Water Management for Auroville

pre-feasibility study

Waste Water Management for Auroville and the surrounding area

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1 Introduction

Wastewater management is nowadays one of the most important focus of many local and international organizations, companies, governments, NGOs and stakeholders concerned with humanity's future. It is directly or indirectly one of the core concern for the Millennium Development Goals.

During the last period, a large range of innovative solutions emerged, but also new ways to approach the problem. Because of enlarging ranges of harmful pollutants broadly generated through human activities like pharmaceutical by-products, hormones but also the unfortunately more conventional heavy metals, petrochemicals and pesticides and their nowadays better known effects, new solutions and approaches are envisaged. Looking at this trend and ways it is quickly integrated in new developments and the worldwide growing concern for sustainability, one can safely predict that the near future will be reach of innovative and better integrated solutions.

Two main tendencies emerge, which may ultimately favor each others while starting on a very different stand point. One is toward development of high-tech solutions like membrane technology, engineered bacteria or catalytic process, often combined with more conventional systems like UASB, ABR, and other sludge activated reactors. The other one is towards reducing the cost, favoring enhanced natural phenomena, simple, steady, low demanding technology and reducing negative impacts of wastewater management.

Where a common concern may emerge it is because high-tech solutions can often be tailored to fit with decentralized (household level) up to large centralized sewage system. It is not only applicable for centralized large systems and the major hurdles it creates (very few centralized sewage and treatment systems are in working conditions or giving good results in India). As such, it is adding to the set of simple appropriate and efficient technology available for the very large demand related to decentralized wastewater generation (small villages, isolated industries, institutions, communities etc) present all over the world. As well, vacuum sewer systems, a high-tech solution, is based on recycling of valuable waste and reduction of water consumption.

Remains that high-tech solutions as well as more conventional solutions are usually power intensive, require high operation and maintenance capacities, and due to there mechanized aspects have a short time life. This should be seen as well in the local context where complex operation and maintenance is a recurring problem, where power break is a daily reality and where often a vacuum exist between the concept and the organization it require to master it properly and completely.

Remains as well that a massive flow of wastewater is pumped daily from Puducherry to the south border of Auroville's Green Belt and infiltrated in the ground. That the proposed Auroville Master plan shows very large range of density pattern and in place multi storey buildings. That some surrounding areas are or will host facilities generating difficult kind of wastewater (hospitals, chemical based factories, and pharmaceutical industries).

This challenging and varied context is calling for flexible and adaptable solutions. While Auroville can and must play a major role to promote sustainable solutions, some of the inside and outside development may call for sophisticated ones.

The objective must be hence to determine the best strategies and technological choices that the present preferences are not impairing the future and can be easily integrated in a positive retroactive loop.

Toujours Mieux!

2 The concern

The main concern of today is that a very large part of the world population and for our direct concern Auroville's area, has no access to adequate sanitation. The conventional approaches are not fitting with a world where water scarcity and pollutions, with the related cortege of public health setbacks, are becoming a common reality. In India, 69% of the population has not access to adequate sanitation.

India pay yearly a heavy levy through water born diseases (80% of total illnesses) and death (25% of the total). This is reflecting the lack of appropriateness of public investment in medical facilities while the main source of public health hazard is not addressed.

A survey carried in villages in the direct vicinity of Auroville reveals that the lack of appropriate sanitation generate a direct lost of 15% of the annual household income through non-worked days and medical expenses.

The conventional forms of central wastewater management, i.e. a combined system with multistage wastewater treatment facilities, are still standard today. Increasing criticism has, however, been leveled at these methods for ecological and economic reasons. Increasing investment costs, high operating and maintenance costs and high water consumption as a result of misusing valuable drinking water just for transport give grounds to question such methods and their pertinence for developing countries.

Very few of the Indian cities are equipped with treatment facilities, all of these ones centralized, very often not performing or dysfunctional.

> *Those whose job is to select and design appropriate systems for the collection and treatment of sewage in developing countries must bear in mind that European and North American practices do not represent the zenith of scientific achievement, nor are they the product of a logical and rational design process. Rather, treatment practices in the developed countries are the product of history, a history that started about 100 years ago when little was known about the fundamental physics and chemistry of the subject and when practically no applicable microbiology had been discovered. … These practices are not especially clever, nor logical, nor completely effective—and it is not necessarily what would be done today if these same countries had the chance to start again (Feachem et al. 1983, pp. 63–64).*

3 Background

The area of Auroville is poorly equipped with sanitation and wastewater treatment facilities.

Most of the villagers do not have access to toilets, and when existing it is often dysfunctional. The population is practicing open defecation, with all the problems of intimacy and hygiene it is creating, mainly for the female part of the society. After the Tsunami, the population leaving on the beach lost totally the minimal intimacy required, this combined with water scarcity creating hygien and health problems for the children, women and young girls mainly.

In the denser villages streets and urbanized area, the black water (toilets) is usually dropped in soak pit, which cannot be considered as a proper treatment system for densely populated areas (pollution to water table). The grey water goes to open drains which, together with uncollected solid waste, become the perfect context for multiplications and proliferation of pathogens and their main vectors.

Most of the institutions around Auroville, mainly located in Kalapet, do not have wastewater treatment, at the notable exception of PIMS, equipped with a highly sophisticated and well operated conventional system. The unprocessed wastewater is dropped to the drain from where it goes to the sea, or infiltrated directly to the ground.

The industries are not equipped. Some of them get several court cases because of the constant nuisances they create for the surrounding and the health of the population. Chemfab for example is dumping daily massive volume of chemical wastes directly in the groundwater table.

The city of Pondicherry is equipped with a treatment facility, the so called Sewage Farm of Pondicherry, situated on the very border of the south Greenbelt of Auroville. The largest part of the daily sewage generated through the city and the suburbs is anyhow discharged to the sea. The large volume of sewage reaching the sewage farm is so far poorly treated, especially while looking at dangerous stuff like heavy metals which can be traced down in the aquifer. Concern is raised because of the growing usage of pharmaceutical stuff in Pondicherry. At the same time, the solid waste collected in Pondicherry are daily brought to the same location, where leaching is occurring with extra contamination of soil and groundwater.

