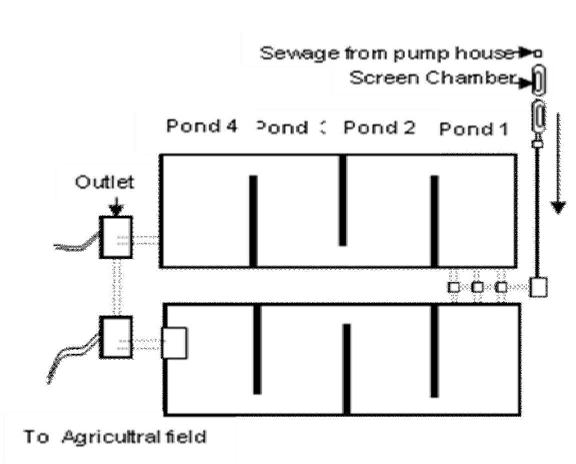
0.5 MLD Sewage Treatment Plant at Village Sandhuan, Roop Nagar, Punjab (Location ID: India_PB_9_WSP)		
1. General Information		
1.1	Location ID	India_PB_9_WSP
1.2	Name and address of STP	0.5 MLD sewage treatment plant at village Sandhuan, Roop Nagar, Punjab
1.3	Contact person	NA
1.4	Phone number	NA
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Village Panchayat, Govt. of Punjab
1.8	Type of wastewater treated	Domestic wastewater of village community
1.9	Mode of conveyance	Sewer line of village community
1.1	Commissioning year the STP's	Still not commissioned
1.11	Treatment technology	WSP
1.12	Treatment chain/ mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond (under commissioning)
1.13	Type of plant/fish species	No plant or fish species used in system
1.14	Downstream reuse of treated wastewater	Treated wastewater will be used in agricultural field
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA
2.2	Cost of treatment (O&M Cost /month)	NA
2.3	Funding agency for wastewater treatment cost	Govt. of Punjab and Govt. of India
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Village Panchayat
3. Design Details		
3.1	Primary treatment units	NA
3.2	Screen chamber:	NA

3.3	Grit chamber	NA
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Type: Coarse and Fine; Number of Screens: 2; Unit Size: NA
3.6	Unit 2 (LxBxD)	Grit chamber, Nos. of units: 2; Unit size: NA; HRT: NA
3.7	Unit 3 (LxBxD)	Anaerobic Pond, 2 nos.; Size NA
3.8	Unit 4 (LxBxD)	Facultative Pond, 4 nos.; Size NA
3.9	Unit 5 (LxBxD)	Maturation pond, 2 nos.; Size NA
4. Design Performance		
4.1	Design flow (MLD)	0.5
4.2	Inflow volume at the time of commissioning (MLD)	Still not commissioned
4.3	Current inflow volume (MLD)	Still not commissioned
4.4	HRT (Days)	20
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	STP not still commissioned
5.2	Treated Sewage	STP not still commissioned
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m3	No post treatment has been given
6.4	If effluent not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater has been used in agricultural field.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	No post treatment will be given

7.3	Is there any risk for people involved in the disposal handling?	No post treatment will be given
7.4	Is there any risk for people living in the surrounding area of the system?	No post treatment will be given
7.5	For which purposes is the water used?	Treated wastewater will be used in agricultural field.
7.6	If water is used for irrigation, what plants are irrigated?	STP not still commissioned
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	STP not still commissioned.

8. Flow Sheet of the STP

9. Photo Gallery



Flow Sheet of STP

(A) Primary treatment Unit

(B) Anaerobic Pond

(C) Facultative Pond 1

(D) Facultative Pond 2

(E) Maturation Pond

1 MLD, Sewage Treatment Plant, Uncha, Roop Nagar, Punjab (Location ID: India_PB_10_DP)		
1. General Information		
1.1	Location ID	India_PB_10_DP
1.2	Name and address of STP	1 MLD sewage treatment plant at village Uncha, Roop Nagar, Punjab
1.3	Contact person	Sarpanch
1.4	Phone number	NA
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Village Panchayat, Govt. of Punjab

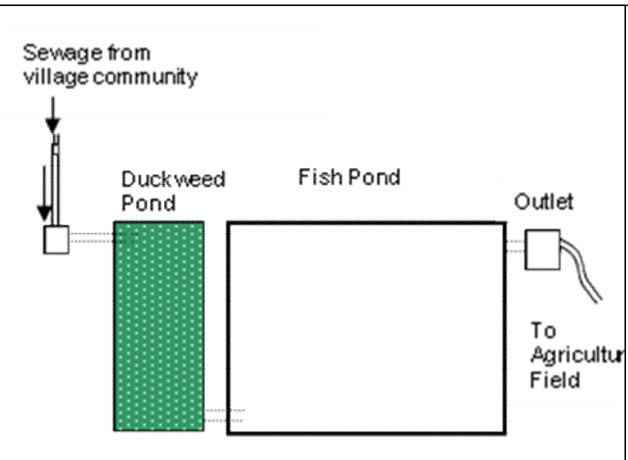
1.8	Type of wastewater treated	Domestic wastewater of village community
1.9	Mode of conveyance	Sewer line of village community
1.1	Commissioning year the STP's	NA
1.11	Treatment technology	DP
1.12	Treatment chain / mode of operation	Duckweed pond followed by fish pond
1.13	Type of plant / fish species	Fish species: Rahu, Katla, Grass
1.14	Downstream reuse of treated wastewater	Treated wastewater from fish pond used in agricultural field
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Govt. of Punjab and Govt. of India
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Village Panchayat
3. Design Details		
3.1	Primary treatment units	NA
3.2	Screen chamber:	NA
3.3	Grit chamber	NA
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Duckweed Pond: Unit size: NA; HRT: 7 days
3.6	Unit 2 (LxBxD)	Fish Pond: Unit size: NA; HRT: 20-22
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	1
4.2	Inflow volume at the time of commissioning (MLD)	0.75
4.3	Current inflow volume (MLD)	1.2

4.4	HRT (Days)	23-25
4.5	Design Performance	BOD_5 (mg/L): ≤20; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 180-200; COD (mg/L): NA; *p*H: 7.5; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 350-400; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: 10^7; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD_5 (mg/L): 15-25; COD (mg/L): NA; *p*H: 7.7; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 50-60; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): NA; Total Coliform Count /100ml: 10^5; Fecal Coliform Count: NA
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m^3	No post treatment has been given
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater has been used in agricultural field.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	NA
7.3	Is there any risk for people involved in the disposal handling?	NA
7.4	Is there any risk for people living in the surrounding area of the system?	NA
7.5	For which purposes is the water used?	Treated wastewater has been used in agricultural field.
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops include wheat, rice, sorghum *etc.* and annual crops like sugarcane.

7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	STP performing well in terms of treated effluent standards. System is slightly overloaded in terms of flow as well as it is not maintained properly. .

8. Flow Sheet of the STP

9. Photo Gallery



Flow Sheet of STP

(A) Duckweed Pond

(B) Duckweed Pond

(C) Duckweed Pond

(D) Fish Pond

(E) Fish Pond

2.6 MLD Sewage Treatment Plant at Sultanpur Lodi, Punjab (Location ID: India_PB_11_WSP)		
1. General Information		
1.1	Location ID	India_PB_11_WSP
1.2	Name and address of STP	2.6 MLD sewage treatment plant at Sultanpur Lodi, Punjab
1.3	Contact person	NA
1.4	Phone number	NA
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Sultanpur Lodi water and sewage Board,

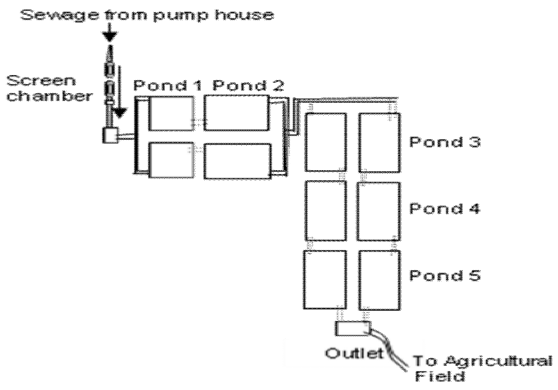
		Punjab
1.8	Type of wastewater treated	Domestic wastewater of Sultanpur Lodi township, Punjab
1.9	Mode of conveyance	Sewer line of Sultanpur Lodi water and sewage board, Punjab
1.1	Commissioning year the STP's	NA
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant / fish species	No plant or fish species used in system
1.14	Downstream reuse of treated wastewater	Treated wastewater is being reused in agricultural field
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Sultanpur Lodi water and sewage board
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Sultanpur Lodi water and sewage board
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2; Unit Size: NA
3.3	Grit chamber	Unit size: NA; Nos. of units: 2; HRT: 2-3 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Anaerobic Pond, 2 nos.: (40.5×23×3.5m)
3.6	Unit 2 (LxBxD)	Facultative Pond, 4 nos.: (136×55×2m)
3.7	Unit 3 (LxBxD)	Maturation Pond, 4 nos.: (75.5×28×3m)
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		

4.1	Design flow (MLD)	2.6
4.2	Inflow volume at the time of commissioning (MLD)	2
4.3	Current inflow volume (MLD)	3.5-4.0
4.4	HRT (Days)	15
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 230- 250; COD (mg/L): 540-560; *p*H: 6.9-7.2; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 420-450; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: 10^7; Fecal Coliform Count: 10^7
5.2	Treated Sewage	BOD_5 (mg/L): 40- 60; COD (mg/L): 100-120; *p*H: 7.5-7.8; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 60-80; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): NA; Total Coliform Count /100ml: 10^6; Fecal Coliform Count: 10^5
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m^3	No post treatment has been given
6.4	If effluent is not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater is being reused in agricultural field.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken

7.4	Is there any risk for people living in the surrounding area of the system?	At present there is no evidence or no assessment has been done
7.5	For which purposes is the water used?	Treated wastewater is being reused in agricultural field
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops include wheat, rice, sorghum *etc.* and annual crops like sugarcane.
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	STP found overloaded in terms of flow, which results in unsatisfactory treatment to the wastewater.

