AUROVILLE RESIDENTIAL ZONE
SECTORS 1&2

# Implementation of Vortex Dewats & Sludge management concept

# Concept Note

January 2014

Auroville Centre for Scientific Research (CSR)

Auroville Centre for Scientific Research (CSR)
Auroshilpam, Auroville 605101 TN, India
00 91 413 2622168 / 277 /748
avcsrdewats@auroville.org.in

# AUROVILLE
# RESIDENTIAL ZONE - SECTORS 1&2

## Concept Note

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**Auroville Centre for Scientific Research (CSR)**

**28 January 2014**

## 1 PREFACE

L'Avenir requested a study in June 2012 on a concept for wastewater management for the Residential Zone, sectors 1&2. Based on this study, a brief, dated 16 December 2013, was received by CSR, entitled "Request to provide the design and operational details of a waste water treatment plant for the Residential Zone 1 and 2". Considering the absence of information on final site conditions the present document is developed as a concept note. A detailed technical study (including dimensioning drawings) can be done only once the site conditions are defined and the concept approved.

CSR's proposed technology is Vortex-Dewats, not "baffle reactor" as mentioned in the brief. This technology is endorsed by Central Pollution Control Board and promoted by the Ministry of Urban Development (MOUD).

The proposal includes a sludge management concept.

Auroville requires sewage treatment systems for processing the produced sewage and allowing safe and adequate recycling.

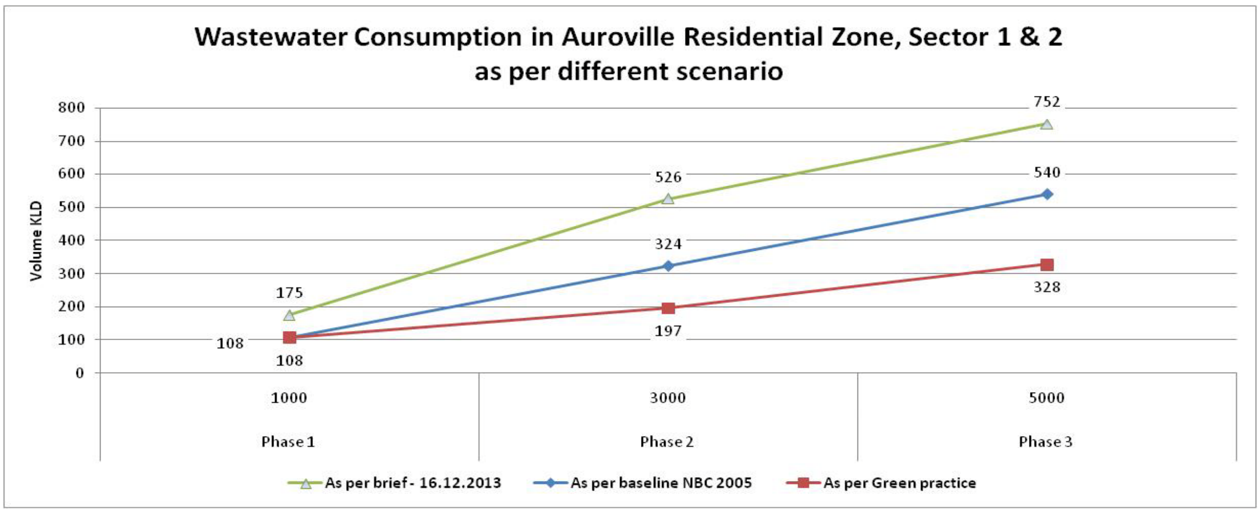
The sectors 1 & 2 are planned for a population of **5000 people** with related housing and other public facilities.

Considering that Auroville's area is classified as water scarce, and that water accessibility will be become more and more challenging and costly, it is necessary to promote the implementation of sustainable and green practices in the context of Auroville.

The present note analyses the basic parameters as proposed in the brief, in comparison to National Building Code values and as per green practice code. Accordingly the adapted design parameters will be defined, in order to evolve as a role model for future town developments.

In the water sector, this approach culminates in major savings regarding water consumption, both for the general domestic use and for the common facilities. In turn, this leads to a major reduction of wastewater generation: the final total wastewater flow as per l'Avenir's brief is **750KLD**, a per NBC statutory norms it should be **540KLD**, while consumption after implementing proper water saving practices and low flow features and devices reduces this volume to **288KLD** only, which is 44% of the initial flow as per l'Avenir brief.

We would like to underline these essential facts and integrate the revised standards within the design features of the concept note to achieve a cost effective and sustainable waste water treatment proposal.




CSR is aware that it is stepping out of the defined parameters of the brief, having experience in the area of integrated water management and especially wastewater management together with the concern for promoting sustainable practices, we believe that this is the way to move forward for implementing water and waste water projects.

Apart from the basics parameters of the brief, some comments are offered on the appropriateness of the choices made in terms of parameters and scope for recycling.

This note does not discuss the appropriateness of a centralized approach in regard to draining and processing the sewage, nor the eventual usage of renewable energy, which can be explored separately.

It is however necessary to point out that the integration of the existing waste water treatment plants, is not defined or proposed as a possibility. Considering that the existing STPs achieve various levels of treatment, that the processed wastewater is most of the time already reused on site, that they altogether represent important assets, and that the investment to re-connect the settlements to a new facility would be considerable.

The existing waste water treatment systems serve an actual population of 520 people (~10% of final population), and should reach 920 with the actual sanctioned projects (~18.4% of final population).

A plan to improve and to upgrade the existing STPs to a desirable standard is therefore advisable.

Our recommendation is to look afresh at the required capacity for the proposed STP. While the maximum capacity for the STP is planned for 5000 people, the above observations lead to estimate that only 4000 people will be connected. The corresponding reduction of the sewage flow is 18% and the related required drainage, treatment and recycling capacity do represent important financial implications.

## 1.1 Observations in regard to Volume parameters

The reason why the water consumption in Auroville is higher today than NBC standards has been discussed extensively in other studies. A major part of it is due to an inadequate distribution network, while this is changing due to the effort done to improve the piping system. Part is due to low quality features, and usage of freshwater for irrigation purpose. We do not consider necessary to develop further on this point, for new development would anyhow require a proper piping network, up to the end user.

We should try to achieve the National Building Code standards in the immediate future, overcoming the challenges, while best green practices should be proactively promoted through building codes, rating of water and guidance to the architects, planners and developers.

Today in India there are several projects integrating successfully such practices, demonstrating they are realistic, achievable and cost effective.

CSR considers it imperative to promote this direction.

Overview of fresh water consumption as per various guidelines and population.

The value for Green Practice in phase I is maintained as per NBC in order to ensure a smooth transition towards further reducing the consumption of water and moving towards a sustainable resource water usage.

| Freshwater consumption | | As per brief - 16.12.2013 (1) | | As per baseline NBC 2005 | | As per Green practice | |
|---|---|---|---|---|---|---|---|
| Building Phase | Total | Quantity per Person | Total Quantity | Quantity per Person | Total Quantity | Quantity per Person | Total Quantity |
| | PE | lcd | KLD | lcd | KDL | lcd | KDL |
| Phase 1 | 1000 | 219 | 219 | 135 | 135 | 135 | 135 |
| Phase 2 | 3000 | 219 | 657 | 135 | 405 | 82 | 246 |
| Phase 3 | 5000 | 188 | 940 | 135 | 675 | 82 | 410 |
| Note: (1) this value is derived from the brief's value of 175lcd of generated wastewater. As per common practices, wastewater generation is accounted for 80% of fresh water consumption. Hence, fresh water consumption is 219lcd initially and 188lcd at phase 3, as per the brief. | | | | | | | |

Auroville Centre for Scientific Research (CSR)
Auroshilpam, Auroville 605101 TN, India
00 91 413 2622168 / 277 /748
avcsrdewats@auroville.org.in

It must be noted that the figures mentioned in "as per Green practice" column are currently used in new national residential complexes, the reduced water consumption figures are based on readily available market products like dual flush toilets, low flushing toilets, faucets aerators and proper piping system. It is not based on sophisticated or costly devices, it is realistic to achieve and cost effective.

Out of this freshwater consumption, part turns into wastewater.

The common figure for wastewater generation retained all over India is 80% of freshwater consumption for domestic-like usage. Considering that this is a well established and verified value, we take this as valid standard.

It is necessary that the proposed waste water treatment system takes into account:

- The evaluated flow
- The NBC flow norms
- The reevaluated flow and pollution load reaching the STP, after applying the saving practices and devices.

The extra load due to rain infiltration into the sewer lines (conditioned by the number of connection chambers) is not part of the present value, the sewer network being unknown at this stage.