We cannot avoid to underline that an ongoing program is conducted by the authority to develop the sewer network until full city and suburbs coverage and to install new treatment facilities in the actual compound which should allow to treat properly the added flow of sewage. From the actual capacity of 13,500 cum/d, the Sewage Farm should reach the impressive volume of 80,000 cum/d of sewage by 2025 or so.

4 Decentralized wastewater management

4.1 Some definition

Decentralized wastewater management may be defined as the collection, treatment, and disposal/reuse of wastewater from individual homes, clusters of homes, isolated communities, industries, or institutional facilities, as well as from portions of existing communities at or near the point of waste generation (Tchobanoglous 1995).

Centralized wastewater management, on the other hand, consists of conventional or alternative wastewater collection systems (sewers), centralized treatment plants, and disposal/reuse of the treated effluent, usually far from the point of origin.

Communities need whole-system, lifecycle analysis of their wastewater system choices to make the right decisions. This means that all costs and benefits of each option must be taken into account, inside and outside the conventional bounds of infrastructure systems, and from initial capital investments through operation and maintenance to eventual rehabilitation or replacement of an aged system.

Decentralized systems are an alternative to conventional, centralized systems.

Decentralized systems include *onsite systems* that treat wastewater from individual homes or buildings, and *cluster systems* that treat wastewater from groups of two or more homes. Typically cluster systems serve less than a hundred homes, but they can serve more. The “line” between decentralized and centralized systems becomes vague when some cluster systems are considered. Wastewater professionals make the distinction in several ways:

- ***Volume.*** Decentralized systems treat relatively small volumes of water: up to 1000m3/d (8,000 to 10,000 equivalent people) is the considered the maximum for one single DEWATS system. The largest existing DEWATS in India is sized to treat 500m3/d. On can realize that considering the wastewater volume Auroville will generate ultimately, such system is already very consequent.
- ***Sewer type.*** Centralized systems typically use conventional gravity sewers, while cluster systems typically use alternatives such as small-diameter pressurized pipes, small-diameter

gravity, and vacuum sewers, often employing on-lot settling tanks and/or grinder pumps before wastewater flows from a lot into the sewer system. One must note that the sewer cost represent often 50% and more of the total sewage system investment. This is of considerable importance for investment but also for installation and maintenance. In the study of Harald Kraft for Auroville, the cost of the sewer network is estimated at 189.552.000 Rs or 40% of the entire construction cost of the wastewater treatment system.

- ***Treatment type**.* Centralized systems typically use activated-sludge processes, while cluster systems typically use alternatives such as sand filters, trickling filters, anaerobic filter, baffled reactor etc. A large part of such technology is well mastered in Auroville.
- ***Discharge method**.* Centralized systems typically discharge treated wastewater to a surface water body. Cluster systems typically discharge treated wastewater for recycling, helping then tremendously to reduce freshwater consumption for greenery and other secondary requirements, or for infiltration into soil, those helping to reduce the pressure on groundwater resources.
- ***Ownership*****.** Centralized systems are typically publicly owned, while cluster systems are usually owned by a developer, homeowners' association, or other private entity. In the context of Auroville where no private ownership prevail, this will refer to operation and maintenance, for which the authority and to a large extend the practical aspects of the work can lay with the connected population.
- ***Relative scale***. Centralized systems are intended to serve entire communities or substantial areas of large communities. Cluster systems serve only a portion of a community.

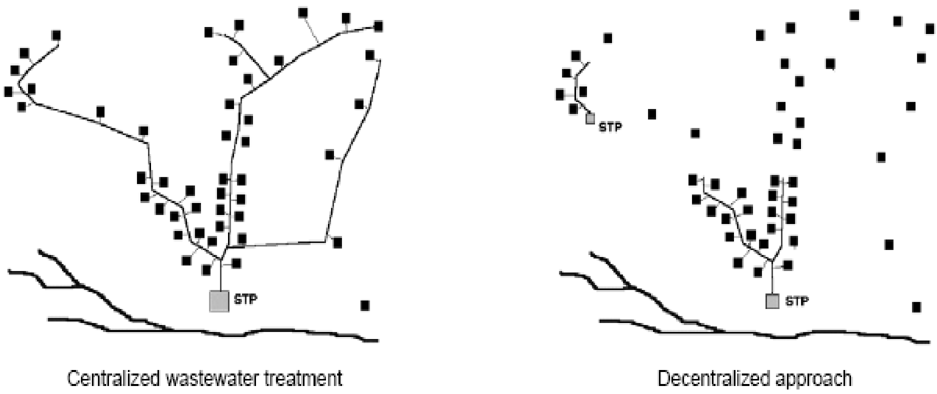


Figure : Comparison of Centralized and Decentralized Approaches to Wastewater Service. STP indicates a centralized or cluster sewage treatment plant. *Source: Draft Handbook for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems (U.S. Environmental Protection Agency 2003a).*

It must be noted that the solution proposed by Harald Kraft for 2 systems (50,000PE West and 17,000PE East) with the related sewer infrastructure it requires, sized to cover the entire Auroville's population does not fall under the decentralized category but is a centralized system as per above criteria.