8. Flow Sheet of the STP

9. Photo Gallery



Flow Sheet of STP

(A) Primary treatment Unit

 **(B) Anaerobic Pond**	 **(C) Facultative Pond**
 **(D) Facultative Pond**	 **(E) Maturation Pond**

20 MLD Sewage Treatment Plant at Village Nanded, Jodhpur, Rajasthan (Location ID: India_RJ_1_WSP)		
1. General Information		
1.1	Location ID	India_RJ_1_WSP
1.2	Name and address of STP	20 MLD, sewage treatment plant, at village Nanded, Jodhpur, Rajasthan
1.3	Contact person	V.K. Vergies, Plant Incharge
1.4	Phone number	+91-9799063080
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Jodhpur Municipal Corporation, Rajasthan

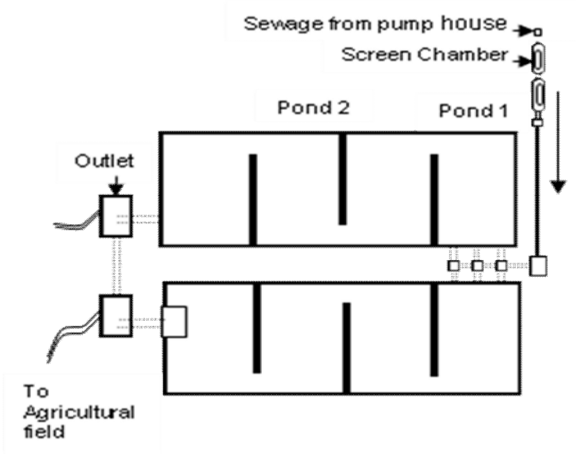
1.8	Type of wastewater treated	Domestic Wastewater of Jodhpur township, Rajasthan
1.9	Mode of conveyance	Jodhpur Municipal Corporation, Rajasthan
1.1	Commissioning year the STP's	2007
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant / fish species	No plant or fish species used in system
1.14	Downstream reuse of treated wastewater	Treated wastewater is being reused in agricultural field
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA (Funded by RUIDP Rajasthan)
2.2	Cost of treatment (O&M Cost /month)	INR 94000 per month
2.3	Funding agency for wastewater treatment cost	Jodhpur Municipal Corporation, Rajasthan
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Jodhpur Municipal Corporation, Rajasthan
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2 nos.; Unit Size: 8.4×4.5m
3.3	Grit chamber	Unit size: NA; 2 nos.; HRT: 2-3 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Anaerobic Pond, 2 nos.: (96×35×6m)
3.6	Unit 2 (LxBxD)	Facultative Pond, 2 nos. (400×135×1.5m)
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	20
4.2	Inflow volume at the time of	10

	commissioning (MLD)	
4.3	Current inflow volume (MLD)	15
4.4	HRT (Days)	15
4.5	Design Performance	BOD_5 (mg/L): ≤60; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 220-240; COD (mg/L): 530-560; *p*H: 7.2-7.5; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 450; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: 10^7; Fecal Coliform Count NA
5.2	Treated Sewage	BOD_5 (mg/L):40- 60; COD (mg/L): 100-120; *p*H: 7.5-7.8; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 60-80; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): NA; Total Coliform Count /100ml: 10^5
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m3	No post treatment has been given
6.4	If effluent not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater is being reused in agricultural field.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken
7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the WSP because system is far away from residential area and plant also

		surrounded by wire mesh. .
7.5	For which purposes is the water used?	Treated wastewater is being reused in agricultural field
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops include wheat, rice, sorghum *etc.*
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	STP performing well in terms of efficiency but more care is to be needed for routine maintenance.

8. Flow Sheet of the STP

9. Photo Gallery



Flow Sheet of STP

(A) Primary Treatment Unit

(B) Anaerobic Pond

(C) Facultative Pond 1

(D) Facultative Pond 2

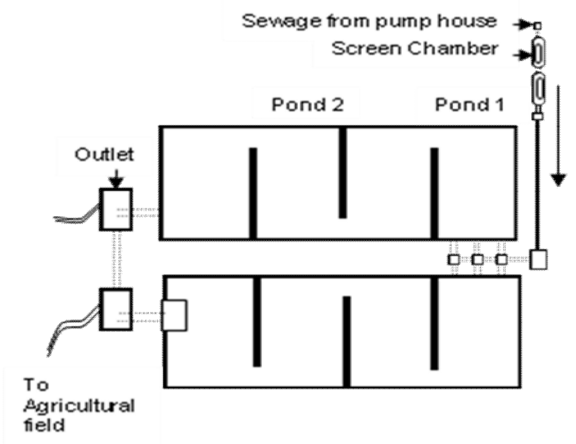
(E) Maturation Pond

20 MLD Sewage Treatment Plant, Vallabh Garden Bikaner, Rajasthan (Location ID: India_RJ_2_WSP)		
1. General Information		
1.1	Location ID	India_RJ_2_WSP
1.2	Name and address of STP	20 MLD sewage treatment plant, Vallabh Garden Bikaner, Rajasthan
1.3	Contact person	M.K. Singh, Plant Manager
1.4	Phone number	+91-9982264361
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Bikaner Municipal Corporation, Rajasthan

1.8	Type of wastewater treated	Domestic Wastewater of Bikaner township, Rajasthan
1.9	Mode of conveyance	Bikaner Municipal Corporation, Rajasthan
1.1	Commissioning year the STP's	2007
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant / fish species	No plant or fish species used in system
1.14	Downstream reuse of treated wastewater	Treated wastewater is being reused in agricultural field
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	INR 462 Lakh (Funded by RUIDP Rajasthan)
2.2	Cost of treatment (O&M Cost /month)	INR One Lakh
2.3	Funding agency for wastewater treatment cost	Bikaner Municipal Corporation, Rajasthan
2.4	Revenue generated per month	INR 1.25 Lakh
2.5	Agency bearing wastewater collection costs	Bikaner Municipal Corporation, Rajasthan
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2 nos.; Unit Size: 8.4×4.5m
3.3	Grit chamber	Unit size: NA; 2 nos.; HRT: 2-3 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Anaerobic Pond, 2 nos. (96×35×6m)
3.6	Unit 2 (LxBxD)	Facultative Pond, 2 nos. (400×135×1.5m)
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	20

4.2	Inflow volume at the time of commissioning (MLD)	5.5
4.3	Current inflow volume (MLD)	5.5
4.4	HRT (Days)	20
4.5	Design Performance	BOD_5 (mg/L): ≤100; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 350-500; COD (mg/L): 600-800; *p*H: 6.5-8.5; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 400; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: 10^7; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD_5 (mg/L): 125-150; COD (mg/L): 300-350; *p*H: 6.5-8.5; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 150-200; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): NA; Total Coliform Count /100ml: 10^5; Fecal Coliform Count: NA
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m3	No post treatment has been given
6.4	If effluent not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater is being reused in agricultural field.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken

7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the WSP because system is far away from residential area and plant also surrounded by wire mesh. .
7.5	For which purposes is the water used?	Treated wastewater is being reused in agricultural field
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops include wheat, rice, sorghum *etc.*
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	STP not performing well because of highly concentrated wastewater reaching to STP. High COD value also indicates the mixing of industrial effluent which may be the major reason in reducing the STP performance.
8. Flow Sheet of the STP		
9. Photo Gallery		



Flow Sheet of STP

(A) Primary Treatment Unit

(B) Anaerobic Pond

(C) Facultative Pond 1

(D) Facultative Pond 2

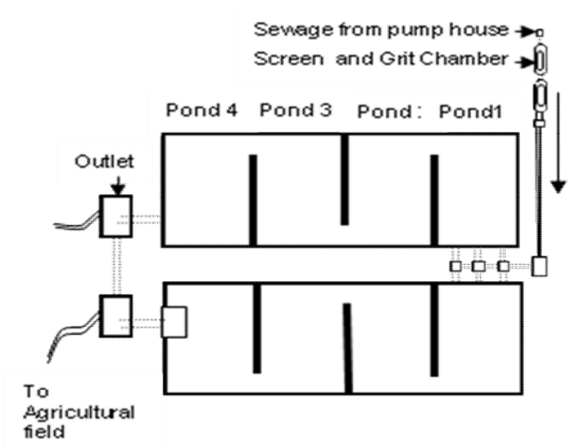
(E) Maturation Pond outlet

2.25 MLD Sewage Treatment Plant at Bhuri Ka Nagla, Agra, Utter Pradesh (Location ID: India_UP_1_WSP)		
1. General Information		
1.1	Location ID	India_UP_1_WSP
1.2	Name and address of STP	2.25 MLD, sewage treatment plant, at Bhuri Ka Nagla, Agra, Utter Pradesh
1.3	Contact person	Er. Babu Lal
1.4	Phone number	NA
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Jal Nigam, Agra, Utter Pradesh
1.8	Type of wastewater treated	Domestic wastewater of Agra township, Utter Pradesh
1.9	Mode of conveyance	Sewer line of Agra Municipal Corporation, Agra, Utter Pradesh
1.1	Commissioning year the STP's	NA
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant / fish species	No plant or fish species used in system
1.14	Downstream reuse of treated wastewater	Treated wastewater is being reused in agricultural field
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA (Funded by Yamuna Action Plan)
2.2	Cost of treatment (O&M Cost /month)	NA
2.3	Funding agency for wastewater treatment cost	Jal Nigam, Agra, Utter Pradesh
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Jal Nigam, Agra, Utter Pradesh
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber

3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2 nos.; Unit Size: NA
3.3	Grit chamber	Unit size: NA; 2 nos.; HRT: 3-3.5 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Anaerobic Pond, 2 nos.: (29.5×28.5×3.5m)
3.6	Unit 2 (LxBxD)	Facultative Pond, 4 nos.: (61×40×1.5m)
3.7	Unit 3 (LxBxD)	Maturation Pond, 2 nos.: (61×40×1.5m)
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	2.25
4.2	Inflow volume at the time of commissioning (MLD)	1.5
4.3	Current inflow volume (MLD)	2.5
4.4	HRT (Days)	15
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 190-220; COD (mg/L): 475-525; *p*H: 7.35; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 485; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: 9×10^7; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD_5 (mg/L): 30-40; COD (mg/L): 130-150; *p*H: 7.5; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 130-150; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: 10^6; Fecal Coliform Count: NA
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m3	No post treatment has been given
6.4	If effluent not being reused now, is there any potential for reuse? If	Treated wastewater is being reused in agricultural field as well as discharges into

	yes, for which purpose	Yamuna River.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken
7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents around the WSP because system is surrounded by wire mesh. .
7.5	For which purposes is the water used?	Treated wastewater is being reused in agricultural field
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops include wheat, rice, sorghum *etc.*
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	STP is not performing well. Highly concentrated wastewater in terms of COD reaching to STP for treatment. High COD value indicates the mixing of industrial effluent, which may be the major reason in reducing the STP performance.
8. Flow Sheet of the STP		