The below table for wastewater generation is derived from the previous one.

| **Waste Water Quantity** | | **As per brief - 16.12.2013** | | **As per baseline NBC 2005** | | **As per Green practice** | |
|---|---|---|---|---|---|---|---|
| **Building Phase** | **Total** | **Quantity per Person** | **Total Quantity** | **Quantity per Person** | **Total Quantity** | **Quantity per Person** | **Total Quantity** |
| | PE | lcd | KLD | lcd | KDL | lcd | KDL |
| Phase 1 | 1000 | 175 | 175 | 108 | 108 | 108 | 108 |
| Phase 2 | 3000 | 175 | 526 | 108 | 324 | 66 | 197 |
| Phase 3 | 5000 | 150 | 752 | 108 | 540 | 66 | 328 |

Considering all the previously mentioned elements, the design parameters for the treatment system are:

1. The pre-treatment (settlers) and balancing systems, designed to fulfill NBC norms with the sewer line rain infiltration flow.
2. The main treatment devices designed as per Green practice values. Note that for phase I the wastewater production per capita as per Green Practice is maintained at 108lcd (NBC values) in order to ensure a smooth learning transition. The system will ensure appropriate storage capacity for irrigation practices.
3. The system will ensure appropriate storage capacity for toilet flushing.

## 1.2 Observations in regard to Quality parameters

Green practices in regard to water are based on implementation of water saving practices, efficient water saving devices and recycling of wastewater. Today's requirement in many Indian states is to treat wastewater at a level sufficient to allow for recycling for irrigation AND for toilet flushing. CSR consider that such level of treatment should be promoted.

In this regard it is worthwhile stating the norms that the Ministry of Urban Development (MOUD) is promoting. We do not see why Auroville should deviate from the National standards.

As per Manual of sewerage and sewage treatment system, Ministry of Urban Development, November 2013, the recommended norms of treated sewage quality for specified activities at point of use are as follow:

| | Parameter | Toilet flushing | Fire protection | Vehicle Exterior washing | Non-contact impoundments | Landscaping, Horticulture & Agriculture | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Horticulture, Golf course | crops | | |
| | | | | | | | Non edible crops | Crops which are eaten | |
| | | | | | | | | raw | cooked |
| 1 | Turbidity (NTU) | <2 | <2 | <2 | <2 | < 2 | AA | < 2 | AA |
| 2 | SS | nil | nil | nil | nil | nil | 30 | nil | 30 |
| 3 | TDS | 2100 | | | | | | | |
| 4 | pH | 6.5 to 8.3 | | | | | | | |
| 5 | Temperature °C | Ambient | | | | | | | |
| 6 | Oil & Grease | 10 | nil | nil | nil | 10 | 10 | nil | Nil |
| 7 | Minimum Residual Chlorine | 1 | 1 | 1 | 0.5 | 1 | nil | nil | nil |
| 8 | Total Kjeldahl Nitrogen as N | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 9 | BOD | 10 | 10 | 10 | 10 | 10 | 20 | 10 | 20 |
| 10 | COD | AA | AA | AA | AA | AA | 30 | AA | 30 |
| 11 | Dissolved Phosphorous as P | 1 | 1 | 1 | 1 | 2 | 5 | 2 | 5 |
| 12 | Nitrate Nitrogen as N | 10 | 10 | 10 | 5 | 10 | 10 | 10 | 10 |
| 13 | Faecal Coliform in 100 ml | Nil | Nil | Nil | Nil | Nil | 230 | Nil | 230 |
| 14 | Helminthic Eggs / litre | AA | AA | AA | AA | AA | <1 | <1 | <1 |
| 15 | Colour | Colourless | Colourless | Colourless | Colourless | Colourless | AA | Colourless | Colourless |
| 16 | Odour | Aseptic which means not septic and no foul odour | | | | | | | |

NOTE: All units in mg/l unless specified; AA-as arising when other parameters are satisfied; A tolerance of plus 5% is allowable when yearly average values are considered.

We like to point out that the discharge parameters defined in the brief do not fulfill the norms either for irrigation, or toilet flushing.

Urban agriculture is likely to be practiced in in Auroville. Therefore, the processed wastewater quality must fulfill appropriate hygiene criteria, which basically turns both requirement for irrigation and toilet flushing into one single set of criteria.

Auroville Centre for Scientific Research (CSR)
Auroshilpam, Auroville 605101 TN, India
00 91 413 2622168 / 277 /748
avcsrdewats@auroville.org.in

CSR therefore reframed the discharge parameters in respect to national discharge standards.

| Parameters | Unit | Inlet parameters | Outlet parameters as per brief | Outlet parameters required |
|---|---|---|---|---|
| pH | - | 6.5-8.5 | | 6.5-8.5 |
| BOD 3 | mg/l | 250-300 | < 25 | < or = 10 |
| COD | mg/l | 400-500 | < 125 | < or = 100 |
| Suspended Solids | mg/l | 200-250 | | |
| Oil & Grease | mg/l | 10_15 | | **< or = 5** |
| TSS | mg/l | | < 35.0 | < or = 10 |
| Turbidity | NTU | | < 2 | < 2 |
| Color | | | | Colorless |
| Odor | | | | Unobjectionable |
| E. coli | count/100 ml | | < 103 | None |
| Helminth eggs | per liter | | < 1 | None |

The parameters as per brief will be retained for irrigation practices while the other one will be used for toilet flushing parameters.

The objective is to treat the effluent according the following design criteria:

1. Discharge quality of sewage meets all national standard criteria
2. Processed effluent shall be odorless, color and turbidity are unobjectionable
3. Safe recycling of processed effluent for decorative water bodies.
4. Safe recycling of processed effluent for irrigation of the green spaces wherever required.
5. Safe and hygienic recycling of processed effluent for toilet flushing
6. Integration of final stage treatment devices (second set of vortex system) as landscape elements
7. If necessary, safe discharge of excess water in water bodies or nearby water ways.

# 2 TECHNOLOGY INTRODUCTION – VORTEX-DEWATS

Natural Decentralized Waste Water Treatment Systems with integrated vortex system (Vortex-DEWATS) are based on several natural physical treatment techniques, put together in different combinations according to the needs, the physical constraints, the natural site conditions, the discharge regulations and the involved investment. The different devices cover primary, secondary and tertiary treatment stages.
The treatment applications are based on the principle of minimal maintenance. The critical parts of the treatment system work continuously and uninterrupted with low energy inputs. The technology provides treatment for domestic and industrial (non-toxic) sources and is able to treat effluent flows from 1 up to 1000 $m^3$ per day.

Operating on biological principles and employing non mechanical devices, the technology is tolerant towards inflow fluctuation and does not require complex maintenance practices. The life time of the main civil constructed components is estimated at 30 years. Due to these characteristics, it can be adapted to a large range of site conditions and provide cost effective solutions comparing favorable with conventional solutions.

The technology produces safe and odorless discharge of effluent, reaching all required effluent parameters. Furthermore, landscape integration introducing flowing water in small water bodies, waterfalls, vortex systems can add esthetical value.

**Executing a Vortex-DEWATS system will require to follow precise standards in the execution of the construction work, especially for the hydraulic components: levels require extra care and attention, while the overall civil structure requires proper execution and finishing to ensure a life time functioning.**

# 3 BIOLOGICAL PRINCIPLES OF EFFLUENT TREATMENT

Natural effluent treatment processes are achieved through methods that make use of physical principles combined with biological activities of microorganisms. Microbial colonies in the treatment devices are generated from microbial populations that occur naturally in the wastewater. The technology is based on the integration and optimization of these natural processes. Nature is effectively using and decomposing organic matter through specialized microorganisms who live in the waste substances. These microorganisms digest the substances present in waste water. The conversion process turns these harmful products into stable, safe end-products. Colonies of microorganism will actively digest the available waste which is present in the sewage or effluent flow through processes involving aerobic or anaerobic conditions. By creating and combining these alternate conditions of oxygen poor and oxygen rich environment, the waste water flow progresses towards clear, odorless, colorless, harmless treated water.

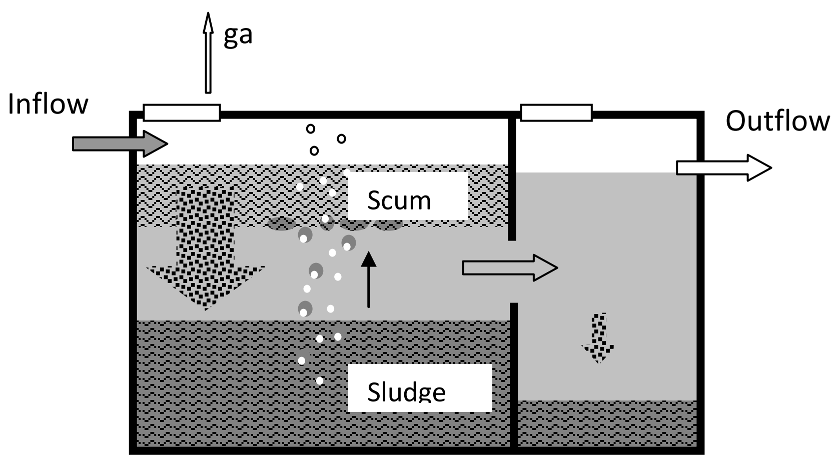
By taking advantage of the powerful purification effects of microorganisms and by designing the various stages of treatment to further enhance this potential, incorporating site conditions, climatic parameters, minimum power requirements, low maintenance practices, no chemical inputs, the designed waste water treatment system accomplishes the highest sustainable requirements.

# 4 DEWATS PRINCIPLES AND DEVICES

## 4.1 Pre-treatment cycle: the settler

A pre-treatment device is used for the sedimentation process to take place, in which the liquid part is separated from the solid matter. A device called **a settler** is used for this phase. If needed, a screening device, for preventing unwanted large materials to enter the system can also be installed. It is useful to install near the kitchen outlet a grease trap, a device designed to intercept most greases and solids before they enter the wastewater disposal system. A grease trap needs very regular cleaning and a special place for the disposal of the removed scum layer.