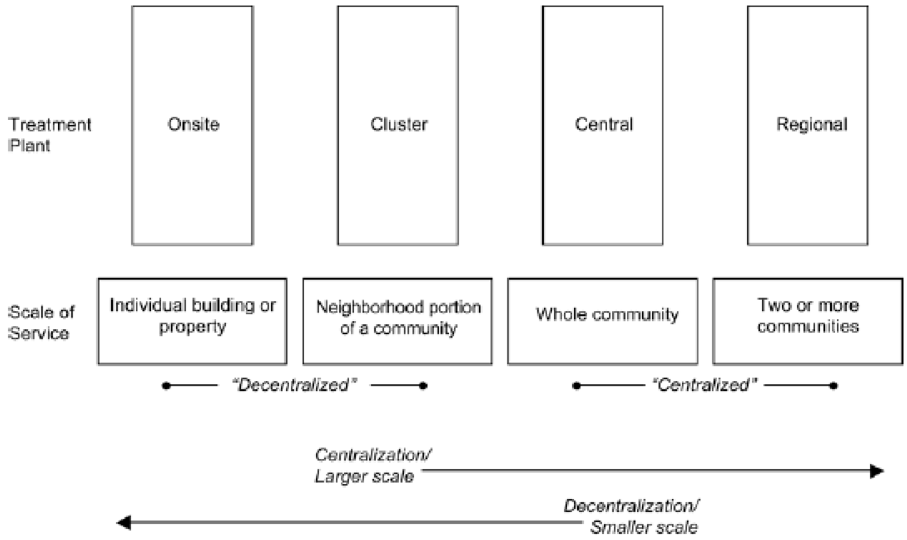


Figure : The Wastewater Scale Continuum

4.2 ***Limitation and appropriateness of decentralized wastewater systems***

Decentralized wastewater systems are not a panacea. Proper sitting, maintenance, management, and regulatory oversight are necessary to ensure their reliability—just as for centralized systems. Only by adequately evaluating the benefits and costs of a full range of wastewater system options vis-à-vis community needs can optimal scale be determined.

Auroville and its surrounding show a large variation as far social aspects, financial and technical capacity, density, environment, land use and infrastructure are concerned. It is very likely that the best and more progressive solution lay in a multiple, beneficiary oriented approach.

Too often wastewater systems are planned with minimal attention to broad community issues. With only a few key parameters such as assumed population growth and development locations, design of treatment facilities and collection systems are developed, bypassing numerous prerequisites for such a task.

Integrated wastewater planning, on the other hand, puts the engineering last, after serious consideration of a range of community, watershed, aesthetic, financial, and other questions. It is the answers to these questions that should define the design problem.

Smart Growth and Cluster Development

Various new “movements” and approaches to development—smart growth, sustainable communities, new urbanism, farmland preservation, urban revitalization, and more—are changing the way many developers, regulators and consumers think about growth. A key objective of these movements is to reduce sprawl by encouraging infill development and facilitating urban expansion in contiguity to already developed areas.

Another hallmark is increased density on parts of a development site and preservation of open space on remaining portions. A growing literature documents the benefits of this “cluster” approach to development:

- Creation of viable, neighborly neighborhoods;
- Reduced per-house development costs;
- Lower costs for public services;
- Increased open space;
- Reduced land disturbance;
- Preservation of natural features of the landscape and valuable habitat areas;
- Reduced amounts of impervious surfaces;
- Reduced runoff volumes and pollutant loads;
- Maintenance of groundwater recharge and base flow of associated streams

All theses criteria find their natural expression in Auroville’s own aspiration for sustainability.

As visible in the graph below, decentralized solution can be easily adapted to population growth. This in return allow for less immobilization of assets and unnecessary infrastructure with related O&M costs.

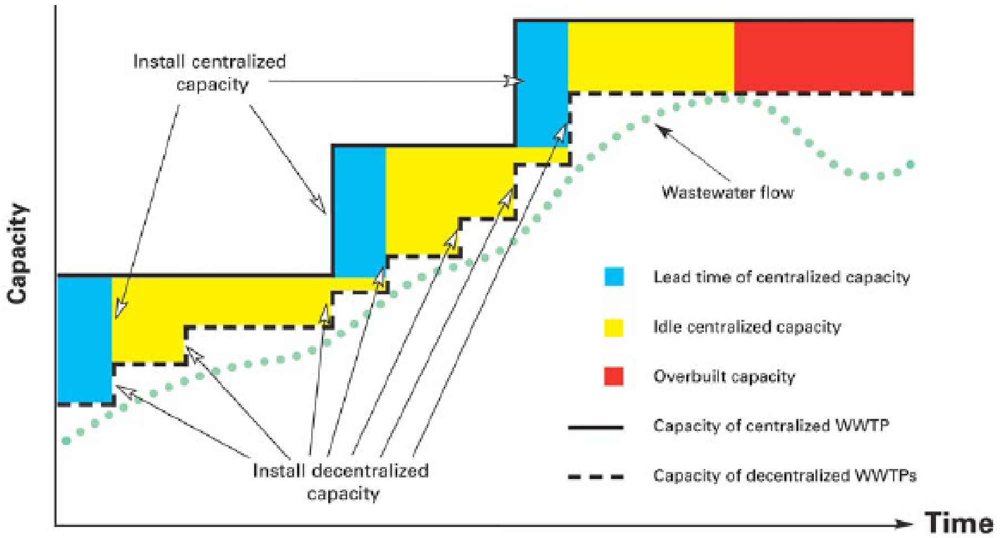


Figure : Flow Versus Capacity for Centralized and Decentralized Wastewater Systems. WWTP stands for Wastewater Treatment Plant.

4.3 <u>*Density factor*</u>

Collection system economies are highly dependent on land use density: capital costs per connection for systems at low suburban development densities are significantly greater than costs at higher densities of close-in urban development *(Adams et al. 1972)*.

One factor contributing to this diseconomy is the length of pipe required per connection. In rural areas, pipe lengths per service (connection to a house, business, etc) can be quite long, making decentralized systems very attractive. As density increases, lengths per service decrease, and collection systems become more economic. Typically higher populations within a service area mean increased density, so the focus in wastewater facility planning is often placed on total population served. However, increasing the size of a service area or combining service areas to increase population served can yield uneconomical results.

As one moves from home to neighborhood to urban to regional scales, increasing amounts of land in parks, schools, roads, parking lots, industrial and institutional campuses, water bodies, etc., are added, decreasing the density of land use. This results in longer lengths of pipe per connection.