9. Photo Gallery



Flow Sheet of STP

(A) Primary Treatment Unit

(B) Anaerobic Pond

(C) Facultative Pond 1

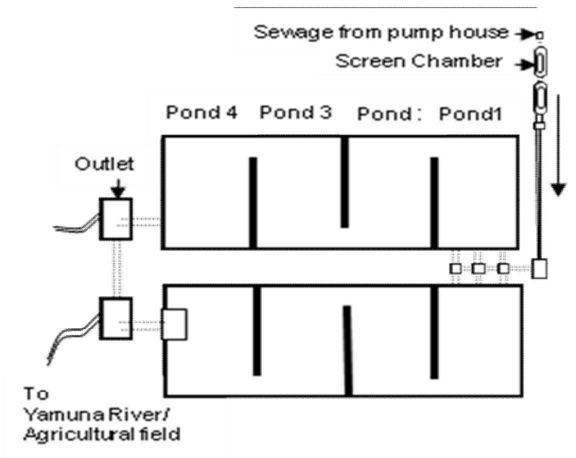
(D) Facultative Pond 2

(E) Maturation Pond

10 MLD Sewage Treatment Plant at Peela Khar, Agra, Utter Pradesh (Location ID: India_UP_2_WSP)		
1. General Information		
1.1	Location ID	India_UP_2_WSP
1.2	Name and address of STP	10 MLD, sewage treatment plant, at Peela Khar, Agra, Utter Pradesh
1.3	Contact person	Mr. Deldar, Plant Supervisor
1.4	Phone number	+91-9897403057
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Jal Nigam, Agra, Utter Pradesh
1.8	Type of wastewater treated	Domestic wastewater of Agra township, Utter Pradesh
1.9	Mode of conveyance	Sewer line of Agra Municipal Corporation, Agra, Utter Pradesh
1.1	Commissioning year the STP's	NA
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant / fish species	No plant or fish species used in system
1.14	Downstream reuse of treated wastewater	Treated wastewater is being reused in agricultural field
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA (Funded by Yamuna Action Plan)
2.2	Cost of treatment (O&M Cost /month)	NA
2.3	Funding agency for wastewater treatment cost	Jal Nigam, Agra, Utter Pradesh
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Jal Nigam, Agra, Utter Pradesh
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber

3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2 nos.; Unit Size: NA
3.3	Grit chamber	Unit size: NA; 2 nos.; HRT: 1-2 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Anaerobic Pond, 2 nos.: (47×20×3.5m)
3.6	Unit 2 (LxBxD)	Facultative Pond, 4 nos.: (97×40×1.5m)
3.7	Unit 3 (LxBxD)	Maturation Pond, 2 nos.: (97×40×1.5m)
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	10
4.2	Inflow volume at the time of commissioning (MLD)	5
4.3	Current inflow volume (MLD)	10
4.4	HRT (Days)	15
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 190-200; COD (mg/L): 490-520; *p*H: 7.35; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 435; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: 8×10^7; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD_5 (mg/L): 25-30; COD (mg/L): 100-120; *p*H: 7.5; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 40-60; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): NA; Total Coliform Count /100ml: 10^6; Fecal Coliform Count: NA
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m3	No post treatment has been given
6.4	If effluent not being reused now, is there any potential for reuse? If yes,	Treated wastewater is being reused in agricultural field.

	for which purpose	
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken.
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken.
7.4	Is there any risk for people living in the surrounding area of the system?	No risk has been assessed
7.5	For which purposes is the water used?	Treated wastewater is being reused in agricultural field.
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops include wheat, rice, sorghum *etc.*
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	The overall performance of the treatment plant is satisfactory.
8. Flow Sheet of the STP		
9. Photo Gallery		



Flow Sheet of STP

(A) Primary Treatment Unit

(B) Anaerobic Pond

(C) Facultative Pond 1

(D) Facultative Pond 2

(E) Maturation Pond

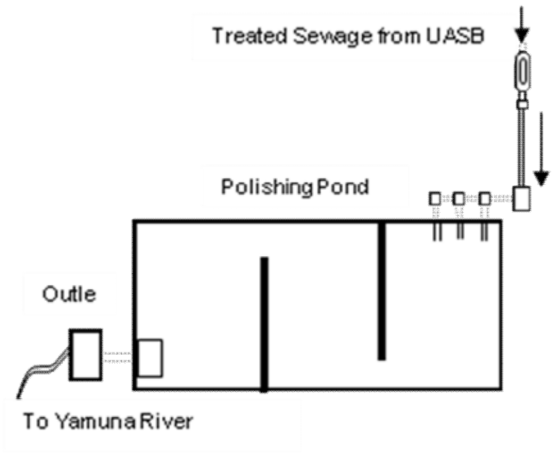
14 MLD, Sewage Treatment Plant, Jaganpur, Dayal Bag, Agra, Utter Pradesh (Location ID: India_UP_3_PP)		
1. General Information		
1.1	Location ID	India_UP_3_PP
1.2	Name and address of STP	14 MLD, sewage treatment plant, at Jaganpur, Dayal Bag, Agra, Utter Pradesh
1.3	Contact person	Mr. Rajiv Gupta, Assistant Engineer
1.4	Phone number	+91-9759366785 (Mr. Naresh, STP Chemist)
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Jal Nigam, Agra, Utter Pradesh
1.8	Type of wastewater treated	Domestic wastewater of Agra township, Utter Pradesh
1.9	Mode of conveyance	Sewer line of Agra Municipal Corporation, Agra, Utter Pradesh
1.1	Commissioning year the STP's	NA
1.11	Treatment technology	UASB followed by Polishing Pond
1.12	Treatment chain / mode of operation	UASB followed by Polishing Pond
1.13	Type of plant / fish species	No plant or fish species used in system
1.14	Downstream reuse of treated wastewater	Treated wastewater discharges into the Yamuna River.
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Yamuna Action Plan Phage II
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Jal Nigam, Agra, Utter Pradesh
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2;

		Unit Size: 50 mm and 20mm
3.3	Grit chamber	Grit chamber, 4 nos.: (10.4×2.5×0.7m); HRT: 3-3.5 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Polishing Pond, 2 nos.: (111.87×50.90×1.25m)
3.6	Unit 2 (LxBxD)	Sludge Drying Bed, 20 nos. (20×20 ft)
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	14
4.2	Inflow volume at the time of commissioning (MLD)	5
4.3	Current inflow volume (MLD)	7.15
4.4	HRT (Days)	24 Hrs in Polishing Pond
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 70-80; COD (mg/L): 160-180; *p*H: 7.0-7.2; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 40-45; VSS (mg/L): 40-50: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD_5 (mg/L): 25-30; COD (mg/L): 130-140; *p*H: 7.5-7.8; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 80-85; VSS (mg/L): 18-20: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count: NA
6. Post Treatment		
6.1	Type of Post Treatment	5 ppm of chlorine dose has been given
6.2	Water quality before post treatment	BOD_5 (mg/L): 25-30; COD (mg/L): 130-140; *p*H: 7.5-7.8; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 80-85; VSS (mg/L): 18-20: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count

		/100ml: NA; Fecal Coliform Count NA
6.3	Cost of post treatment/m^3	NA
6.4	If effluent not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater maybe used in agricultural field.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken
7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the STP because system is far away from residential area as well as covered by RCC wall. .
7.5	For which purposes is the water used?	Treated wastewater discharges into the Yamuna River.
7.6	If water is used for irrigation, what plants are irrigated?	NA
7.7	If vegetables are planted, are the eaten raw?	NA
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	The treatment performance of polishing pond is good and able to achieve the design parameters.

8. Flow Sheet of the STP

9. Photo Gallery



Flow Sheet of STP

(A) USAB Unit

(B) Polishing Pond

(C) Polishing Pond

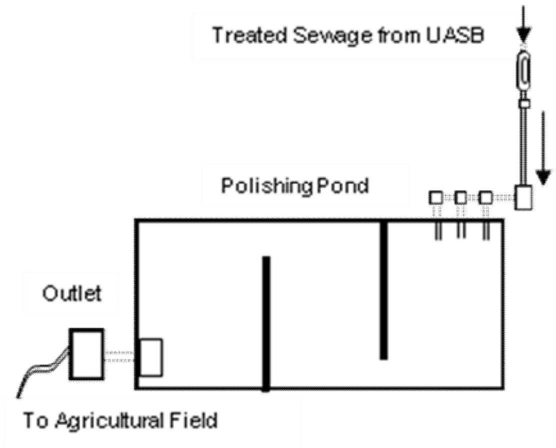
(D) Sludge Drying Beds

(E) Chlorination Unit

78 MLD, Sewage Treatment Plant, Dhandpur, Agra, Utter Pradesh (Location ID: India_UP_4_PP)		
1. General Information		
1.1	Location ID	India_UP_4_PP
1.2	Name and address of STP	78 MLD, sewage treatment plant, at Dhandpur, Agra, Utter Pradesh
1.3	Contact person	Mr. Subhash Chaudhary, STP Manger
1.4	Phone number	+91-9719039498
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Jal Nigam, Agra, Utter Pradesh
1.8	Type of wastewater treated	Domestic wastewater of Agra township, Utter Pradesh
1.9	Mode of conveyance	Sewer line of Agra Municipal Corporation, Agra, Utter Pradesh
1.1	Commissioning year the STP's	NA
1.11	Treatment technology	UASB followed by Polishing Pond
1.12	Treatment chain / mode of operation	UASB followed by Polishing Pond
1.13	Type of plant / fish species	No plant or fish species used in system
1.14	Downstream reuse of treated wastewater	Treated wastewater used in agricultural field
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Yamuna Action Plan Phage II
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Jal Nigam, Agra, Utter Pradesh
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2;

		Unit Size: 50 mm and 20mm (6×2.5)
3.3	Grit chamber	Grit chamber, 1 nos.: 12.15×1.5×0.1m+0.5m FB; HRT: 3-3.5 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Polishing Pond 1: 214×93×1.25 m +0.25m FB
3.6	Unit 2 (LxBxD)	Polishing Pond 2: 129.70×160×1.25 m +0.25m FB
3.7	Unit 3 (LxBxD)	Polishing Pond 3: 123×162.50×1.25 m +0.25m FB
3.8	Unit 4 (LxBxD)	Sludge Drying Bed, 36 nos.: (26.20×14×0.90 TD)
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	78
4.2	Inflow volume at the time of commissioning (MLD)	30
4.3	Current inflow volume (MLD)	43
4.4	HRT (Days)	24 Hrs in Polishing Pond
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 70- 80; COD (mg/L): 180-205; *p*H: 7.0-7.4; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 90-95; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD_5 (mg/L): 25- 29; COD (mg/L): 100-120; *p*H: 7.4-7.7; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 40-45; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count: NA
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m3	No post treatment has been given
6.4	If effluent not being reused now, is there any potential for reuse? If yes,	Treated wastewater has been used in agricultural field.

	for which purpose	
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken.
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken.
7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the STP because system is far away from residential area as well as surrounded by the wall. .
7.5	For which purposes is the water used?	Treated wastewater has been used in agricultural field.
7.6	If water is used for irrigation, what plants are irrigated?	Treated wastewater has been used in agricultural field.
7.7	If vegetables are planted, are the eaten raw?	Treated wastewater has been used in agricultural field.
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	The treatment performance of polishing pond is good and able to achieve the design parameters.
8. Flow Sheet of the STP		
9. Photo Gallery		