The settler is an underground constructed tank with **one partition wall**. Within the settler two main treatment processes take place, first a sedimentation and second a stabilization and digestion of the settled sludge through biological treatment. Storage volume is provided for 12 upto 36 months, this parameter defines the necessary desludging period.




Typical Section of a Settler

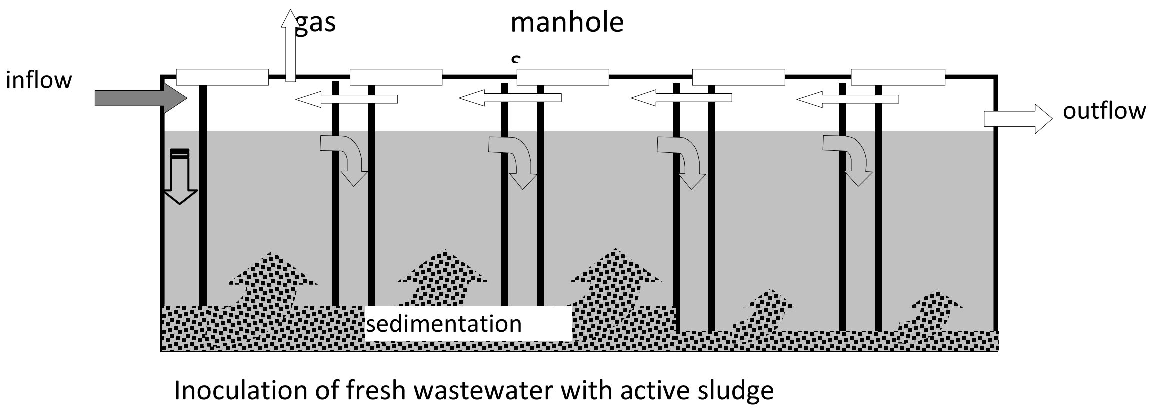
**Desludging** is the process of emptying the sludge at regular intervals from the first and second chamber, which is an absolute necessity. Sludge is very rich with useful bacteria. While desludging it is necessary to ensure that a portion is left in the bottom of the settler, this in order to provide fresh inoculation material for restarting the process after the regular - 1 year interval - cleaning period.

The settler can be a separate device or can also be incorporated with the main treatment componants.

## 4.2 First treatment cycle: the anaerobic baffled tank

In the first treatment phase, biological and natural chemical processes are used to digest and remove most of the organic matter.

A device called an anaerobic **baffled tank** is used for this phase. Several tanks are constructed in series to digest degradable substances. Baffle walls or down-flow PVC pipes direct the waste water stream between the chambers from top to bottom and up again. During this process the fresh influent is mixed and inoculated for digestion with the active blanket deposit of suspended particles (floating bacteria media) and microorganisms occurring naturally at the bottom of each chamber. Because of the physical separation (multiple chambers), various microorganisms are present at different stages, allowing a high treatment efficiency.




Typical section of an Anaerobic Baffled Tank

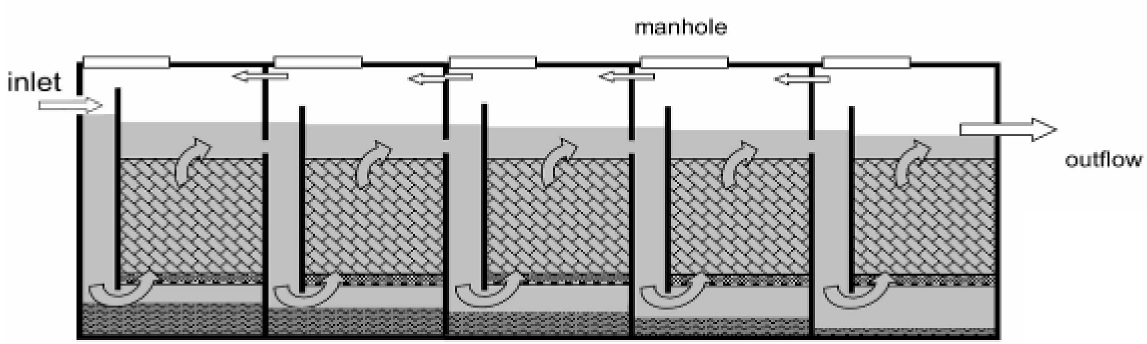
**Desludging** will also be required at regular interval for this component as it will naturally accumulate in the chambers of the baffled reactor. Sludge is the media in which helpful bacteria develop and where the treatment occurs in the baffled reactor. During desludging it is necessary to keep a 30cm portion in the bottom of the settler, in order to provide fresh inoculation material for restarting the process after the regular - 1 year interval - cleaning process.

Auroville Centre for Scientific Research (CSR)
Auroshilpam, Auroville 605101 TN, India
00 91 413 2622168 / 277 /748
avcsrdewats@auroville.org.in

### 4.3 Second treatment cycle: the anaerobic filter

After passing through the multiple chambers of the baffled tank reactor the sewage is virually free of easily settling solids, hence very little sludge can accumulate at the bottom of the chambers and no proper further treatment can occur in this context. At this stage, extra chambers are designed as an **anaerobic filter** in order to improve further the treatment efficiency. A filter media that allows widespread contact with the effluent stream is used which is also efficient in retaining and digesting the left over pollutants. The problem of encountering clogging is minimized due to the digestion and treatment that occurred already in the baffled tank treatment. The process works with fixed bacteria media. Self cleaning mechanism is eased by providing free space below the filtering media, where sludge can accumulate and be removed easily.

The effluent passing out of the anaerobic filters will have at least a 90% of the original pollution load removal.




Typical section of an Anaerobic filter

**Desludging,** while less in comparison to settler and baffled reactor, will be required at regular intervals . It is necessary to desludge every year.

The pre-treatment (settler), first treatment (baffled tank) and second treatment (anaerobic filter) can be constructed underground and integrated into various building spaces. The different treatment phases can be constructed together, or as separate modules.

The required discharge standards are met at this stage and the wastewater can be, if required, safely reused for infiltration into the soil and recharge the ground water table.

The system works by gravity and does not require any mechanical part as far as the treatment process is concerned. More compact designs can integrate the necessity to equilibrate the flow fluctuation and/or spread it over a longer period. In such cases, a balancing tank equipped with a pump may be required for achieving the necessary flow.

Auroville Centre for Scientific Research (CSR)
Auroshilpam, Auroville 605101 TN, India
00 91 413 2622168 / 277 /748
avcsrdewats@auroville.org.in

## 4.4 Third treatment cycle

### 4.4.1 Third treatment cycle: the vortex system

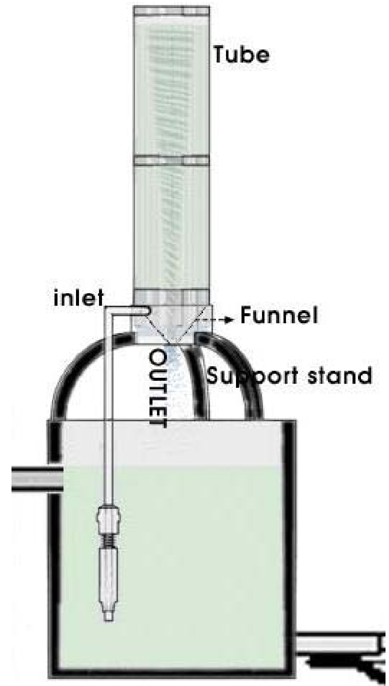
A slow speed vortex system is a device for advanced treatment with excellent results. The new device replaces completely the previously used and space demanding planted filter. The vortex system has the advantage of having a tiny implementation footprint but necessitates an electrical supply.

Odour with this innovative device is completely controlled while BOD and COD are further reduced since the effluent receives extra continuous oxygen through the vortex movement.

Vortex systems include a sump used to guarantee enough looping of the water through the vortex, which in turn ensures that the water reach full oxygen saturated with maximum oxygen supply.

The sump can be equipped with a specially designed aerobic filtering media system, which in turn will ensure efficient turbidity and color control, reaching the required discharge levels.

At this stage, 95% of the original pollution load removal is achieved.




Typical section of vortex

This efficient device offers plenty of scope for beautification and can easily be part of the onsite landscape design.