Density favors centralization. The more urban the area served, the more likely it is that a larger wastewater system will be most economical.

However, to the extent expansion of a service area decreases overall density diseconomies will come into play. In such situations, smaller systems (e.g. cluster systems) can take advantage of higher "spot density" while avoiding the low-density penalties that come with extending sewers across a larger area of lower overall density.

Both centralization and decentralization can provide the volumes of water necessary for certain types of reuse. Where the point of use is close to the treatment facility, such uses can be extremely cost-effective, both for the wastewater facility that can save on discharge costs, and for the user who can obtain necessary volumes at less cost than using conventional water supplies. Agricultural irrigation reuse is the largest volume use of treated wastewater from centralized facilities. An other large use is for urban landscape but can be addressed as well, and often at lesser cost, trough decentralized systems. Habitat creation is another important use for reclaimed wastewater.

4.4 <u>*Other considerations*</u>

Decentralized systems likely keep more money circulating within a local economy—supporting local income and creating local jobs—than centralized systems of similar lifecycle cost.

Simon Gruber of the Gaia Institute summarizes this point nicely:
Larger, more centralized collection and treatment systems clearly involve major capital expenditures on the collection network. These costs (together with the costs of the treatment plant itself) ultimately include major interest payments as loans or bonds that are paid over time. While the principal component of these expenditures is typically invested in the community, creating jobs and purchasing some local materials, the interest portion of this flow of capital, generally, leaves the community. Similarly, over the lifetime of a mechanized WWT system, a significant portion of the operating costs of the treatment plant (and any pump stations in the collection network) goes into paying for electricity to run pumps, aerators, sludge processing, etc. Expenditures for both of these categories of costs (interest on capital investment, and power charges) tend to be siphoned out of the local community, going to investors and shareholders of the various entities that lend money, supply power, etc. Expenditures for chemical additives used in treatment also tend to leave the community.

Decentralized wastewater systems are "growth neutral" from a public investment. That is, while centralized systems typically involve a public investment that requires additional users in order to pay for the installed capacity, decentralized systems need not involve either excess capacity or public investment.

Wastewater re-use control measures and related health risks

Control measures water	Waste water	Field or Pond	Crop		Worker	Consumer
	Level of Contamination				Level of risk	
No protective measures	High	High	High	Desirable sanitary barrier	High	High
Crop restriction	High	High	High		High	Safe
Application measures	High	Safe	Safe		Safe	Safe
Human exposure control	High	High	High		Low	Low
Partial treatment in ponds	Low	Low	Low		Safe	Low
Partial treatment by conventional methods	Low	Low	Low		Low	Low
Partial treatments in ponds, plus crop restrictions	Low	Low	Low		Safe	Safe
Partial treatment by conventional methods, plus crop restrictions	Low	Low	Low		Low	Safe
Partial treatment, plus human exposure control	Low	Low	Low		Safe	Low
Crop restriction, plus human exposure control	High	High	High		Low	Safe
Full treatment	Safe	Safe	Safe		Safe	Safe

Source: Guidelines on municipal wastewater management - UNEP

5 Water efficiency as a way toward investment and maintenance savings

The sizing and therefore the cost of wastewater conveyance and treatment facilities are directly related to the volume of sewage. By working on providing water saving solutions at household and collective levels, one may achieve important reduction in the water consumption pattern and hence in the wastewater generated. Some of the most advanced technology reduce as well the pollutants and the related treatment costs.

5.1 *Water saving at household level*

A large range of appliances designed to reduce water consumption at any level are now available on the market: low flushing toilet, faucet aerator for tap and shower, pressure regulators, water efficient cloth and dish washers etc. New washing machines are now able to do a perfect job with as little than 50 liters of water per 5kg wash.

The reduction can be as important as 50% for domestic water consumption and therefore for the wastewater generated.

5.2 *Advocating for public facilities*

A national study conducted in USA (*A National Study of Water & energy consumption in Multifamily Housing: In-Apartment Washers vs. Common Area Laundry Rooms, march 2001, National Research Centre Boulder Colorado*) revealed that residents of apartments with in-unit laundry facilities used 3.3 times more water and 5 times more energy than residents in apartments using common laundry facilities.

Other collective facilities like canteen, collective kitchen etc are known for a much better water efficiency than domestic family likes facilities, providing they are properly designed and equipped. With standard equipment, the water consumption for similar activities (cooking, dish washing etc) may be halved if to compare to household pattern.

5.3 Innovative technologies

The worldwide concern for forecasted water crises is generating a lot of effort in innovative solutions that the water can be used more efficiently. In that line, one can easily see that the coming years and decades will come with much more water and energy efficient facilities, but also with less pollutant requiring systems (washing powder etc.)

One can start to find (Sanyo in Japan, Daewoo in Korea) cloth and dishwashing machines using electrolysis and ultrasound and some time air, which are then soap-free washing machines… and require much less energy as well.

It is important to remember that detergents and other whiteners are amongst the most difficult and trouble making largely sprayed products. By using either less difficult products or the mentioned technologies, the potential impact to the environment is largely reduced and the wastewater generated easier to handle without side effects.

5.4 Recommendations

By combining regulations and guidelines on water saving appliances in each and every buildings, promotion of collective facilities and usage of innovative technologies, a very important saving can be generated on wastewater infrastructure, maintenance, space requirement, but also on power consumption and potential arm to the environment.

Such guidelines, revised regularly and framed for developers, constructors and architects must be fully part of the work planning authorities for Auroville but also around.

Public facilities must be fully part of the detailed master plan, like community kitchen, dinning room, laundry. They can be developed sub sector wise for low to medium density areas and be integrated in the buildings for the high density areas.

A technology watch cell must be created, that innovative solutions can be identified, tested out and promoted through time.

6 The Auroville experience

For the last 25 years and with growing intensity, Auroville has been deeply engaged in research and development and then dissemination of innovative natural decentralized wastewater management and promotion of appropriate sanitation solutions.