Flow Sheet of STP

(A) USAB Unit

(B) Polishing Pond

(C) Polishing Pond

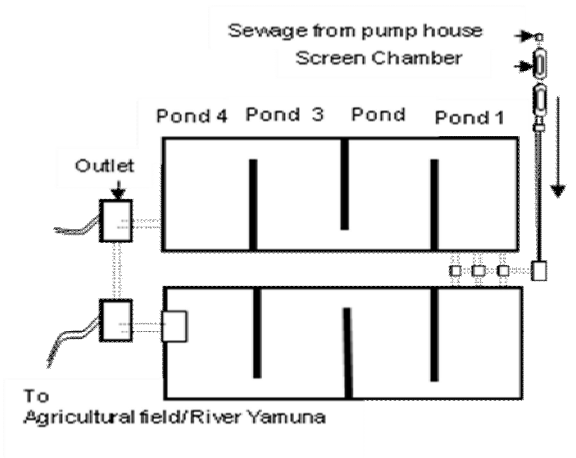
(D) Sludge Drying Beds

(E) Agricultural field

13.59, MLD Sewage Treatment Plant, Masani, Mathura, Utter Pradesh (Location ID: India_UP_5_WSP)		
1. General Information		
1.1	Location ID	India_UP_5_WSP
1.2	Name and address of STP	13.59 MLD, sewage treatment plant, at Masani, Mathura, Utter Pradesh
1.3	Contact person	NA
1.4	Phone number	NA
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Jal Nigam, Mathra, Utter Pradesh
1.8	Type of wastewater treated	Domestic Wastewater of Mathura township, Utter Pradesh
1.9	Mode of conveyance	Sewer line of Mathura Municipal Corporation, Mathura, Utter Pradesh
1.1	Commissioning year the STPs	2001
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant / fish species	No plant or fish species used in system
1.14	Downstream reuse of treated wastewater	Some proportion of treated wastewater is being reused in agricultural and rest discharges into River Yamuna.
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA (Funded by Yamuna Action Plan)
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Jal Nigam, Mathura, Utter Pradesh
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Jal Nigam, Mathura, Utter Pradesh
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2 nos.; Unit Size: NA
3.3	Grit chamber	Unit size: NA; 2 Nos.; HRT: 3-3.5 minutes
3.4	Secondary treatment units	

3.5	Unit 1 (LxBxD)	Anaerobic Pond, 2 nos.: (90×50×3.8m)
3.6	Unit 2 (LxBxD)	Facultative Pond, 4 nos.: (82×75.5×1.5m)
3.7	Unit 3 (LxBxD)	Maturation Pond, 2 nos.: (179×75.5×1.5m) and (117×82×1.5m)
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	13.59
4.2	Inflow volume at the time of commissioning (MLD)	10
4.3	Current inflow volume (MLD)	16
4.4	HRT (Days)	15
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 220-240; COD (mg/L): 450-500; *p*H: 7.3; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 480-520; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: 7×10^7; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD_5 (mg/L): 40-60; COD (mg/L): 120-140; *p*H: 7.3; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 100-120; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): NA; Total Coliform Count /100ml: 10^6; Fecal Coliform Count: NA
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m3	No post treatment has been given
6.4	If effluent not being reused now, is there any potential for reuse? If yes, for which purpose	Some proportion of treated wastewater is being used in agricultural and rest discharges into River Yamuna.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has

		been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken.
7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the STP because system is far away from residential area as well as surrounded by the wire mesh. .
7.5	For which purposes is the water used?	Some proportion of treated wastewater is being used in agricultural and rest discharges into River Yamuna.
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops include wheat, rice, sorghum *etc.*
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	STP is not able to meet the prescribed standards because plant is overloaded in terms of flow.
8. Flow Sheet of the STP		
9. Photo Gallery		



Flow Sheet of STP

(A) Primary Treatment Unit

(**B) Anaerobic Pond**

(**C) Facultative Pond 1**

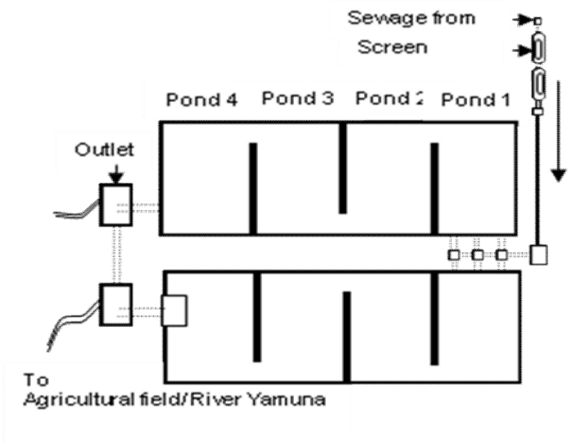
(**D) Facultative Pond 2**

(**E) Maturation Pond**

14.5 MLD, Sewage Treatment Plant, Bangali Ghat, , Mathura, Utter Pradesh (Location ID: India_UP_6_WSP)		
1. General Information		
1.1	Location ID	India_UP_6_WSP
1.2	Name and address of STP	14.5 MLD, sewage treatment plant, at Bangali Ghat, Dairy Farm Zone, Mathura, Utter Pradesh
1.3	Contact person	Mr. Pawan Kumar
1.4	Phone number	+91-9761334407
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Jal Nigam, Mathra, Utter Pradesh
1.8	Type of wastewater treated	Domestic Wastewater of Mathura township, Utter Pradesh
1.9	Mode of conveyance	Sewer line of Mathura Municipal Corporation, Mathura, Utter Pradesh
1.1	Commissioning year the STP's	2001
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant / fish species	No plant or fish species used in system
1.14	Downstream reuse of treated wastewater	Some proportion of treated wastewater is being used in agricultural and rest discharges into River Yamuna.
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA (Funded by Yamuna Action Plan)
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Jal Nigam, Mathura, Utter Pradesh
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Jal Nigam, Mathura, Utter Pradesh
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber

3.2	Screen chamber:	Type: Coarse; Number of Screens: 4 nos.; Unit Size: NA
3.3	Grit chamber	Unit size: NA; 4 nos.; HRT: 3-3.5 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Anaerobic Pond, 2 nos.: (94×52×3.5m)
3.6	Unit 2 (LxBxD)	Facultative Pond, 4 nos.: (127×85×1.5m)
3.7	Unit 3 (LxBxD)	Maturation Pond, 2 nos.: (127×85×1.5m)
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	14.5
4.2	Inflow volume at the time of commissioning (MLD)	10
4.3	Current inflow volume (MLD)	14
4.4	HRT (Days)	15
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 160-180; COD (mg/L): 450-500; *p*H: 7.5; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 580-620; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: 8×10^7; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD_5 (mg/L): 50-60; COD (mg/L): 160-180; *p*H: 7.8; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 160-180; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): NA; Total Coliform Count /100ml: 10^6; Fecal Coliform Count: NA
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m3	No post treatment has been given
6.4	If effluent not being reused now, is there any potential for reuse? If yes,	Some proportion of treated wastewater is being used in agricultural and rest

	for which purpose	discharges into River Yamuna.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken.
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken.
7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the STP because system is far away from residential area as well as surrounded by the wire mesh. .
7.5	For which purposes is the water used?	Some proportion of treated wastewater is being used in agricultural and rest discharges into River Yamuna.
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops include wheat, cauliflower, rice, sorghum *etc.*
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	STP is not able to meet the prescribed standards of treated effluent. In wastewater high value of COD and TSS are being reported which indicate the mixing of industrial wastewaters into the sewage and hence may be the major cause of reduced efficiency of STP.

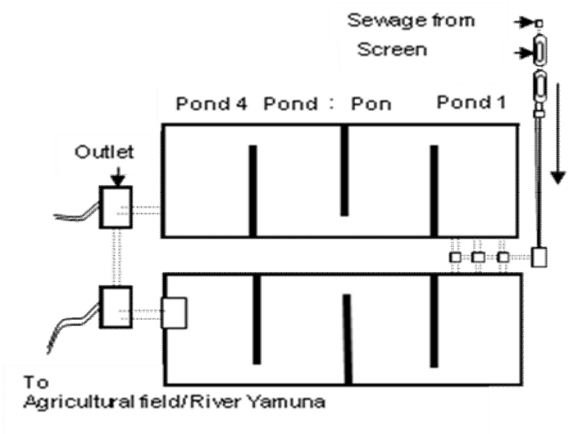
8. Flow Sheet of the STP	
9. Photo Gallery	
 **Flow Sheet of STP**	 **(A) Primary Treatment Unit**
 **(B) Anaerobic Pond**	 **(C) Facultative Pond 1**
 **(D) Facultative Pond 2**	 **(E) Maturation Pond**

4 MLD, Sewage Treatment Plant, Vrindavan, Utter Pradesh (Location ID: India_UP_7_WSP)		
1. General Information		
1.1	Location ID	India_UP_7_WSP
1.2	Name and address of STP	4 MLD, sewage treatment plant, near Pagal Baba Temple, Vrindavan, Utter Pradesh
1.3	Contact person	General Manager, Drainage and Sewerage Unit
1.4	Phone number	NA
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Jal Nigam, Vrindavan, Utter Pradesh
1.8	Type of wastewater treated	Domestic Wastewater of Vrindavan township, Utter Pradesh
1.9	Mode of conveyance	Sewer line of Mathura Municipal Corporation, Vrindavan, Utter Pradesh
1.1	Commissioning year the STP's	NA
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant / fish species	No plant or fish species used in system
1.14	Downstream reuse of treated wastewater	Treated wastewater is being reused in agricultural.
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA (Funded by NRCD, Govt, of India)
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Jal Nigam, Vrindavan, Utter Pradesh
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Jal Nigam, Vrindavan, Utter Pradesh
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber

3.2	Screen chamber:	Type: Coarse; Number of Screens: 3 nos.; Unit Size: NA
3.3	Grit chamber	Unit size: NA; 3 nos.; HRT: 3-3.5 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Anaerobic Pond, 2 nos.: (47×34×3.5m)
3.6	Unit 2 (LxBxD)	Facultative Pond, 4 nos.: (94×44.6×1.5m)
3.7	Unit 3 (LxBxD)	Maturation Pond, 2 nos.: (94×44.6×1.5m)
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	4
4.2	Inflow volume at the time of commissioning (MLD)	3
4.3	Current inflow volume (MLD)	6.5
4.4	HRT (Days)	10
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 230-250; COD (mg/L): 440-480; *p*H: 7.5; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 550-580; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: 10^8; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD5 (mg/L): 110-130; COD (mg/L): 160-200; *p*H: 7.9; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 120-140; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): NA; Total Coliform Count /100ml: 10^6; Fecal Coliform Count: NA
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m3	No post treatment has been given
6.4	If effluent not being reused now, is there any potential for reuse? If yes,	Treated wastewater is being reused in agricultural.

	for which purpose	
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken
7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the STP because system is far away from residential area as well as surrounded by the wire mesh. .
7.5	For which purposes is the water used?	Treated wastewater is being reused in agricultural.
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops include wheat, cauliflower, rice, sorghum *etc.*
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	STP is not able to meet the prescribed standards of treated effluent. Maintenance of STP is avoided by plant operators from a long time due to the lack of availability of fund.
8. Flow Sheet of the STP		