## 4.5 Post-treatment cycle: the polishing tank (open water body)

**This is an optional treatment**

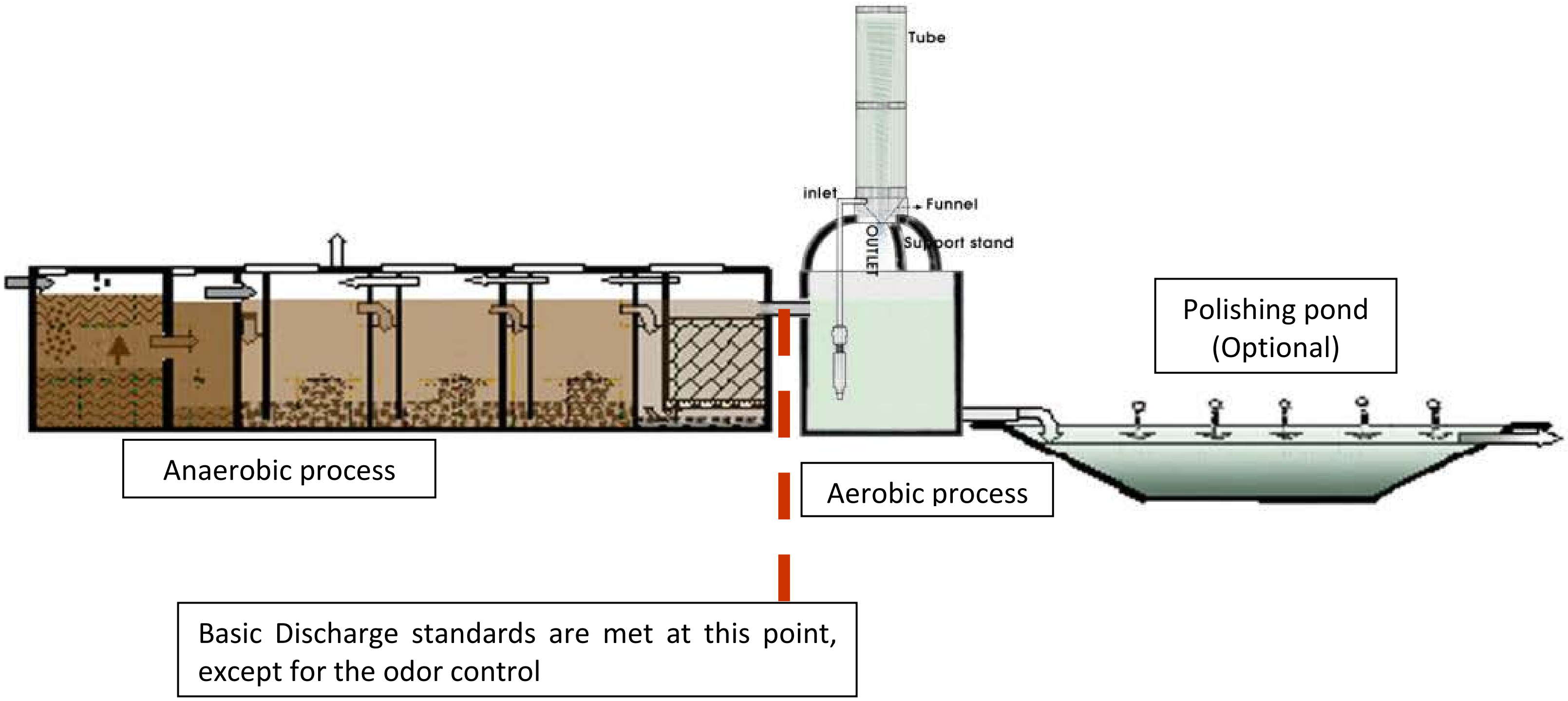
While the entire treatment is ensured at this stage, it is possible to collect the processed water in a polishing pond. Further than offering storage for further recycling, it can also be part of the beautification of the site, changing the otherwise functional oriented STP into an aesthetic element.

At this stage the recycled wastewater is extremely valuable for irrigation; the water is high in nutrient contents and beneficial for plant growth.

The above described devices concern the main treatment components of the system. Secondary elements play a role in operating such system but not in the process as such. They are described further

Auroville Centre for Scientific Research (CSR)
Auroshilpam, Auroville 605101 TN, India
00 91 413 2622168 / 277 /748
avcsrdewats@auroville.org.in

Schematic overview of a typical Vortex DEWATS (decentralized waste water treatment system):



Auroville Centre for Scientific Research (CSR)
Auroshilpam, Auroville 605101 TN, India
00 91 413 2622168 / 277 /748
avcsrdewats@auroville.org.in

# 5 PROPOSED DESIGN PARAMETERS

## 5.1 Basic characteristics of sewage

As per received data, the site sewage has the following characteristics:

| Parameters | Unit | Inlet parameters | Outlet parameters for irrigation | Outlet parameters for toilet flushing |
|---|---|---|---|---|
| pH | - | 6.5-8.5 | | 6.5-8.5 |
| BOD 3 | mg/l | 250-300 | < 25 | < or = 10 |
| COD | mg/l | 400-500 | < 125 | < or = 100 |
| Suspended Solids | mg/l | 200-250 | | |
| Oil & Grease | mg/l | 10-15. | | **< or = 5** |
| TSS | mg/l | | < 35.0 | < or = 10 |
| Turbidity | NTU | | < 2 | < 2 |
| Color | | | | Colorless |
| Odor | | | | Unobjectionable |
| E. coli | count/100 ml | | < 103 | None |
| Helminth eggs | per liter | | < 1 | None |

In addition parameters like nitrates affecting the quality of treated water to be recycled will be controlled.

Efficiency of the treatment is guaranteed under given climatic and population variations.

The treated wastewater is safe for toilet flushing, gardening, usage in decorative water bodies and landscaping elements and for discharge in open drains or channels. The processed water will be odorless, color transparent and safe for human handling (hygienic).

## 5.2 Optimization

The sizing of the Vortex-DEWATS is determined, amongst other parameters, by the hourly peak flow. In order to reduce the size of the installation and consequently the investment it is advisable to balance and distribute the sewage flow after the settler over a larger number of hours than occurring through natural flow. For that reason a balancing tank and related measurement and distribution devices are part of the design of the STP.

It must be noted that the Vortex capacity can be adjusted to a rather large extend. Therefore, there is no need to change the vortex while the system will evolve, but simply to adapt them. The pumps will need to be changed to fit with the flow requirement.

Auroville Centre for Scientific Research (CSR)
Auroshilpam, Auroville 605101 TN, India
00 91 413 2622168 / 277 /748
avcsrdewats@auroville.org.in

## 5.3 Design parameters

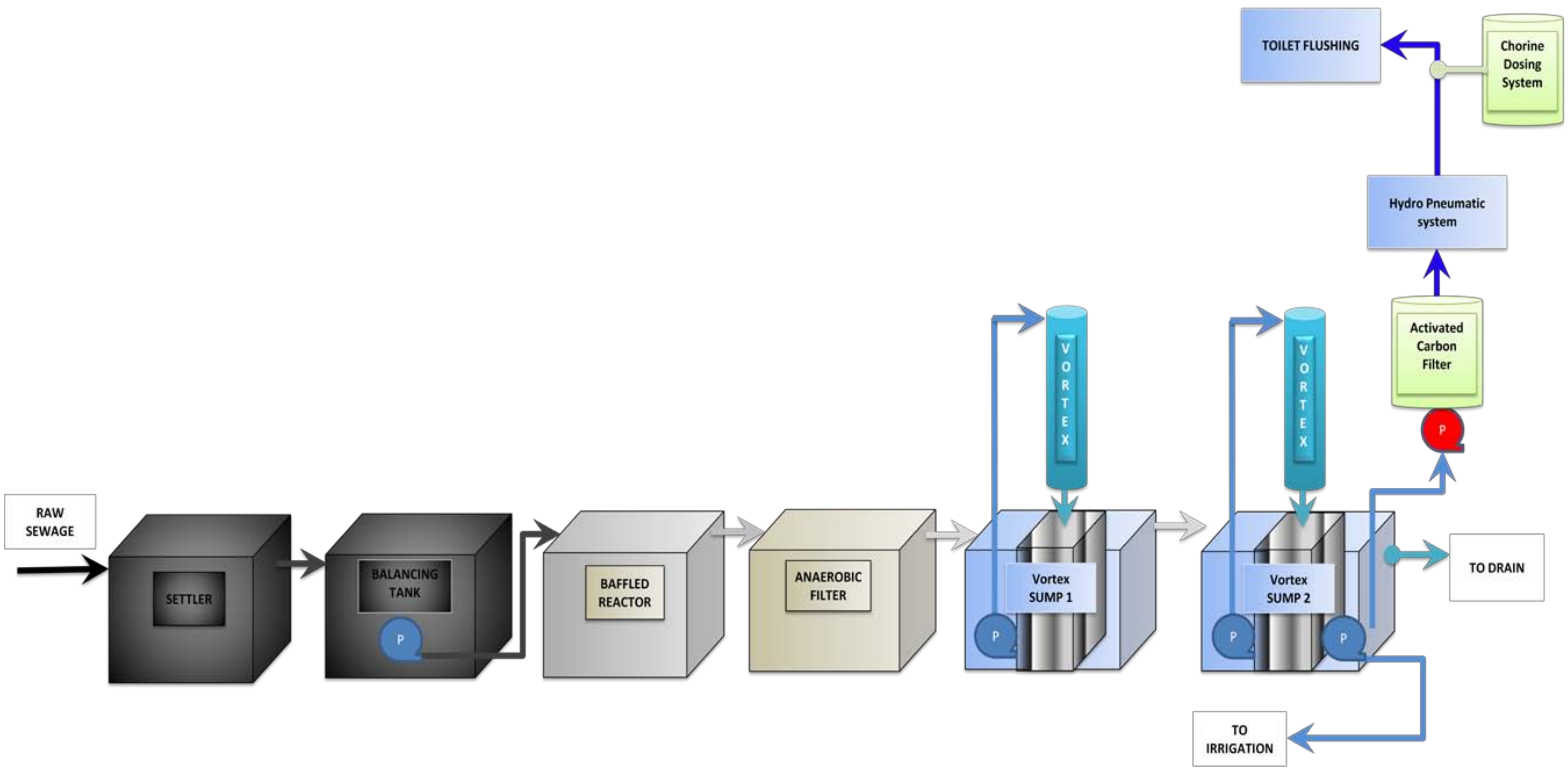
Below is a synthesis of all required design parameters.