Well in line with Auroville’s development process, the initial motivation for developing capacity in the field of wastewater management was to respond to an internal growing concern, fitting with the reality encountered: a population sprayed on a large area, with some clustered residences and services. It is around these communities and a few of these public services that the initial systems were developed. Through time, most of the large communities has been equipped, as well as many of the public services and some of the commercial units. Some micro projects for individual houses or small clusters of houses have been realized as well. Because of the long standing involvement of Auroville in village development, some public toilets facilities with appropriate treatment systems was made as early as 1995.

Through the “in-house” trial and error process, an in-depth and somewhat unique practical knowledge has been gained which then was transmitted to other areas and to more specific wastewater. While gaining skill through the development of many systems and being engaged in networking with organizations working in the same field in India and abroad, Auroville became a well known place for the design and dissemination of decentralized wastewater techniques. In fact, it became the place of Asia where the largest and most diversified systems and techniques related to this field can be visited. The set of selected solutions was then approved by Central Pollution Control Board.

While other Auroville groups and individuals are also involved in such techniques, the leading for the development and promotion of sustainable technical solutions, the Centre for Scientific Researches, started then to be engaged in training process, consultancy work all over India and advocacy towards government authorities.

6.1 DEWATS

The set of technology selected by CSR and its partners to address decentralized wastewater management, grouped under the label DEWATS, are addressing much further issues than decentralized conditions as such.

- It is working on natural process only, without chemical or mechanical part, by gravity and without power requirement as far as the process is concerned.
- Modular, it can be split and grouped at various level of treatment to address space, requirement and cost constraints, but also to allow for scalability, though fitting closely with demand and investment.
- It is design to achieve high treatment efficiency without nuisance and to allow safe recycling.
- According to site conditions it can be designed to fit into limited space and can easily be integrated in the landscaping and general layout of the area.

To date, about 80 systems has been realized by CSR, and more than 300 hundreds with the Indian partners clubbed into a Consortium for DEWATS Dissemination working all over India. Tailored to address wastewater treatment demand from residences and settlements, hostels, public facilities, factories, institutions etc. for domestic or non domestic wastewater, all of systems are developed through decentralized technology. While the main area of experience of CSR is in Tamil Nadu, projects have been executed successfully in West Bengal, Gudjarat, Maharastra, Nepal etc, with processed flow ranging from few hundreds of liters to 500 cubic meters per day, treated consistently within the discharge standards fixed by CPCB and demonstrating the versatility and robustness of the selected set of solution.

DEWATS Technologies

- Settler
- Septic tank
- Imhoff tank
- Anaerobic Baffled Reactor
- Anaerobic Filter
- Horizontal planted filter (aslo called root zone system, constructer wetland …)
- Anaerobic pond
- Aerobic facultative pond

As well, other groups or individuals from Auroville have been involved in research and promotion of decentralized wastewater techniques, and a few outside experts as well, chiefly Harald Kraft. The proposed systems are anyhow very similar in nature or even part of the DEWATS set of technology and offer the same range of results and scope for recycling, while cost factor and space requirement may greatly vary.

With the Tsunami a new step was covered by developing innovative designs, offering the first prefabricated treatment systems in India. A large effort of advocacy is still going on to propose adequate and cost effective solutions for the new settlements along the Tsunami affected cost.

6.2 *Ecological sanitation and Auroville efforts in the villages*

During the last few years, while more and more involved in promoting appropriate sanitation solutions to the villages, several Auroville units like Auroville Water Harvest, Auroannam, Auroville Health Service, Palmyra, Pitchandikulam have been involved in the promotion and construction of ecosan (Ecological Sanitation) toilets, offering a proper and well accepted solution for some of the most critical sanitation problems in the villages. Auro Annam in particular is deeply involved at nation level in the promotion of sanitation solution through EM (Effective Microorganism) technology and ecosan. In our direct surrounding the village of Kottakarai is targeted for 100% sanitation coverage, chiefly through ecosan.

6.3 *Addressing centralized wastewater flow*

Lately, some important potential emerge to address the problem of Pondicherry Sewage Farm. Through Auroville's international network, renowned international institutions came to know about the problem and propose to collaborate with Auroville and Pondicherry authorities to address it. The Municipality is very positive about it. The foreseen method, in line with the deep concern of Auroville environmental issues, will not be based on conventional means but could well turn this large volume of wastewater into blue – and safe - gold for Auroville's thirsty area.

6.4 *Conclusion*

Auroville has gained a great experience in the field of natural decentralized wastewater management, and is very actively engaged in finding solutions for all scales and density, which can be easily valorized in the context of an integrated wastewater management for Auroville and the surrounding.

One must mention that consistent efforts are made to address other problems of sanitation through solid waste management, in Auroville but also in the surrounding villages. Such experience must be valorized and should form the backbone of the wastewater management strategy, at least at initial stages of development.