9. Photo Gallery



Flow Sheet of STP

(A) Primary Treatment Unit

(B) Anaerobic Pond

(C) Facultative Pond 1

(D) Facultative Pond 2

(E) Maturation Pond

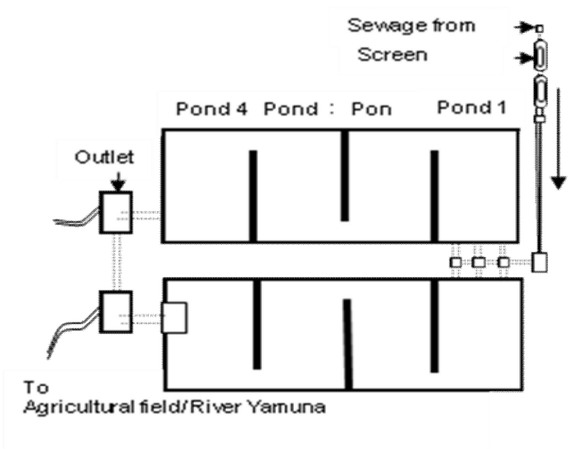
0.5 MLD, Sewage Treatment Plant Kali Deh, Vrindavan, Utter Pradesh (Location ID: India_UP_8_WSP)		
1. General Information		
1.1	Location ID	India_UP_8_WSP
1.2	Name and address of STP	0.5 MLD, sewage treatment plant, Kali Deh, Vrindavan, Utter Pradesh
1.3	Contact person	NA
1.4	Phone number	NA
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Jal Nigam, Vrindavan, Utter Pradesh
1.8	Type of wastewater treated	Domestic Wastewater of Vrindavan Township, Utter Pradesh
1.9	Mode of conveyance	Sewer line of Mathura Municipal Corporation, Vrindavan, Utter Pradesh
1.1	Commissioning year the STP's	NA
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant / fish species	No plant or fish species used in system
1.14	Downstream reuse of treated wastewater	Treated wastewater is being discharges into adjoining nallah.
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA (Funded by NRCD, Govt, of India)
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Jal Nigam, Vrindavan, Utter Pradesh
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Jal Nigam, Vrindavan, Utter Pradesh
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse; Number of Screens: 2 nos.; Unit

		Size: NA
3.3	Grit chamber	Unit size: NA; 2 Nos.
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Anaerobic Pond, 2 nos.; Size: NA
3.6	Unit 2 (LxBxD)	Facultative Pond, 4 nos.; Size: NA
3.7	Unit 3 (LxBxD)	Maturation Pond, 2 nos.; Size: NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	0.5
4.2	Inflow volume at the time of commissioning (MLD)	NA
4.3	Current inflow volume (MLD)	STP is not in operation
4.4	HRT (Days)	STP is not in operation
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	STP is not in operation
5.2	Treated Sewage	STP is not in operation
6. Post Treatment		
6.1	Type of Post Treatment	STP is not in operation
6.2	Water quality before post treatment	STP is not in operation
6.3	Cost of post treatment/m3	STP is not in operation
6.4	If effluent not being reused now, is there any potential for reuse? If yes, for which purpose	STP is not in operation
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	STP is not in operation

7.3	Is there any risk for people involved in the disposal handling?	STP is not in operation
7.4	Is there any risk for people living in the surrounding area of the system?	STP is not in operation
7.5	For which purposes is the water used?	STP is not in operation
7.6	If water is used for irrigation, what plants are irrigated?	STP is not in operation
7.7	If vegetables are planted, are the eaten raw?	NA
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	STP has been demolished and a new STP based on UASB is being constructed.

8. Flow Sheet of the STP

9. Photo Gallery



Flow Sheet of STP

(A) Primary Treatment Unit

 (B) Anaerobic Pond	 (C) Facultative Pond 1
 (D) Facultative Pond 2	 (E) Treated Wastewater

10.445 MLD, Sewage Treatment Plant, Etawah, Utter Pradesh (Location ID: India_UP_9_WSP)		
1. General Information		
1.1	Location ID	India_UP_9_WSP
1.2	Name and address of STP	10.445 MLD, sewage treatment plant, at Etawah, Utter Pradesh
1.3	Contact person	Mr. Subhash Chaudhary
1.4	Phone number	+91-9719039498
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Jal Nigam, Etawah, Utter Pradesh

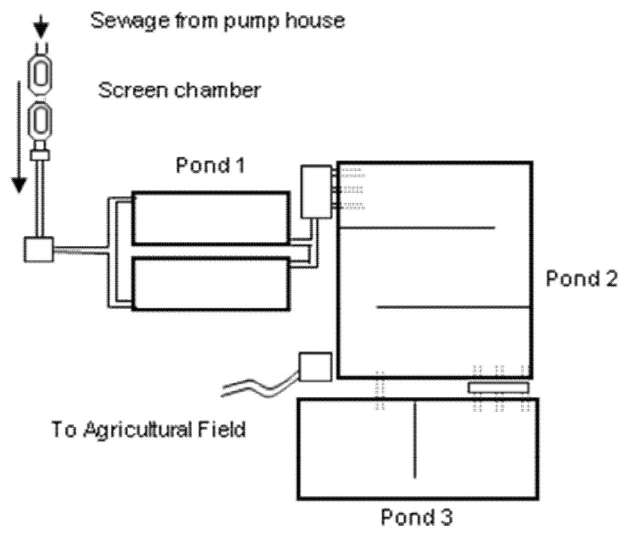
1.8	Type of wastewater treated	Domestic Wastewater of Etawah township, Utter Pradesh
1.9	Mode of conveyance	Sewer line of Etawah Municipal Corporation, Vrindavan, Utter Pradesh
1.1	Commissioning year the STP's	2001
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant / fish species	No plant or fish species used in system
1.14	Downstream reuse of treated wastewater	Treated wastewater is discharges into River Yamuna.
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA (Funded by NRCD, Govt, of India)
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Jal Nigam, Etawah, Utter Pradesh
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Jal Nigam, Etawah, Utter Pradesh
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse; Number of Screens: 3 nos.; Unit Size: NA
3.3	Grit chamber	Unit size: NA; 3 Nos.; HRT: 3-3.52 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Anaerobic Pond, 2 nos.: Size: NA
3.6	Unit 2 (LxBxD)	Facultative Pond, 3 nos.: Size: NA
3.7	Unit 3 (LxBxD)	Maturation Pond, 2 nos.: Size: NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	10.445

4.2	Inflow volume at the time of commissioning (MLD)	12
4.3	Current inflow volume (MLD)	15-16, 10.445 MLD treated at the STP and rest bypass to adjoining
4.4	HRT (Days)	15
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 175-200; COD (mg/L): 400-450; *p*H: 7.3; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 350-400; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: $5{\times}10^7$; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD_5 (mg/L): 25-30; COD (mg/L): 100-120; *p*H: 7.71; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 40-60; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): NA; Total Coliform Count /100ml: 10^6; Fecal Coliform Count: NA
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m3	No post treatment has been given
6.4	If effluent not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater may be used in agricultural field.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken
7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the STP because system is

		far away from residential area.
7.5	For which purposes is the water used?	Treated wastewater is being discharge into the River Yamuna.
7.6	If water is used for irrigation, what plants are irrigated?	NA
7.7	If vegetables are planted, are the eaten raw?	NA
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	STP meeting the prescribed standards of treated effluent

8. Flow Sheet of the STP

9. Photo Gallery



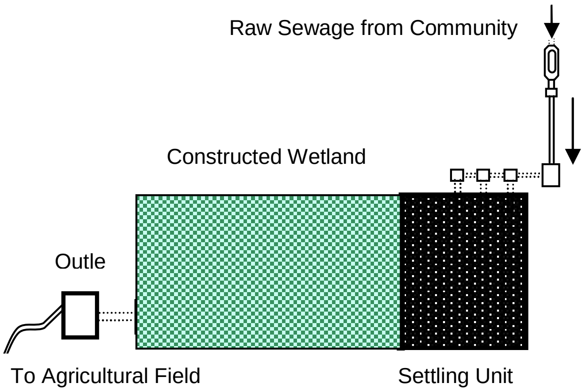
Flow Sheet of STP

50KLD, Sewage Treatment Plant, Kachpura, Agra (Location ID: India_UP_10_CW)		
1. General Information		
1.1	Location ID	India_UP_10_CW
1.2	Name and address of STP	50KLD, Sewage Treatment Plant, Kachpura village in Agra
1.3	Contact person	Dr. Renu Khosla Director, Social Development Centre for Urban and Regional Excellence
1.4	Phone number	+91-9259752314 (Meera)
1.5	Fax number	NA
1.6	E-mail address	renukhosla@cureindia.org
1.7	Legal status	Jal Nigam, Agra, Utter Pradesh
1.8	Type of wastewater treated	Domestic wastewater of Kachpura village in Agra, Utter Pradesh
1.9	Mode of conveyance	Sewer line of Agra Municipal Corporation, Agra, Utter Pradesh
1.1	Commissioning year the STP's	2010
1.11	Treatment technology	CW
1.12	Treatment chain/ mode of operation	Septic tank followed by CW
1.13	Type of plant / fish species	*Canna Indica* has been planted in CW bed
1.14	Downstream reuse of treated wastewater	Treated wastewater used in irrigation
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	10-11 Lakh, System was installed with financial assistance from Water Trust UK and London Metropolitan University and technical support by Vijay Vigyan foundation
2.2	Cost of treatment (O&M Cost / month)	INR 70,000-80,000 per year
2.3	Funding agency for wastewater treatment cost	Agra Jal Nigam
2.4	Revenue generated per month	NA

2.5	Agency bearing wastewater collection costs	Agra Jal Nigam
3. Design Details		
3.1	Primary treatment units	Screen chamber and septic tank
3.2	Screen chamber:	Type: Coarse; Number of Screens: 1 nos.; Unit Size: 50 mm (2×1.5)
3.3	Grit chamber	Unit size: NA; 1 nos.; HRT: 10-15 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Septic tank, 1 nos.: (20×2.5×2.5m)
3.6	Unit 2 (LxBxD)	CW bed, 1 nos.: (30×2.5×1m)
3.7	Unit 3 (LxBxD)	Collection tank, 1 nos.: (2× 2.5× 2.5m)
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	50KLD
4.2	Inflow volume at the time of commissioning (MLD)	50KLD
4.3	Current inflow volume (MLD)	50KLD
4.4	HRT (Days)	1.5 days
4.5	Design Performance	NA
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 200-220; COD (mg/L): 400-450; *p*H: 7.35; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 435; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: 7×10^7; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD reduction: 61% COD reduction: 64% TDS reduction: 94%
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment / m^3	No post treatment has been given

6.4	If effluent is not being, reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater may be used in agricultural field.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken.
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken.
7.4	Is there any risk for people living in the surrounding area of the system?	There is no such kind of associated risk to operators because proper precautions has been taken.
7.5	For which purposes is the water used?	Treated wastewater reused in irrigation.
7.6	If water is used for irrigation, what plants are irrigated?	Seasonal crops include wheat, cauliflower, rice, sorghum *etc.*
7.7	If vegetables are planted, are the eaten raw?	No
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	No
7.11	Are there any wells near the area where the treated water is reused?	No
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	The aim of establishing this plant was to improve the sanitation conditions in the slum areas. The system treats approximately 50 KLD of the total wastewater which it receives from 5 clusters of slums through a common drain.
8. Flow Sheet of the STP		