NOTE: In order to fulfil the requirement of CPCB, one need to justify that the capacity of the STP at inlet point is sufficient to address NBC standards, while there is no further concern for the capacity in the following stages. Consequently, the design parameters take into account NBC volume standards during the 1stage, while in the second stage treatment the actual sewage flow is used.

| Sr. No. | Parameters | Values for Vortex Dewats | |
|---|---|---|---|
| **1** | **Implemented Technology** | **Vortex-Dewats** | |
| **2** | Peak factor | 1,7 | |
| **3** | Operating Period | 12h/d | |
| **4** | Minimum sewage flow required | 1/10 of reference flow | |
| **5** | Volume to be processed | 1st stage as per NBC | 2nd stage as per real flow |
| | Phase 1 | 108 | 108 |
| | Phase 2 | 324 | 197 |
| | Phase 3 | 540 | 328 |
| **6** | Inlet parameters | | |
| a | PH | 6.5-8.5 | |
| b | BOD 3 | 250-300 mg/lit. | |
| c | COD | 400-500 mg/lit. | |
| d | Suspended Solids | 200-250 mg/lit. | |
| e | Oil & Grease | 10-15 mg/lit. | |
| **7** | Output parameters | | |
| a | pH | 6.5-8.5 | |
| b | BOD 3 | <or =10 mg/lit. | |
| c | COD | <or =100 mg/lit. | |
| d | Suspended Solids | <or =10 mg/lit. | |
| e | Oil & Grease | <or =5 mg/lit. | |
| f | TSS | < or = 10 mg/l | |
| g | Turbidity | < 2 NTU | |
| h | Color | Colorless | |
| i | Odor | Unobjectionable | |
| j | E. coli | None | |
| k | Helminth eggs | None | |
| **8** | Level of Automation | Automatic | |

Auroville Centre for Scientific Research (CSR)
Auroshilpam, Auroville 605101 TN, India
00 91 413 2622168 / 277 /748
avcsrdewats@auroville.org.in

## 5.4 Simplified Flow Diagram




**Note:** the present flow diagram is indicative only. Considering that standards requirement are similar, the recycling line for irrigation and for toilet flushing could be combined. The final choice is to be made in accordance site specifications and chosen standards.

## 5.5 Proposed sequence of devices

The sequence of devices will be the same for the 3 phases. The flow is mentioned for each phase.

The system is design based on the premises that most of the effluent flow will be generated 10 hours per day. Furthermore, the system can absorb the expected flow variations, including a peak flow factor of 1.7 from average. The proposed design system is sturdy and flexible, allowing predictable changes from the submitted basic flow data and has a long-lasting life cycle.

| Ref | Component | Description | Sewage Flow to process As per phases |
|---|---|---|---|
| 1 | Bar screen chamber | **Bar screen chamber**, accessible underground structure, to screen out large unwanted solids to enter and eventually chock the STP. The grit chamber is equipped with a bar screen and is manually cleaned once a day. Concerning the cost and energy demand, an automatic cleaning mechanism is not proposed. | 108 KLD peak flow 18.4m3/h<br>324 KLD peak flow 45.4m3/h<br>540 KLD peak flow 91.8m3/h<br>Operating time approx 10h/d |
| 2 | Inlet box | **Inlet box,** underground structure, serving as an entry point to the STP, where all wastewater generated from the site is collected. The inlet box is equipped with a manhole and the main vent lines for the entire system. | 108 KLD peak flow 18.4m3/h<br>324 KLD peak flow 45.4m3/h<br>540 KLD peak flow 91.8m3/h<br>Operating time approx 10h/d |
| 3 | Settler | **Settler,** underground structure, divided into two chambers. Equipped with inlet box, air tight manholes, appropriate openings, vent lines and piping. Handling part of the flow as per sewer layout. Connected by gravity to the main treatment devices through a separate sewage line up to the inlet box. Flow and location as per site layout and sewer system design. | 108 KLD peak flow 18.4m3/h<br>324 KLD peak flow 45.4m3/h<br>540 KLD peak flow 91.8m3/h<br>Operating time approx 10h/d |
| 4 | Balancing tank | **Balancing tank**, underground structure, equipped with level control, 2 submersible pumps running on alternate days, flow regulating valves, related piping and an overflow structure (for emergency), vent lines. | 108 KLD peak flow 18.4m3/h<br>324 KLD peak flow 45.4m3/h<br>540 KLD peak flow 91.8m3/h<br>Operating time approx 10h/d |
| 5 | V-notch Box | **V-notch bo**x, on top of Balancing tank, composed of a decompression chamber and a measurement channel equipped with a V-notch plate for flow measurement purpose, in order to ensure that the flow reaching the next treatment devices is adequate. Equipped with a removable cover | 108 KLD hourly flow 5.4m3/h<br>197 KLD hourly flow 9.9m3/h<br>328 KLD hourly flow 16.4m3/h<br>Operation time 20h/d |

| | | | |
|---|---|---|---|
| **6** | Repartition box | **Repartition box**, on top of Balancing tank, allowing proper flow distribution to the parallel lines of the subsequent devices. The repartition boxes are equipped with a V-saw plate, a distribution channel and **3** compartments. The connection will be done as per phase extension. Equipped with airtight manholes. | 108 KLD hourly flow 5.4m3/h<br>197 KLD hourly flow 9.9m3/h<br>328 KLD hourly flow 16.4m3/h<br>Operation time 20h/d |
| **7** | Distribution channel | **Distribution channel**, underground structure, ensuring that every line gets an optimal flow distribution from the entry point.<br>Equipped with air tight manholes, proper piping and vent lines | 108 KLD hourly flow 5.4m3/h<br>197 KLD hourly flow 9.9m3/h<br>328 KLD hourly flow 16.4m3/h<br>Operation time 20h/d |
| **8** | Baffled Reactor | **Baffled Reactor,** underground structure, made of 3 parallel lines with **5** chambers each.<br>All lines work with an equalized sewage flow.<br>Equipped with air tight manholes, proper piping and vent lines | 108 KLD hourly flow 5.4m3/h<br>197 KLD hourly flow 9.9m3/h<br>328 KLD hourly flow 16.4m3/h<br>Operation time 20h/d |
| **9** | Anaerobic filter | **Anaerobic Filter,** underground structure, consisting of 3 parallel lines with **4** chambers each.<br>The chambers are with perforated slabs and filled with a filtering media (cinder)<br>All lines work with equalized flow.<br>Equipped with air tight manholes, distribution pipes, desludging devices and vent lines | 108 KLD hourly flow 5.4m3/h<br>197 KLD hourly flow 9.9m3/h<br>328 KLD hourly flow 16.4m3/h<br>Operation time 20h/d |
| **10** | Collection channel | **Collection channel**, underground structure, collecting by gravity the 3 parallel lines to the next device.<br>Equipped with air tight manholes, a sampling opening for monitoring purpose and vent lines. | As per requirement |
| **10** | First vortex sump | **First vortex sump**, underground structure, allowing for vortex treatment.<br>The sump includes a partition wall, perforated slab and filtering media (cinder).<br>Equipped with level control and overflow structure for emergency, air tight manholes, 2 submersible pumps running on alternate days for Vortex system feeding,<br>Equipped with flexible pipes and floating devices for feeding to the irrigation system, vent lines provided. | 108 KLD hourly flow 5.4m3/h<br>197 KLD hourly flow 9.9m3/h<br>328 KLD hourly flow 16.4m3/h<br>Operation time 20h/d |
| **11** | First vortex system | **First vortex systems**, equipped with proper regulation system.<br>Made of stand, funnel, inlet pipe of appropriate dimension, flow control system and appropriate piping. The vortex system is equipped with a timer in order to run the | 108 KLD<br>197 KLD<br>328 KLD |