7 Ecological Sanitation: a step further

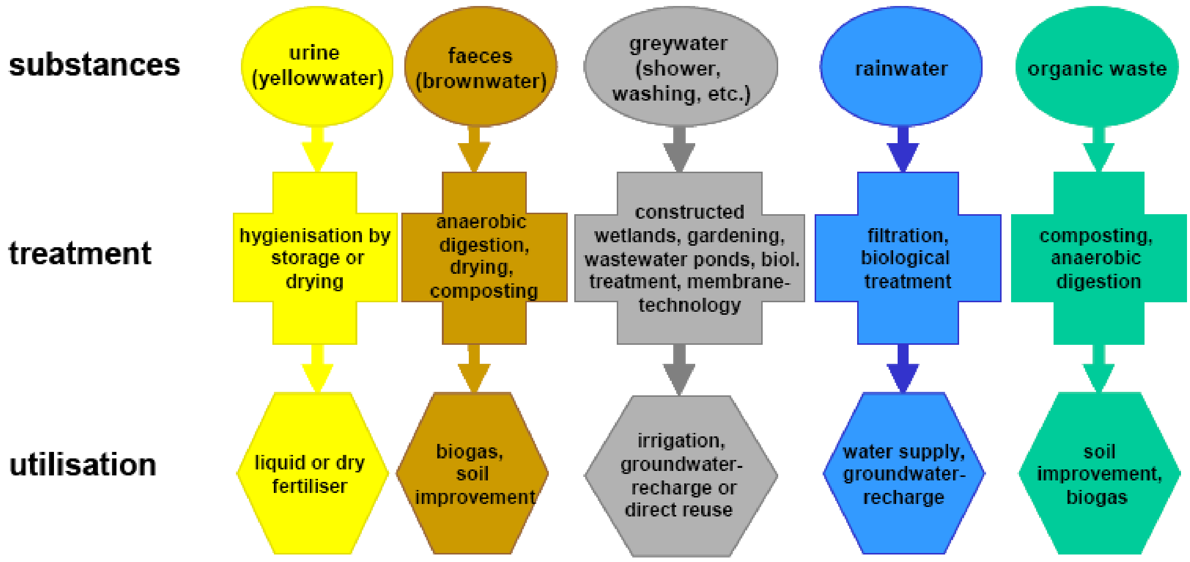
Since a few years Auroville has entered into a new paradigm very actively propagated worldwide and called ecological sanitation or ecosan. The knowledge gained in the field of decentralized wastewater management, solid waste, public health and social issues is of great help in stepping further in this new and very promising endeavor, very much rooted in sustainable development.

7.1 *What is Ecosan?*

Although conventional sewage systems transport excreta away from the users, they often fail to contain and sanitize, instead releasing pathogens and valuable nutrients into the downstream environment. In fact, conventional wastewater systems are largely linear end-of-pipe systems where drinking water is misused to transport waste into the water cycle, causing environmental damage and hygienic hazards.

Many different technical options have been developed, ranging from low cost systems - such as composting toilets, urine diverting dehydration latrines and DEWATS technology - to high tech waterborne applications - such as vacuum sewers, anaerobic treatment, chemical processing or membrane technology, most suitable for use in densely populated urban areas all over the world.

Innovative approaches are looking at human waste generation as potential resources better than a nuisance to eliminate through heavy infrastructure which often generates negative impacts.



These approaches do not favor a specific technology, but constitutes a new paradigm in handling substances that have so far been seen merely as wastewater and water-carried waste for disposal. This is based on an overall view of material flows as part of ecologically and economically sustainable wastewater management systems tailored to local needs. Accordingly, they may offer a large flexibility and be integrated in integrated water management for Auroville and its surrounding.

The actual decentralized wastewater management practices in Auroville are part of the ecosan approach, but can be brought much further by looking at better valorization of resources.

fraction	characteristic
1. faeces	• hygienically critical • consists of organics, nutrients and trace elements • improves soil quality and increases water retainability
2. urine	• less hygienically critical • contains the largest proportion of nutrients available to plants • may contain hormones or medical residues
3. greywater	• of no major hygienic concern • volumetrically the largest portion of wastewater • contains almost no nutrients (simplified treatment) • may contain sprent washing powders etc.

Ideally, ecosan systems enable almost complete recovery of all nutrients and trace elements in household wastewater and their reuse in agriculture - after appropriate treatment. This way, they help preserve soil fertility and safeguard long-term food security.

As an integral alternative, a characteristic of ecosan is its interdisciplinary approach that goes beyond the domestic water supply and technological aspects to include agricultural use, sociology, hygiene, health, town planning, economy/small-enterprise promotion, administration, etc. in system development., those creating multifold benefits.

This approach is very fast spraying all over the world, in developed and developing countries alike, using large range of technical options, from very simple to very sophisticate. India is very active in this domain. Specific financial schemes exist in Tamilnadu to help promote ecosan solutions as part of the Total Sanitation Campaign. Ecosan is one of the very few solutions adapted, and therefore promoted to the Tsunami affected area.

7.2 Ecological sanitation closes the loop between sanitation and agriculture

The concept behind ecological sanitation (ecosan) is that sanitation problems could be solved more sustainably and efficiently if the resources contained in excreta and wastewater were recovered and used rather than discharged into the water bodies and the surrounding environment.

The end-of-pipe sanitary systems that are used today are based on the modern misconception that human excreta are simply wastes with no useful purpose and must be disposed of.

Ecological sanitation is a new paradigm in sanitation that recognizes human excreta and water from households not as waste but as resources that can be recovered, treated where necessary and safely used again.

Ideally, ecological sanitation systems enable a complete recovery of nutrients in household wastewater and their reuse in agriculture or other green areas. In this way, they help preserve soil fertility and safeguard long-term food security, whilst minimizing the consumption and pollution of water resources.

- Many villages are chronically short of water, which makes the use of water borne sanitation an unrealistic option.
- The capital cost required for water borne sanitation is prohibitive in most of the cases.
- It has conclusively been proven that nitrate loaded effluent from pit latrines is directly responsible for widespread contamination of valuable groundwater resources.
- The regular operating and maintenance costs of sanitation systems such as bucket latrines, septic tanks, chemical and water borne toilets are very high.
- Large part of the water consumption in urbanized area is used to flush latrines and to carry wastes away.
- A very large part of the domestic wastewater pollution load is coming from human excreta and faeces are the great carrier of pathogens which contaminate the entire wastewater flow in conventional systems.