9. Photo Gallery



Flow Sheet of STP

(A) Primary Treatment Unit(Grit Chamber)

(B) Underground Septic Tank

(C) Constructed Wetland

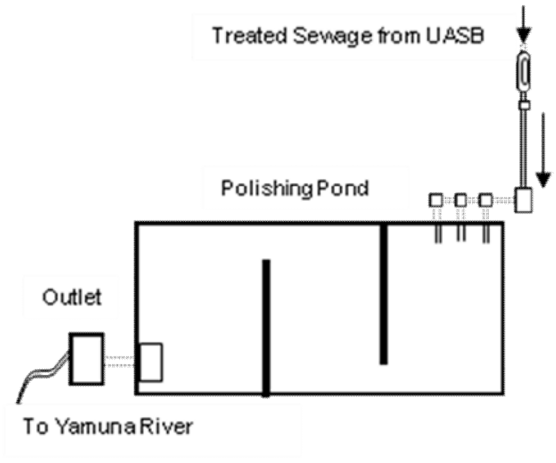
(D) Constructed Wetland

(E) Treated Wastewater

38 MLD, Sewage Treatment Plant Saharanpur, Utter Pradesh (Location ID: India_UP_11_PP)		
1. General Information		
1.1	Location ID	India_UP_11_PP
1.2	Name and address of STP	38 MLD, sewage treatment plant, Saharanpur, Utter Pradesh
1.3	Contact person	Rakesh Tomar (Contractor), Naresh Kumar (Site in-charge)
1.4	Phone number	+91-9675503416
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Nagar Nigam, Saharanpur, Utter Pradesh
1.8	Type of wastewater treated	Domestic wastewater of Saharanpur City, Utter Pradesh
1.9	Mode of conveyance	Sewer line of Nagar Nigam, Saharanpur, Utter Pradesh
1.1	Commissioning year the STP's	NA
1.11	Treatment technology	UASB-PP
1.12	Treatment chain / mode of operation	UASB followed by PP
1.13	Type of plant / fish species	No plant or fish species cultivated in system
1.14	Downstream reuse of treated wastewater	Treated wastewater is discharges into .River Yamuna.
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA (Funded by Yamuna Action Plan)
2.2	Cost of treatment (O&M Cost / month)	93 Lakh per month
2.3	Funding agency for wastewater treatment cost	Nagar Nigam, Saharanpur, Utter Pradesh
2.4	Revenue generated per month	No Revenue being generated
2.5	Agency bearing wastewater collection costs	Nagar Nigam, Saharanpur, Utter Pradesh
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber

3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2; Unit Size: 50 mm and 20mm
3.3	Grit chamber	Grit chamber, 4 nos.: (10.4×2.5×0.7m); HRT: 3-3.5 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Polishing Pond, 2 nos.: (270×130×1.25m)
3.6	Unit 2 (LxBxD)	Sludge Drying Bed, 20 nos.: (20×20 ft)
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	38
4.2	Inflow volume at the time of commissioning (MLD)	12
4.3	Current inflow volume (MLD)	20
4.4	HRT (Days)	24 hrs
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 75-85; COD (mg/L): 200-220; *p*H: 7.0-7.4; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 120-130; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD_5 (mg/L): 20-30; COD (mg/L): 120-140; *p*H: 7.4-7.7; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 40-45; VSS (mg/L): NA; TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: NA; Fecal Coliform Count: NA
6. Post Treatment		
6.1	Type of Post Treatment	5 ppm of chlorine dose has been given
6.2	Water quality before post treatment	NA
6.3	Cost of post treatment/m3	NA
6.4	If effluent not being reused now, is	Treated wastewater has been discharged

	there any potential for reuse? If yes, for which purpose	into Yamuna River.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken
7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the STP because system is far away from residential area as well as surrounded by the wall.
7.5	For which purposes is the water used?	Treated wastewater has been discharged into Yamuna River.
7.6	If water is used for irrigation, what plants are irrigated?	Treated wastewater has been discharged into Yamuna River.
7.7	If vegetables are planted, are the eaten raw?	Treated wastewater has been discharged into Yamuna River.
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	No
7.11	Are there any wells near the area where the treated water is reused?	No
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	The treatment performance of polishing pond is good and able to achieve the design parameters.
8. Flow Sheet of the STP		
9. Photo Gallery		



Flow Sheet of STP

(A) USAB Unit

(B) Polishing Pond

(C) Polishing Pond

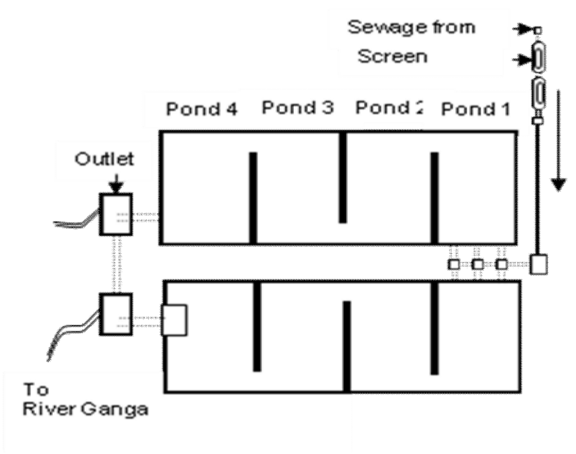
(D) Sludge Drying Bed

(E) Treated Wastewater

6 MLD, Sewage Treatment Plant, Lakkad Ghat, Reshikesh, Uttrakhand (Location ID: India_UA_1_WSP)		
1. General Information		
1.1	Location ID	India_UA_1_WSP
1.2	Name and address of STP	6 MLD, sewage treatment plant, at Lakkad Ghat, Uttrakhand
1.3	Contact person	Mr. Harish Bansal
1.4	Phone number	+91-9412964039
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Gharwal Jal Sansthan, Uttrakhand
1.8	Type of wastewater treated	Domestic wastewater of Rishikesh township, Uttrakhand
1.9	Mode of conveyance	Sewer line of Rishikesh Municipal Corporation
1.1	Commissioning year the STP's	1985
1.11	Treatment technology	WSP
1.12	Treatment chain / mode of operation	Screen Chamber-Grit Chamber Anaerobic Pond-Facultative Pond-Maturation Pond
1.13	Type of plant / fish species	No plant or fish species cultivated in system
1.14	Downstream reuse of treated wastewater	Treated wastewater is discharges into Ganga River.
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	NA (Funded by NRCD, Govt, of India)
2.2	Cost of treatment (O&M Cost / month)	NA
2.3	Funding agency for wastewater treatment cost	Gharwal Jal Sansthan, Uttrakhand
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Rishikesh Municipal Corporation
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse; Number of Screens: 3 nos.; Unit Size: NA

3.3	Grit chamber	Unit size: NA; 3 nos.; HRT: 3-3.5 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Anaerobic Pond, 2 nos.; Size: NA
3.6	Unit 2 (LxBxD)	Facultative Pond, 3 nos.; Size: NA
3.7	Unit 3 (LxBxD)	Maturation Pond, 2 nos.; Size: NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	8
4.2	Inflow volume at the time of commissioning (MLD)	12
4.3	Current inflow volume (MLD)	15-16, 10.445 MLD treated at the STP and rest by pass to adjoining wastewater canal
4.4	HRT (Days)	15
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 175-200; COD (mg/L): 400-450; *p*H: 7.3; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 350-400; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 0; Total Coliform Count /100ml: 5×10^7; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD_5 (mg/L): 25-30; COD (mg/L): 100-120; *p*H: 7.71; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): 40-60; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): NA; Total Coliform Count /100ml: 10^6; Fecal Coliform Count: NA
6. Post Treatment		
6.1	Type of Post Treatment	No post treatment has been given
6.2	Water quality before post treatment	No post treatment has been given
6.3	Cost of post treatment/m^3	No post treatment has been given
6.4	If effluent is not being, reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater may be used in agricultural field/discharge into Yamuna River.

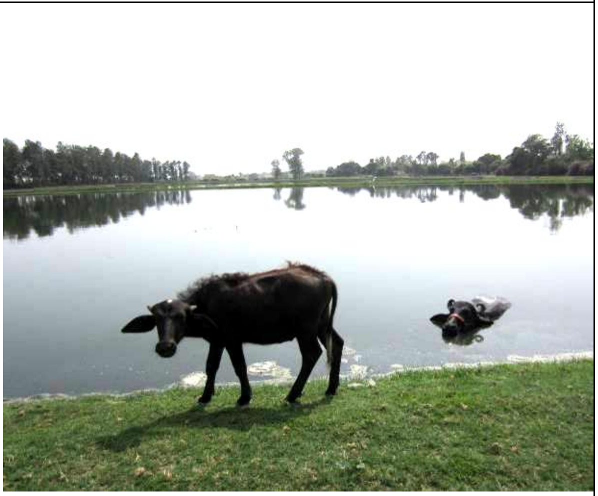
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken.
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken.
7.4	Is there any risk for people living in the surrounding area of the system?	There is no associated risk to residents surrounding the STP because system is far away. .
7.5	For which purposes is the water used?	Treated wastewater is being discharge into the River Yamuna.
7.6	If water is used for irrigation, what plants are irrigated?	Treated wastewater is being discharge into the River Ganga.
7.7	If vegetables are planted, are the eaten raw?	Treated wastewater is being discharge into the River Ganga.
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	STP meeting the prescribed standards of treated effluent. The operation and maintenance of the system is avoided by plant operators.
8. Flow Sheet of the STP		
9. Photo Gallery		



Flow Sheet of STP

(A) Primary Treatment Unit

(B) Anaerobic Pond



(C) Facultative Pond

(D) Facultative Pond 2

(E) Maturation Pond

30 MLD, Sewage Treatment Plant, Nallacheruvu, Hyderabad, Andhra Pradesh (Location ID: India_AP_1_PP)		
1. General Information		
1.1	Location ID	India_AP_1_PP
1.2	Name and address of STP	30 MLD, sewage treatment plant, Nallacheruvu, Hyderabad, Andhra Pradesh
1.3	Contact person	General Manager (Engg)
1.4	Phone number	NA
1.5	Fax number	NA
1.6	E-mail address	NA
1.7	Legal status	Hyderabad Municipal Corporation
1.8	Type of wastewater treated	Domestic wastewater of Hyderabad city
1.9	Mode of conveyance	Sewer line of Hyderabad Municipal Corporation
1.1	Commissioning year the STP's	2009
1.11	Treatment technology	UASB-PP
1.12	Treatment chain / mode of operation	UASB followed by PP
1.13	Type of plant / fish species	No plant or fish species used in system
1.14	Downstream reuse of treated wastewater	Treated wastewater used in irrigation and also discharge into River.
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	1500 Lakh
2.2	Cost of treatment (O&M Cost / month)	2.25 Lakhs(O&M) + 4 Lakhs(Electricity)
2.3	Funding agency for wastewater treatment cost	HMWSSB
2.4	Revenue generated per month	NA
2.5	Agency bearing wastewater collection costs	Hyderabad Municipal Corporation
3. Design Details		
3.1	Primary treatment units	Screen chamber and Grit chamber
3.2	Screen chamber:	Type: Coarse and Fine; Number of Screens: 2;