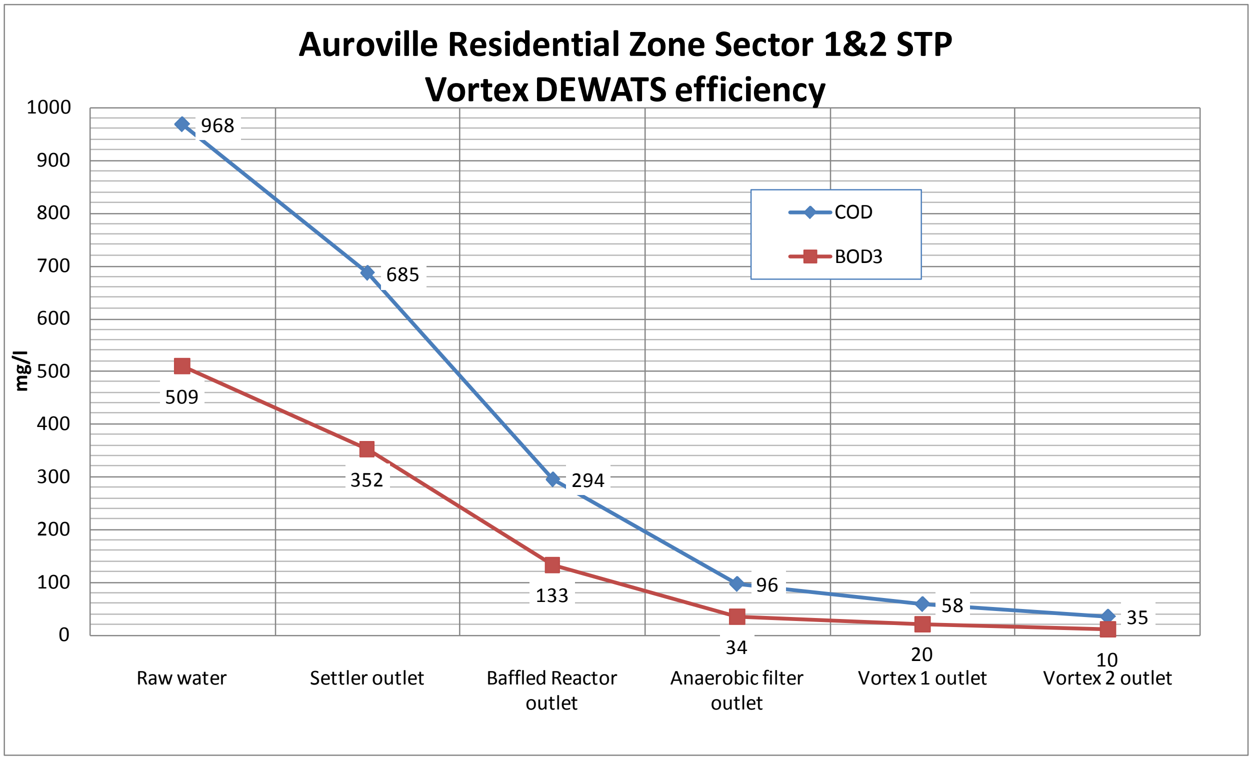
Auroville Centre for Scientific Research (CSR)
Auroshilpam, Auroville 605101 TN, India
00 91 413 2622168 / 277 /748
avcsrdewats@auroville.org.in

| | | | |
|---|---|---|---|
| | | system as per requirement, and is calibrated to ensure optimal treatment effects.<br>The first vortex system is connected to the first vortex sump. It is installed on the vortex sump or alternatively in the pump house. | Operation time 20h/d max |
| **12** | Second vortex sump | **Second vortex sump**, underground structure, allowing for vortex treatment , and including extra storage capacity for toilet flushing purposes (50% of daily demand) and for irrigation (2/3 of daily flow). The sump includes a partition wall, perforated slab and filtering media (cinder). Equipped with level control and overflow pipe for emergency, air tight manholes. 2 submersible pumps running on alternate days for Vortex system feeding,<br>Piping devices, provided to supply the hydro pneumatic system for toilet flushing, equipped with flexible pipes and floating devices for feeding to the irrigation system. Vent lines provided. | 108 KLD hourly flow 5.4m3/h<br>197 KLD hourly flow 9.9m3/h<br>328 KLD hourly flow 16.4m3/h<br>Operation time 20h/d |
| **13** | Second vortex system | **Second vortex systems** equipped with proper regulation system. Made of stand, funnel, inlet pipe of appropriate dimension, flow control system and appropriate piping. The vortex system is equipped with a timer in order to run the system as per requirement, and is calibrated to ensure optimal treatment effects.<br>The vortex system is connected to the second vortex sump. It is installed on the vortex sump or alternatively in the pump house. | 108 KLD<br>197 KLD<br>328 KLD<br>Operation time 20h/d max |
| **14** | Activated Carbon filter (optional) | **Activated carbon Filter**, installed in the Pump house, to ensure no left over particles leave the system before entering the recycling lines. The ACF is equipped with proper piping and backwash system and proper pressure control system. | 108 KLD<br>197 KLD<br>328 KLD |
| **15** | Hydro-pneumatic system | **Hydro-pneumatic**, installed in the Pump house, system equipped with proper control system, pumps, electronic control etc, to maintain the pressure in the treated water distribution network. Installed in the pump house. Excluded from CSR's consultancy job. | As per requirement |
| **16** | CDS | **Chlorine dosing system**, installed in the Pump house, equipped with a storage barrel for chlorine solution and a dosing pump. Connected to the outlet of the hydro pneumatic system. | As per requirement |

Auroville Centre for Scientific Research (CSR)
Auroshilpam, Auroville 605101 TN, India
00 91 413 2622168 / 277 /748
avcsrdewats@auroville.org.in

| | | | |
|---|---|---|---|
| **17** | Pump house | **Pump house**, housing the electrical control panel, the first vortex system, the hydro pneumatic system, the chlorine dosing system, small tools for operation and maintenance. It is provided with proper access for daily operation and replacement of equipment. | As per requirement |
| **18** | Control system | **Wattmon Control system (Cynergy)**, installed in the Pump house, will ensure easy and optimized control and operation for the entire operation of the STP, evolving in parallel to the phases. It can operate through internet. | As per requirement |

## 5.6 Treatment Efficiency




## 5.7 Approximate space requirement

**NOTE:** In absence of details on the site characteristics, the actual space requirement is not optimized. It can easily be reduced by 15% if site conditions allow.

| | Number of users | Volume of sewage flow KLD | Area | Area per KLD | Area per user |
|---|---|---|---|---|---|
| | PE | KLD | sqm | sqm | sqm |
| Phase 1 | 1000 | 108 | 200 | 1,85 | 0,20 |
| Phase 2 | 3000 | 197 | 440 | 2,24 | 0,15 |
| Phase 3 | 5000 | 328 | 680 | 2,07 | 0,14 |

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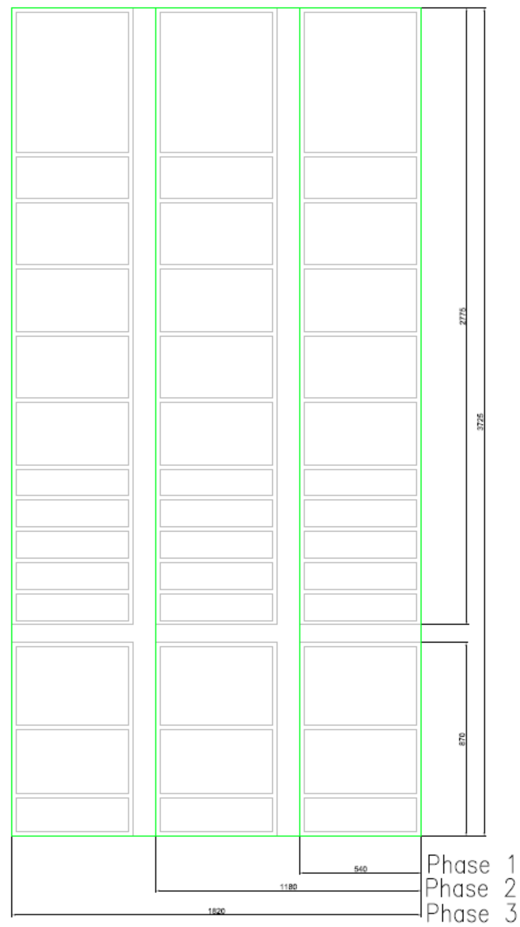
00 91 413 2622168 / 277 /748
avcsrdewats@auroville.org.in




**NOTE:** Most of the components in the present design are underground structures; several of them will emerge above ground level: The pump house, the V-Notch box, the Repartition box. It is possible to construct the two last mentioned below ground level, but necessitating a layout revision resulting in a more complex structure.

In the absence of details on the site conditions, the design is not optimized at this stage. It is based on 3.5m deep structures.

The actual design is made of 3 systems of equal size, for the flows are more or less proportional from one phase to the other. This is allowing for an easy phasing of the STP. Once the site conditions are known, the design will be reframed in order to optimize the phasing and reduce the foot print and cost accordingly. The settler, balancing tank and vortex sumps could be modified as per the phasing, hence reducing the construction cost.

# 6 POWER REQUIREMENT

| | Phase 1 | | Phase 2 | | Phase 3 | |
|---|---|---|---|---|---|---|
| **Components** | Installed power HP | Running power HP | Installed power HP | Running power HP | Installed power HP | Running power HP |
| Balancing tank transfer pump | 2 | 1 | 2 | 1 | 4 | 2 |
| First Vortex pump | 2 | 1 | 3 | 1,5 | 4 | 2 |
| Second Vortex pump | 2 | 1 | 3 | 1,5 | 3 | 1,5 |
| Activated Carbon Filter | 2 | 1 | 3 | 1,5 | 3 | 1,5 |
| **TOTAL** | **8** | **4** | **11** | **5,5** | **14** | **7** |

**NOTE:**

The power requirement for the Activated Carbon Filter is indicative only. In practice, it will be integrated in the hydro pneumatic system. In the absence of definition of the recycling network, this device will be defined at a later stage.

# 7 BIOGAS GENERATION

The proposed Vortex DEWATS includes several anaerobic functioning components.