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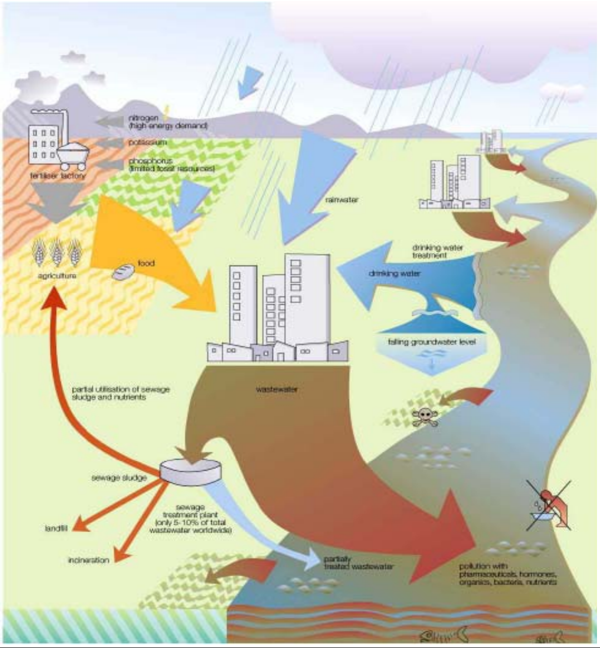
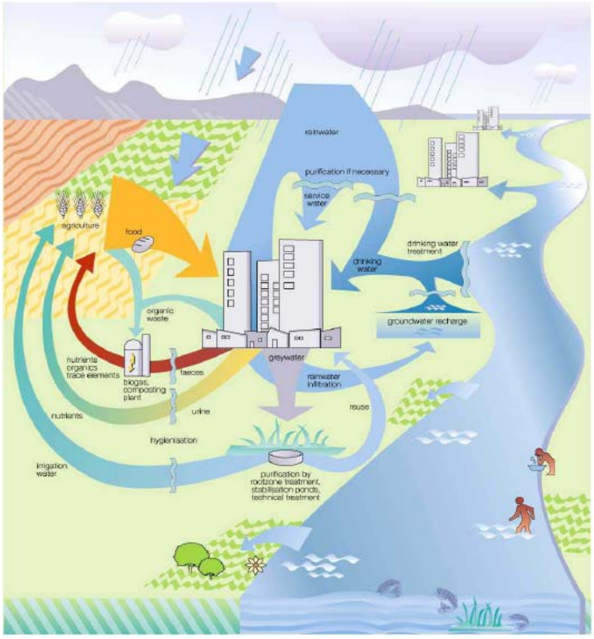
<tr><td>
</td><td>
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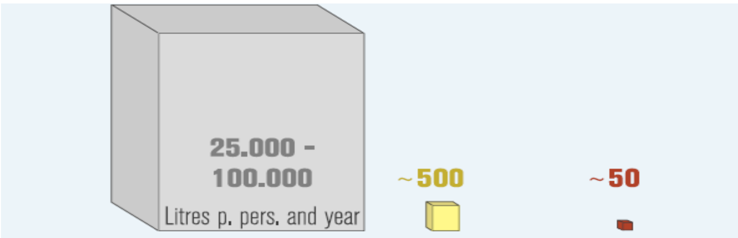
Unsatisfactory purification or uncontrolled discharge of more than 90 %of wastewater worldwide
Precedence of central combined systems in organized disposal
Consumption of precious water for transport
High investment, energy, operating and maintenance costs
Frequent subsidization of prosperous areas, neglect of poor settlements
Pollution of waters by nutrients, hazardous substances, pathogens, pharmaceutical residues, hormones, etc.
Loss of nutrients and trace elements contained in excrement through discharge into waters
Impoverishment of agricultural soils, dependence on fertilizers
Linear end-of-pipe technology

</td><td>

Re-utilization (hygienically safe extraction and use of nutrients, trace elements, water and energy)
Resource conservation (less water consumption, substitution of fertilizer, minimization of water pollution)
Preference for modular, decentralized partial-flow systems
Appropriate, economical solutions
Preservation of soil fertility
Food security
Integral, interdisciplinary approach (household water management, resource conservation,
environmental protection, town planning, (urban) agriculture, irrigation, food security, small enterprise promotion, hygiene)
Material-flow cycle instead of disposal

</td></tr>
</table>

In practice, the ecosan strategies of separation and separate treatment of faeces, urine and greywater minimizes the consumption of valuable drinking water and treats the separate wastewaters at low cost for subsequent use for soil amelioration, as fertilizer or as service or irrigation water.



Yearlyloads kg/P·year		Greywater	Urine	Feaces (option: add biowaste)
N	~4 - 5	~3%	~87%	~10%
P	~0,75	~10%	~50%	~40%
K	~1,8	~34%	~54%	~12%
COD	~30	~41%	~12%	~47%
		Treatment ▼ Reuse / Water Cycle	Treatment ▼ Fertiliser	Biogas-Plant Composing ▼ Soil-Conditioner

Table 1: characteristics of the main components of household wastewater (otterpohl 2001)

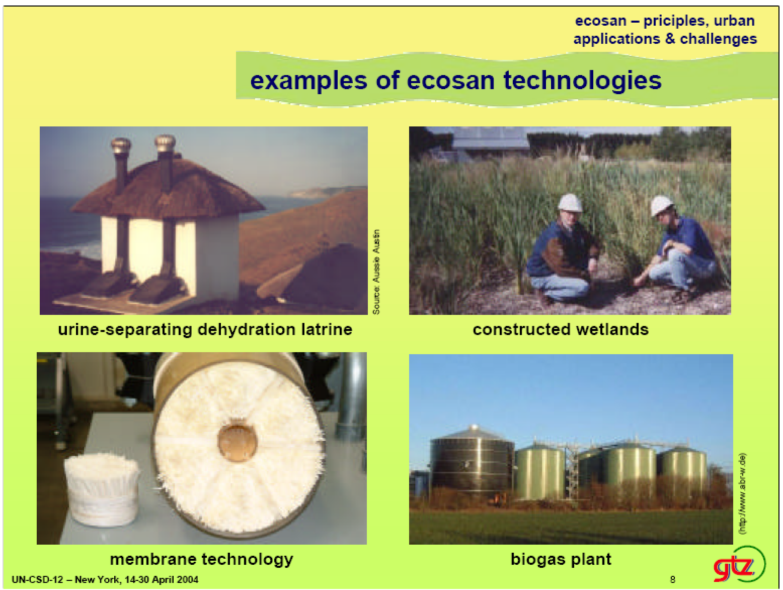
7.3 *Advantages of ecological sanitation*

7.3.1 Advantages to the environment and agriculture

If ecological sanitation could be adopted on a large scale, it would protect our groundwater, drains, water bodies and the sea from faecal contamination. Less water would be consumed (-20%). Farmers would require less expensive commercial fertilizer, much of which today washes out of the soil into surface and groundwater and burning its organic content, thereby contributing to environmental degradation.