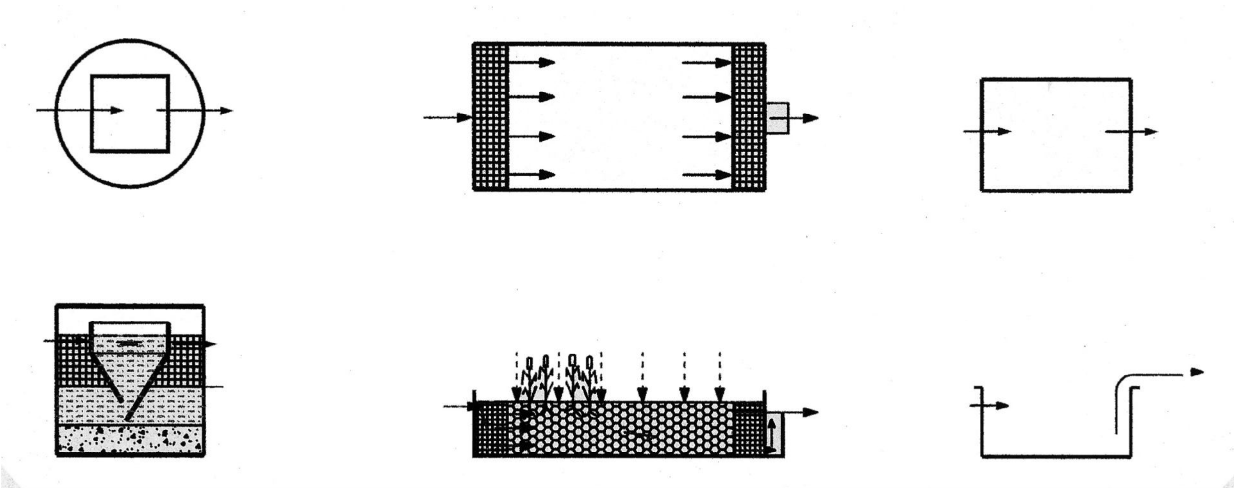
		Unit Size: 50 mm and 20mm
3.3	Grit chamber	Grit chamber, 4 nos.: (10.4×2.5×0.7m); HRT: 3-3.5 minutes
3.4	Secondary treatment units	
3.5	Unit 1 (LxBxD)	Polishing Pond, 2 nos.: (117×70×1.5m)
3.6	Unit 2 (LxBxD)	Sludge Drying Bed, 12 nos. (23.3×13.7m)
3.7	Unit 3 (LxBxD)	NA
3.8	Unit 4 (LxBxD)	NA
3.9	Unit 5 (LxBxD)	NA
4. Design Performance		
4.1	Design flow (MLD)	30
4.2	Inflow volume at the time of commissioning (MLD)	NA
4.3	Current inflow volume (MLD)	NA
4.4	HRT (Days)	10 hrs
4.5	Design Performance	BOD_5 (mg/L): ≤30; COD (mg/L): 250; *p*H: 5.5-9; TSS (mg/L): 100; TDS (mg/L): 2100
5. Actual Performance		
5.1	Raw Sewage	BOD_5 (mg/L): 30; COD (mg/L): 120; *p*H: 8; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): NA; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 4; Total Coliform Count /100ml: NA; Fecal Coliform Count: NA
5.2	Treated Sewage	BOD_5 (mg/L): 20; COD (mg/L): 100; *p*H: 8; TP (mg/L): NA; Ammonia (mg/L): NA; TSS (mg/L): NA; VSS (mg/L): NA: TDS (mg/L): NA; Dissolved Oxygen (mg/L): 4.2; Total Coliform Count /100ml: NA; Fecal Coliform Count: NA
6. Post Treatment		
6.1	Type of Post Treatment	Chlorine dose: 2 mg/L
6.2	Water quality before post treatment	BOD_5 (mg/L): 147; COD (mg/L): 246; *p*H: 7.40; Nitrate (mg/L): 56.5; Sulphates (mg/L): 212; TDS (mg/L): 853; DO (mg/L): 0.56 mg/l

6.3	Cost of post treatment/m3	NA
6.4	If effluent not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater may be used in agricultural field.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	NA
7.2	Is there any risk for the person operating the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.3	Is there any risk for people involved in the disposal handling?	There is no such kind of associated risk to operators because proper precautions has been taken
7.4	Is there any risk for people living in the surrounding area of the system?	There is no such kind of associated risk to operators because proper precautions has been taken
7.5	For which purposes is the water used?	Treated wastewater may be used in agricultural field.
7.6	If water is used for irrigation, what plants are irrigated?	Paragrass, Rice and vegetables
7.7	If vegetables are planted, are the eaten raw?	Yes
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	NA
7.11	Are there any wells near the area where the treated water is reused?	NA
7.12	Are there any other possible risks to the environment	NA
7.13	Additional remarks	The treatment performance of polishing pond is good and able to achieve the design parameters.

10 KLD, Sewage Treatment Plant, Auroville, Tamil Naidu (Location ID: India_TN_1_CW)		
1. General Information		
1.1	Location ID	India_TN_1_CW
1.2	Name and address of STP	Auroville Centre for Scientific Research (CSR) Auroshilpam – Auroville 605101
1.3	Contact person	NA
1.4	Phone number	Phone: +91 (0)413 2622174
1.5	Fax number	NA
1.6	E-mail address	Email: csr@auroville.org.in
1.7	Legal status	NA
1.8	Type of wastewater treated	Domestic wastewater from residential complex
1.9	Mode of conveyance	Sewer line
1.1	Commissioning year the STP's	1998
1.11	Treatment technology	Constructed wetland
1.12	Treatment chain / mode of operation	Imhoff tank – constructed wetland – polishing tank
1.13	Type of plant / fish species	Arundo donax
1.14	Downstream reuse of treated wastewater	Treated wastewater used in gardening
2. Financial Details		
2.1	Capital cost of the STP (INR In Lakh)	Not available
2.2	Cost of treatment (O&M Cost / month)	
2.3	Funding agency for wastewater treatment cost	
2.4	Revenue generated per month	
2.5	Agency bearing wastewater collection costs	
3. Design Details		
3.1	Imhoff tank	84 m^3 (total), three units
3.2	Secondary treatment units	Unit 1 (Planted gravel filter) (LxBxD)

		400 m² x 0.75m granite stones, pebbles, sand
		Unit 2 (Polishing pond) (LxBxD) 190 m² x 0.9m
4. Design Performance		
4.1	Design flow (MLD)	10 m³ per day (57 persons)
4.2	Inflow volume at the time of commissioning (MLD)	NA
4.3	Current inflow volume (MLD)	NA
4.4	HRT (Days)	10 hrs
4.5	Design Performance	BOD5 (mg/L): ≤30; COD (mg/L): 250; pH: 5.5-9; TSS: 100; TDS: 2100
5. Actual Performance		
5.1	Raw Sewage (6 samples between September 2000 and August 2001)	BOD5 (mg/L):59-108; COD (mg/L):162 - 320; pH: NA; TP (mg/L): NA; Ammonia (mg/L): NA; Total Kjeldahl N (mg/l): 31-50 TSS (mg/L): NA; VSS:NA, TDS (mg/L): NA; Dissolved Oxygen: ; Total Coliform Count /100ml: NA; E.Coli Count/ 100 ml:$46x10^5$-$24x10^9$
5.2	Treated Sewage (6 samples between September 2000 and August 2001)	BOD5 (mg/L):7-58; COD (mg/L):16 - 160; pH: 6,9 – 7,8; TP (mg/L): NA; Ammonia (mg/L): NA; Total Kjeldahl N (mg/l): 12 - 36 TSS (mg/L): NA; VSS:NA, TDS (mg/L): NA; Dissolved Oxygen: ; Total Coliform Count /100ml: NA; E.Coli Count/ 100 ml:$24x10^2$-$49x10^4$
6. Post Treatment		
6.1	Type of Post Treatment	Only polishing tank
6.2	Water quality before post treatment	NA
6.3	Cost of post treatment/m3	No costs
6.4	If effluent not being reused now, is there any potential for reuse? If yes, for which purpose	Treated wastewater may be used in gardening.
7. Health and Environmental Risks		
7.1	Are there any incidences of source pollution which occurred in the past?	No

7.2	Is there any risk for the person operating the system?	No
7.3	Is there any risk for people involved in the disposal handling?	No
7.4	Is there any risk for people living in the surrounding area of the system?	No
7.5	For which purposes is the water used?	Treated wastewater may be used in gardening.
7.6	If water is used for irrigation, what plants are irrigated?	NA
7.7	If vegetables are planted, are the eaten raw?	NA
7.8	How many people are exposed to the wastewater before treatment and after treatment?	NA
7.9	Are there any wells near the area where the treated water is reused?	no
7.11	Are there any wells near the area where the treated water is reused?	no
7.12	Are there any other possible risks to the environment	no
7.13	Additional remarks	The treatment performance of polishing pond is good and able to achieve the design parameters.
8. Flow Sheet of the STP		
9. Photo Gallery		



Imhoff tank Planted filter (400 m²) Polishing tank (190 m²)

(A) Flow Sheet of STP

(B) Residential complex Near CW

(C) Covered Imhoff tank

(D) Constructed wetland

(E) Polishing tank

Annexure C: **Available post-treatment and reuse of the wastewater effluents from NTSs in India**

S. No.	Types of NTSs	Capacity (MLD)	Year of comm.	Type of Post-treatment	Down streams use of treated effluent	Location
1	WSP	14	2003	No Post-treatment	Godavari River	Ramagundam I, Andhra Pradesh
2	WSP	4	2003	No Post-treatment	Godavari River	Ramagundam II, Andhra Pradesh
3	WSP	4	2003	No Post-treatment	NA	Bhadrachalam, Andhra Pradesh
4	WSP	14	2004	No Post-treatment	Godavari River	Ramagundam IV, Andhra Pradesh
5	WSP	4	1988	No Post-treatment	Punpun, Ganga	Kermallichak, Bihar
6	WSP	2	1988	No Post-treatment	Ganga River	Chapra, Bihar
7	WSP	46	1965	No Post-treatment	Seonath River	Kutelabhata vill, Bhilai Nagar, Chhatisgarh
8	WSP	14	1965	No Post-treatment	NA	Risali village, Bhilai Nagar, Chhatisgarh
9	WSP	9	1965	No Post-treatment	NA	Bhilai House, Bhilai Nagar, Chhatisgarh
10	WSP	27.27	2003	No Post-treatment	Yamuna River	Timarpur, Delhi
11	PP	20	2000	No Post-treatment	Yamuna River	Faridabad I, Haryana
12	PP	45	2000	No Post-treatment	Yamuna River	Faridabad II, Haryana
13	PP	50	2000	No Post-treatment	Yamuna River	Faridabad III, Haryana
14	WSP	8	2000	No Post-treatment	Yamuna River	Karnal II, Haryana
15	WSP	1	2001	No Post-treatment	NA	Chhchhrauli, Haryana