Considering the volume of wastewater generated, it is interesting to look at the volume of biogas generated from these components both from the point of environmental impact and potential power generation.

| Phase | Biogas generation cum/d | Inbuilt energy KWh/d | Potential Power generation KWh/d |
|---|---|---|---|
| Phase 1 | 24 | 141 | 47 |
| Phase 2 | 52 | 313 | 104 |
| Phase 3 | 86 | 518 | 173 |

(The present concept is not addressing biogas generation and usage as such.)

It is anyhow proposed to design and give indications for the execution of the Vortex DEWATS which will allow for upgrading/retrofitting towards capturing biogas and potential usage for power generation.

The quality of execution in regard to air tight manholes, accurate levels in the hydraulic system, supply lines are of crucial importance to ensure a smooth and problem free functioning resulting in a effective biogas capture.

Auroville Centre for Scientific Research (CSR)
Auroshilpam, Auroville 605101 TN, India
00 91 413 2622168 / 277 /748
avcsrdewats@auroville.org.in

# 8 COST ESTIMATE

## 8.1 Investment estimate

The present estimate is based on RCC structure of appropriate thickness and quality, including double special plastering for protection against corrosion.

| Auroville Residential Zone - Sector 1 & 2 | | | | | |
|---|---|---|---|---|---|
| **Phase 1** | | | | | |
| **Bill of Quantity - Abstract** | | | | | |
| **Sl No** | **Description** | **Quantity** | **Unit** | **Rate** | **Amount** |
| | | | | | |
| **1** | Earth work excavation | 2460,16 | $m^3$ | 110 | 270 618 |
| **2** | Back filling | 579,81 | $m^3$ | 45 | 26 091 |
| **3** | PCC 1:4:8 for foundation | 73,04 | $m^3$ | 2 950 | 215 468 |
| **4** | RCC work | 214,80 | $m^3$ | 10 300 | 2 212 389 |
| **5** | Perforated slab | 6,00 | Units | 12 000 | 72 000 |
| **6** | Shuttering | 2652,86 | $m^2$ | 220 | 583 629 |
| **7** | Two coat Plastering inside wall & Floor | 1275,90 | $m^2$ | 220 | 280 698 |
| **8** | Supplying & laying PVC pipes | | LS | | 109 800 |
| **9** | Providing filter media | 429,00 | $m^3$ | 1 400 | 600 600 |
| **10** | GI manhole cover | 17 | No | 1 500 | 25 500 |
| **11** | Supplying & installing Vortex system | 2 | No | 285 000 | 570 000 |
| **12** | Special piping, valves, control & divers | 1 | No | 150 000 | 150 000 |
| **13** | Supplying & installing Pumps | 8 | No | 30 000 | 240 000 |
| **14** | Unforeseen | 5% | | | 267 840 |
| **15** | Consultancy | 10% | | | 575 000 |
| | **TOTAL COST ESTIMATE** | | | | **6 200 000** |

The design life of the STP is 20 years for the structure and piping. The pumps and related control valves have a design life of 3 to 5 years.

| | Cost estimate Phase 1 | Cost estimate Phase 2 | Cost estimate Phase 3 | Total |
|---|---|---|---|---|
| **TOTAL Rs** | **6 200 000** | **4 500 000** | **4 500 000** | **15 200 000** |
| **Added Capacity KLD** | 108 | 89 | 131 | 328 |
| **Added Users EP** | 1 000 | 2 000 | 2 000 | 5 000 |
| **Rs/m3** | 57 497 | 49 676 | 33 749 | 46 974 |
| **Rs/user** | 6 210 | 2 211 | 2 211 | 3 544 |

**NOTE**: The cost estimate include the pumps for the process and 2 vortex systems of 60cm dia/ 2 meter height as per requirement.
It does not include the required pumps for irrigation and the hydro-pneumatic systems, nor the electrical setup.

## 8.2 Yearly Running cost estimate

The present running cost estimate include electrical consumption, man power and desludging cost (mobile unit, disposal at dedicated sludge processing site).

| | Phase 1 | Phase 2 | Phase 3 |
|---|---|---|---|
| TOTAL Rs | 148 700 | 265 075 | 317 925 |

The STP will need one operator half time during first phase, and one operator full time (8h/d) during following phases.
Desludging will be organised once a year.

# 9 SLUDGE MANAGEMENT CONCEPT

## 9.1 Introduction

Vortex-DEWATS technology is able to guarantee safe and odorless discharge of effluent, reaching all requirements of the effluent parameters. The sludge generated from any STP system has an unpleasant and persistent odor and contains still pathogens. It should be handled in an appropriate way to avoid pathogen propagation and odor control.

The objectives for disposing and processing sludge are:

1. Producing safe (hygienic) processed sludge for soil fertilizer of the greenery within the settlement,
2. Aiming at an odorless process,
3. Reduction of sludge volume
4. Obtaining an easy to handle end product (solid form).

These objectives are obtained through employing a desludging unit, which collect the liquid sludge in air tight containers for further disposal and treatment in a dedicated specialized compound, away from residents, or through mechanical devices (centrifuge, sludge filter press) which will reduce the high water content to a much lower value, for further treatment and disposal.

The proposal explores the possibility to integrate an onsite sludge management, including recycling, keeping in mind all the requirements for nuisance free processing and disposal, without the help of mechanical solutions.

## 9.2 Sludge producing devices

Treated wastewater produces sludge which needs to be eliminated in order to ensure proper pollution removal and working conditions.

Within Vortex-DEWATS, sludge is accumulating in 3 places:

- The Settler, where sludge is physically separated by sedimentation and by floatation (scum). Scum is digested through time, and turns into sludge collapsing at the bottom of the tank. The accumulated sludge at the bottom of the chambers is removed on a yearly basis by a desludging device/unit.
- The Baffled Reactor, where sludge will accumulate naturally and is used to treat the sewage flow by forcing the wastewater to pass through the accumulated layer of sludge (up flow system). Sludge accumulating at the bottom of the chambers is removed on a yearly basis by a desludging device/unit.
- The Anaerobic Filter, where the sludge volume carried by the sewage flow becomes negligible as it is already captured in the previous treatment stages, but where a second generation occurs by the development of microorganism (film) on the surface of the filtering media (cinder). After a period it collapses naturally by its own weight when it becomes too voluminous (self cleaning mechanism) and gathers in the provided space below the filtering media by falling through a properly designed perforated slab. In order to easily desludge, each chamber is fitted with a large size desludging pipe reaching the empty space below the filtering media. Sludge accumulating at the bottom of the chambers is removed on a yearly basis by a desludging device/unit.

## 9.3 Yearly sludge production

According to sewage flow, the volume of sludge generated for each phase will be as follow:

| | **Phase 1** | **Phase 2** | **Phase 3** |
|---|---|---|---|
| **$m^3/y$** | 77 | 171 | 283 |

**NOTE:** the values for the sludge volume are based on actual sewage flow and not on the NBC values.

## 9.4 Potential for biogas generation

The sludge accumulated and stored in the various chambers of a Dewats system is, after one year, stable and will therefore hardly decompose, while becoming more compact and mineralized. Scope for extra biogas generation is negligible after such a long retention period *(see paragraph 7).*

Auroville Centre for Scientific Research (CSR)
Auroshilpam, Auroville 605101 TN, India
00 91 413 2622168 / 277 /748
avcsrdewats@auroville.org.in

### 9.5 Sludge collection and disposal

If onsite treatment is envisaged, the end product needs to be fully odorless, harmless and hygienic safe. It should be easy to handle once processed (dry) and ready for reuse on site in the green area as a fertilizer, or marketed to outside parties.

The main issues with sludge collection and disposal, are the relatively large volumes and consequently the cost for transportation, the emitting odors and the potential health hazards.

Health hazards are related to the high density of pathogens in sludge and the attraction of health hazard carriers like flies. Pathogens are eliminated either through time or through other thermal or chemical processes. The simplest and the most ecological way to address it is by leaving the sludge to decompose by itself. Setting up an onsite sludge treatment program needs to incorporate all these facts in a practical and efficient way.

The proposed options are:

1. Collect the sludge from the STP with a desludging unit for transport and processing, to a common dumping/ treatment site.
2. Collect the sludge through a sludge pump for disposal and treatment at an onsite sludge processing plant.

The first option of using lorry transport with relatively small loading quantities (5-10 $m^3$ per truck) of sludge over long distances and risk of inadequate disposal is to be seen in regard to practicality and cost.

For completing the exploration for the second option, more details are required regarding the actual site conditions, space availability and prevailing surrounding conditions to determine the appropriateness of such choice and potential hazard and risks.

It is understood that a study is on going to identify a site suitable for all sludge generated from Auroville's STPs or septic tanks. This element would help in deciding the most suitable solution.