S. No.	Types of NTSs	Capacity (MLD)	Year of comm.	Type of Post-treatment	Down streams use of treated effluent	Location
16	WSP	1.5	2001	No Post-treatment	NA	Indri, Haryana
17	WSP	1	2001	No Post-treatment	NA	Radaur, Haryana
18	WSP	9	2003	No Post-treatment	Agricultural Field	Palwal, Haryana
19	WSP	3	2004	No Post-treatment	NA	Gharaunda, Haryana
20	WSP	3.5	2004	No Post-treatment	NA	Gohana, Haryana
21	WSP	19.45	2001	No Post-treatment	Tungabhadra	Davanagere, Karnataka
22	WSP	5.83	2001	No Post-treatment	Bhadra River	Bhadravati, Karnataka
23	WSP	1.47	2001	No Post-treatment	NA	Nanjagud, Karnataka
24	WSP	1.36	2001	No Post-treatment	NA	Sri Rangapatna , Karnataka
25	WSP	18.16	2003	No Post-treatment	Tunga River	Shimoga, Karnataka
26	WSP	1.45	2004	No Post-treatment	NA	K R Nagar, Karnataka
27	WSP	4.5	2007	No Post-treatment	NA	Pamba, Kerla
28	WSP	8	NA	No Post-treatment	NA	Bherkheda, Bhopal, Madhya Pradesh
29	WSP	52	2001	No Post-treatment	Shipra River	Ujjain, Madhya Pradesh
30	KT	1.67	2001	No Post-treatment	Shipra River	Barogarh, Ujjain, Madhya Predesh
31	KT	1.67	2001	No Post-treatment	Shipra River	Barogarh, Ujjain, Madhya Predesh
32	KT	1.2	2001	No Post-treatment	NA	Chapara, Madhya Pradesh

S. No.	Types of NTSs	Capacity (MLD)	Year of comm.	Type of Post-treatment	Down streams use of treated effluent	Location
33	KT	0.75	2001	No Post-treatment	NA	Keolari, Madhya Pradesh
34	KT	9	2004	No Post-treatment	Betwa River	Vidisha, Madhya Pradesh
35	WSP	6	2005	No Post-treatment	Tapi River	Burhanpur, Madhya Pradesh
36	WSP	2.5	1995	No Post-treatment	Sina, Bhima River	Aurangabad, Maharashtra
37	WSP	5	NA	No Post-treatment	Salim Ali Lake	JNEC, Aurangabad, Maharashtra
38	OP	18.9	1995	No Post-treatment	Gima River	Jalgaon, Maharashtra
39	OP	12.87	Pre 95	No Post-treatment	Manjeera River	Latur , Maharashtra
40	WSP	26/8.9	2000	No Post-treatment	Godavari River	Nanded-Waghala, Maharashtra
41	WSP	1	2003	No Post-treatment	NA	Trimbakeshwar, Maharashtra
42	WSP	23.82	2004	No Post-treatment	Krishna River	Sangli-Miraj and Kupwad, Maharashtra
43	WSP	33	2003	No Post-treatment	Mahanadi River	Cuttak, Orissa
44	WSP	2	2005	No Post-treatment	NA	Talcher, Orissa
45	WSP	2.6	2003	No Post-treatment	NA	Sultanpur Lodhi, Punjab
46	WSP	2.56	2004	No Post-treatment	Satluz river	Phillaur, Punjab
47	PP	25	NA	**Chlorination**	Agricultural Field	Kapoorthala, Punjab
48	PP	22.73	2005	Information Not Available	NA	Raipur Kalan,Chandigarh,
49	DP	0.5	NA	No Post-treatment	Agricultural Field	Bais Village, Ludhiana, Punjab

S. No.	Types of NTSs	Capacity (MLD)	Year of comm.	Type of Post-treatment	Down streams use of treated effluent	Location
50	DP	0.5	NA	No Post-treatment	Agricultural Field	Village Saidpur, Ludhiana, Punjab
51	DP	0.5	NA	No Post-treatment	Agricultural Field	Village Sandhuan, Roop Nagar, Punjab
52	WSP	0.5	NA	No Post-treatment	Agricultural Field	Village Dedwal, Ludhiana, Punjab
53	WSP	0.5	NA	No Post-treatment	Agricultural Field	Village Sandhuan, Roop Nagar, Punjab
54	DP	1	NA	No Post-treatment	Agricultural Field	Village Uncha, Roop Nagar, Punjab
55	WSP	20	2007	No Post-treatment	Agricultural Field	Village Nanded, Jodhpur, Rajasthan
56	WSP	20	2007	No Post-treatment	Agricultural Field	Vallabh Garden Bikaner, Rajasthan
57	PP	111	2004	No Post-treatment	Agricultural Field	Ludhiana, Zone B, Punjab
58	PP	152	2004	Information Not Available	Agricultural Field	Ballok, Ludhiana
59	PP	48	2005	Information Not Available	Agricultural Field	Jmalpur, Ludhiana
60	WSP	28	2003	No Post-treatment	Kaveri	Tiruchirappalli II, Tamil Nadu
61	WSP	3.94	2003	No Post-treatment	NA	Bhawani, Tamil Nadu
62	WSP	58	2004	No Post-treatment	Kaveri	Tiruchirappalli, Tamil Nadu
63	WSP	20	2004	No Post-treatment	Kaveri	Erode I, Tamil Nadu
64	WSP	3.96	1988	No Post-treatment	NA	Farrukhabad, Uttar Pradesh
65	WSP	9	1999	No Post-treatment	Yamuna River	Noida III, Uttar Pradesh

S. No.	Types of NTSs	Capacity (MLD)	Year of comm.	Type of Post-treatment	Down streams use of treated effluent	Location
66	WSP	10	2001	No Post-treatment	Yamuna River	Peela Khar, Agra, Uttar Pradesh
67	PP	14	NA	**Chlorination**	Yamuna River	Dayal Bag, Agra, Utter Pradesh
68	PP	78	NA	No Post-treatment	Agricultural Field	Dhandpur, Agra, Utter Pradesh
69	WSP	2.5	2001	No Post-treatment	Yamuna River	Burhi ka Nagla, Agra, Uttar Pradesh
70	WSP	32	2001	No Post-treatment	Kali River	Muzaffarnagar, Uttar Pradesh
71	PP	70	2001	Information Not Available	NA	Hindone I, Ghaziabad, Uttar Pradesh
72	PP	56	2001	Information Not Available	NA	Hindone II, Ghaziabad, Uttar Pradesh
73	PP	34	NA	Information Not Available	NA	Noida I, Uttar Pradesh
74	PP	27	NA	Information Not Available	NA	Noida II, Uttar Pradesh
75	PP	27.5	NA	No Post-treatment	NA	Mirzapur, Uttar Pradesh
76	WSP	14.5	2001	No Post-treatment	Agricultural Field /Yamuna River	Bangalighat dairy farm, Mahura, Uttar Pradesh
77	WSP	4	NA	No Post-treatment	Agricultural Field	Baba Temple, Vrindavan, Utter Pradesh
78	WSP	12.5	2001	No Post-treatment	Agricultural Field /Yamuna River	Masani, Mathura, Uttar Pradesh

S. No.	Types of NTSs	Capacity (MLD)	Year of comm.	Type of Post-treatment	Down streams use of treated effluent	Location
79	WSP	0.5	NA	No Post-treatment	Agricultural Field	Kali Deh, Vrindavan, Utter Pradesh
80	WSP	10.45	2001	No Post-treatment	Yamuna River	Etawah Uttar Pradesh
81	WSP	10	1987	No Post-treatment	Ganga River	E (Madrail),Bhatpara, West Bengal
82	WSP	30	1987	No Post-treatment	Ganga River	.S.Sub-E, Kolkata, West Bengal
83	WSP	4.54	1987	No Post-treatment	Ganga River	Chandannagar II, West Bengal
84	WSP	8	1987	No Post-treatment	Beel	Baharampur, West Bengal
85	WSP	16.5	1988	No Post-treatment	Irrigation, Pisciculture	Panihati, West Bengal
86	WSP	45	1988	No Post-treatment	Irrigation, Pisciculture	Bally, West Bengal
87	WSP	14.1	1988	No Post-treatment	Irrigation, Pisciculture	Bandipur, West Bengal
88	WSP	4.54	1988	No Post-treatment	Pisciculture	Titagarh, West Bengal
89	WSP	10	1988	No Post-treatment	Ganga River	Nabadwip, West Bengal
90	WSP	3	2003	No Post-treatment	Ganga River	Khardaha, West Bengal
91	WSP	3.93	2003	No Post-treatment	Ganga River	Maheshtala, West Bengal
92	WSP	5.9	2003	No Post-treatment	Ganga River	Barrackpur, West Bengal
93	WSP	1	2003	No Post-treatment	Ganga River	Barrackpur, West Bengal

S. No.	Types of NTSs	Capacity (MLD)	Year of comm.	Type of Post-treatment	Down streams use of treated effluent	Location
94	WSP	10.9	2003	No Post-treatment	Ganga River	Barrackpur, West Bengal
95	WSP	4.35	2003	No Post-treatment	Ganga River	Barrackpur, West Bengal
96	WSP	1.9	2005	No Post-treatment	NA	Murshidabad, West Bengal
97	WSP	0.52	2005	No Post-treatment	NA	Diamond Harbour, West Bengal
98	WSP	1.39	2006	No Post-treatment	NA	Jiagani Ajimganj, West Bengal
99	CWs	21.25m×5.5m	NA	No Post-treatment	NA	Kakatiya Musical Garden of Warangal City, Andhra Pradesh
100	CWs	NA	NA	No Post-treatment	NA	Mahindra Mahindra, Igatpuri, Nashik.
101	CWs	NA	NA	No Post-treatment	NA	Presidency Kid Leather Ltd. Kannivakkam Tamil Nadu
102	CWs	NA	NA	No Post-treatment	NA	Guru govind singh Park (Ekant Park)Southern area Bhopal
103	CWs	1	NA	No Post-treatment	NA	Kankhal, Haridwar, UttaraKhand
104	CWs	NA	NA	No Post-treatment	NA	Sainik School Bhuneshwar, Orissa
105	CWs	0.5	NA	No Post-treatment	NA	village Pipal Majra, District Ropar, Pumjab

S. No.	Types of NTSs	Capacity (MLD)	Year of comm.	Type of Post-treatment	Down streams use of treated effluent	Location
106	CWs	2.5 acres	NA	No Post-treatment	NA	village Shekhupur in District Patiala, Punjab
107	CW	7.8	2008	No Post-treatment	Mansagar Lake (Recreational)	Mansagar Lake, Jaipur, Rajasthan
108	CW	NA	NA	No Post-treatment	NA	Ujjain