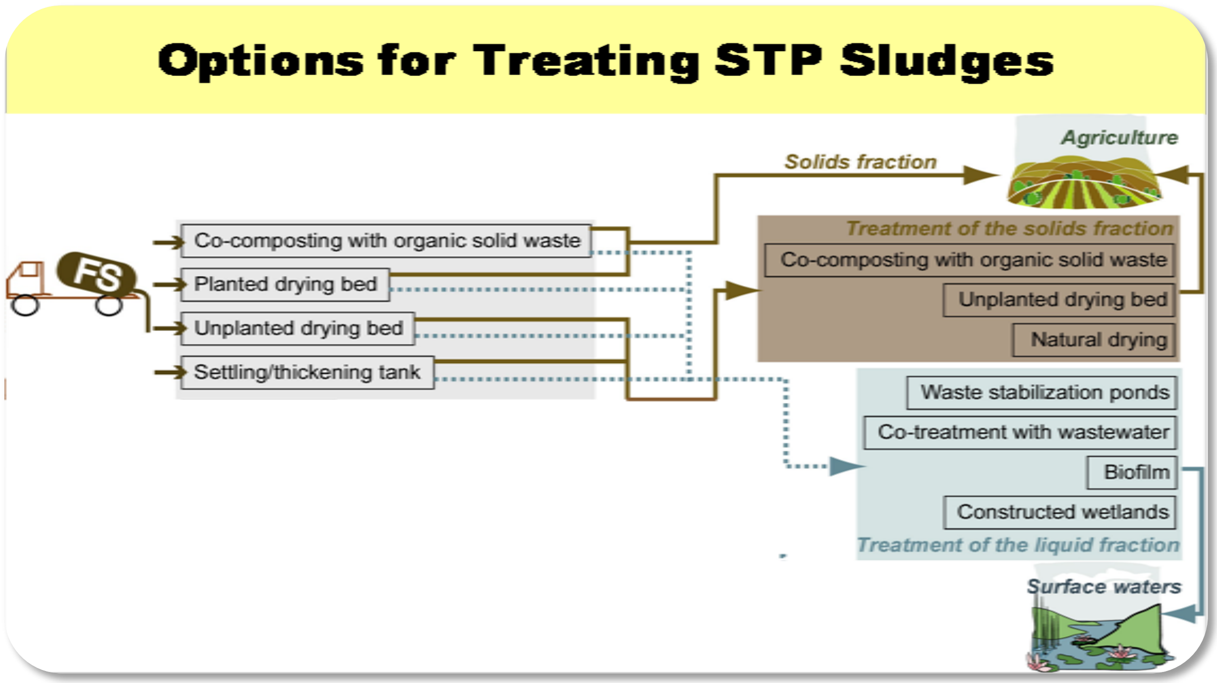
Nevertheless, it must be noted that the running cost evaluation is based on sludge disposal at a dedicated site, note attached to the STP.

The advantage of the last solution is that the entire sewage cycle is under the control of the STP in-charge.

It is possible to optimize the treatment facilities (reduced size and therefore investment cost) by properly planning and organizing the desludging operation. The proposed STP is designed on a one yearly desludging period in order to ensure proper efficiency and cost effectiveness of the STPs; however the desludging sequence periods can be planned on a rotational basis, element per element. This would reduce the volume to be treated while still ensuring treatment efficiency and proper end product.

The mixing of such processed sludge with organic waste from the settlements will ensure a good end product of processed sludge in the form of compost which offers a direct benefit for the greenery and beautification of the site.

The most feasible solution for on onsite sludge processing plant is either co-composting or a planted drying bed.




## 9.6 Dewatering of sludge

Dewatering of sludge is a relatively fast process (a couple of weeks), while further process of drying up together with pathogen control takes more time. WHO recommendations are for a 6 months period to destroy pathogens, including ameba, parasites, worms and worm eggs. Storing the sludge for such period will ensure a complete drying up process and a massive reduction in volume.

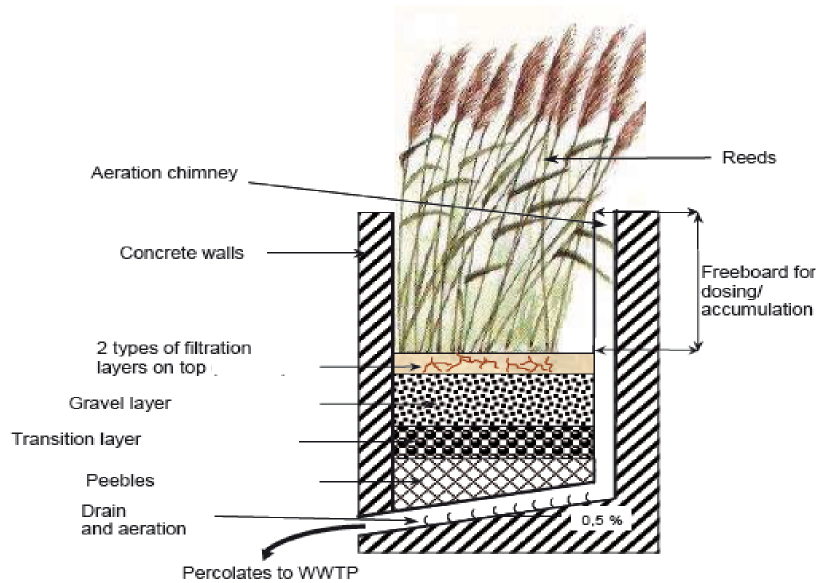
Sludge volume is inversely proportional to the solids content. Assuming that the dewatering process (e.g. by sludge drying beds) yields a reduction of the water content from 98 % to 75 % (equivalent to an increase of the solids content from 2 % to 25 %), the dewatered sludge volume to be transported would be 12 times smaller than the raw sludge volume.

In this case, the produced sludge volume from the STP of 283m$^3$/y in phase 3 will reduce and produce about 23m$^3$/y of compost.

In order to maintain the pump and the sludge processing unit in optimal conditions, a one year desludging period is recommended, but conducting it on a rotational basis of one month, element per element. This would amount to a volume of about 25m³/month (more when the settlers are desludged, less for the other components).

In the context this study, the proposal could be to:

Either collect and process the sludge to a common sludge processing unit or,




- Collect the sludge from the STP with a sludge pump.
- Dispose of the sludge to a properly designed sludge processing unit close to the STP (can be integrated with solid waste processing site)
- The collected liquid from the sludge processing, which is still highly contaminated, can be treated by redirecting back to STP.
- In order to optimize the investment and treatment process, it is suggested to collect the sludge from the various elements of the STP on a rotational basis, on a 1 month interval between desludging operation, and a full rotation (back to the first element) in 1 year.

## 9.7 Odors control

Space availability for safe handling and processing of sludge needs to be identified.

Therefore it is essential to integrate a proper odors control system in the process.

Available options:

1. EM (Efficient Micro-organism)technology,

   EM stands for Effective Microorganisms. It is a combination of various beneficial, naturally occurring microorganisms mostly used for or found in foods. These effective microorganisms secrete beneficial substances when in contact with organic matter. The anti-oxidation effects of these microorganisms pass directly to the soil or indirectly to plants. This process increases the humus content of the soil. EM is also an effective eliminator of offensive odors.

2. a physical barrier with a plant house with compost pit control for ventilation.

# 10 CSR WATER AND SANITATION

For more than thirty years CSR has developed waste water treatment methods that evolved from individual household systems to a technology applicable for large scale settlements, treating waste water volumes of 1000 KLD and above.

Milestones in this journey were the exposure to waste water dynamics by Pr. Charbonnel, H Kraft and others prior to 1995. Borda through Ludwig Sasse and Dirk Esser helped CSR to take a major leap by introducing to Auroville a large range of natural waste water treatment techniques, with the aim to test and adapt them in tropical conditions. A R&D project funded by the EU helped to develop the knowhow and to introduce and test Anaerobic Baffled Reactor, which were already implemented previously in China and Latin America.

In 2001 CPCB (Central Pollution Control Board) recognized and officially adapted Dewats technology for implementation on a national scale.

Further on, through trial and error, an appropriate natural treatment technology adapted to tropical conditions was developed, although we still had to employ the planted filter device for controlling the odor. Prior to 2008 Aquadyn and especially JF Audic experimented with a device called a vortex, first for drinking water, later on for wastewater treatment. It was this system that provided the breakthrough for substituting the planted filter with a surprisingly efficient method for oxygenating the waste water and reaching the required standards. The vortex created the possibility for implementing the technology in an urban context due to the minimized footprint required to remove the odour out of the waste water. Further R&D were conducted by CSR leading to improvements which allows today to reach flushing standards.

Tracing back the start in 1981 of exploring a way of treating and recycling individual household waste water, we observe that it took 32 years to evolve a technology researched and developed within Auroville context. It is gratifying to watch that the technology has received recognition and is being implemented within India and abroad.

We would like to thank the countless individuals and organisations which helped us to progress further.

## Natural Waste Water Treatment Systems

**Selected milestones**

2003 Arvind Eye hospital, Puducherry – 500 KLD
2007 Surya Nepal Tobacco factory – 160 KLD & Surya Nivas Colony – 60 KLD
2008 Kalapet Jail Puducherry – prefab 75 KLD
2009 ITC Pune Tobacco factory – 160 KLD
2009 Hansa Niwas Trichy – prefab 90 KLD
2010 VBHC Bangalore – 710 and 410 KLD
2011 VBHC Chennai – prefab 80 KLD
2012 Villefranche resort – 40 KLD
2013 ITC Munger Dairy plant – 30 KLD
2013 Tollygunge Golf Club Kolkata – 200 KLD
2013 ITC Guntur settlement – 175 KLD
2013 ALEAP Industrial park (Nandigama –AP) – 1050 KLD

Gilles Boulicot, Tency Baetens, Csr
28/01/2014