Ecosan allows us to make use of the high fertilizer value of urine and the soil-enriching properties of dried or composted faeces. Urine is rich in nitrogen, phosphorous and potassium. Urine is naturally hygienic and can be diluted with water and put directly on vegetable gardens and agricultural fields or saved in underground tanks for later use.

Human faeces can be turned into a valuable soil conditioner rich in carbon, providing both good soil structure and a good medium for essential soil micro-organisms. With ecosan we can replenish the soils, both for agricultural use and to restore wasteland, and continue to enrich those soils more and more over time by tapping a permanent source. Returning human urine and sanitized



faeces to soils on a regular basis has the potential to replenish soil nutrients to levels at which productivity will become sustainable.

Scientists have recently begun to focus on the ability of soils to serve as a sink for excess atmospheric carbon. (In soils carbon is stored in the form of humus and decaying organic matter.) A number of factors influence the accumulation of carbon in soils. Returning sanitized human excreta to degraded lands would play a significant role in this process by increasing the amount of carbon in the soil, enhancing soil fertility, increasing plant growth and hence the amount of CO_2 fixed from the atmosphere through photosynthesis.

7.3.2 Advantages to households and neighborhoods in the villages or small Auroville communities

Individual households can improve their conditions considerably by adopting an ecosan system. Many of the options available are relatively inexpensive and not difficult to build. Households can immediately have the privacy, convenience and aesthetic advantages of an odorless and flyless toilet, attached to or even built right into their homes, however small. This is of course particularly important for women. Groups of households with access only to public toilets and open defecation can improve their neighborhood dramatically.

The nutrition of families can also improve if urine and faeces are recycled to grow additional vegetables in garden plots, on rooftops and balconies or even on walls.

The fertilizer value of recycled urine and the soil-improving properties of decomposed faeces produce excellent crops even from poor soil or soil-less horticulture.

The emptying of ordinary pit toilets and the sludge removal from septic tanks is messy, expensive and technically difficult. In many informal settlements, the vacuum trucks needed for the process cannot negotiate the narrow streets and the steep slopes or a simply not available. If contents are removed by hand, which is illegal in India but constantly practiced, the sludge is smelly, wet and dangerous to the workers. Ecosan systems based on dehydration or decomposition reduce the volume of material to be handled and transported and result in a dry, soil-like, completely inoffensive and easy-to-handle product. As the toilet is built completely above ground there is easy access to the sanitized faeces for recycling and easier management of contents for pathogen destruction.

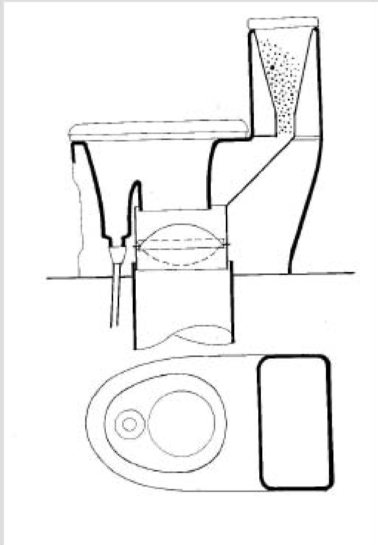
A great problem of building toilets in some areas is the subsoil and groundwater conditions. In Kottakarai area or along the beach the water-table is close to the surface, while further inland the soild is rocky. These conditions prevent or make difficult the construction of pit toilets, VIP toilets or pour-flush toilets. As eco-san toilets can be built entirely above ground, they allow construction anywhere a house can be built, they do not collapse, they do not destabilize the foundations of nearby buildings and they do not pollute the groundwater.

Most of ecosan toilets do not require expensive or high-tech equipment. Jobs can be created for builders and for collectors of urine and sanitized faeces. These products can be sold to farmers or households could use them to grow food. An entire mini-economy could potentially develop around eco-san systems, especially in urban areas.

It must be noted that innovative financial design from TN government to develop ecosan toilets is bringing half of the supportive funds through a loan which can be reimburse through accounted for urine and composted faeces.

From the programs conducted by Auroville's development agencies in the surrounding, many villagers find it attractive to know that if a large area of their community can be made more sanitary, the likelihood of diarrhea and worm infections will decrease, leading to overall better health and better study results for school children. In our area where water born diseases and the related expenses to families are so high, it is of great impact.

7.3.3 Advantages to municipalities



A modern waterless separation toilet has been developed in the China-Sweden Erdos Eco-Town Project (for contact see table 2).

The toilet is designed for use in multi-storey buildings and allows dry faeces collection and separate urine collection.

Made from ceramics, it has the comfort and aestetics of a modern flush toilet.

It is equipped with a flushing device for ash and a mecanism to seal off the drop shaft.

Municipalities all over the world are experiencing greater and greater difficulty in supplying water to households and neighborhoods. In many Indian cities water is rationed and supplied only a few hours a day. Wealthier households collect this water in large tanks while the poor queue up at public taps to receive their daily ration. Ecosan systems reduce the use of these scarce water resources and may result therefore in a more equitable allocation of water to rich and poor households. A major advantage of ecosan systems is that they have the potential to increase sustainable sanitation coverage of the unserved more quickly than any other method. Municipal governments are under increasing pressure to provide sanitation coverage for the entire urban population. Even if there is political will, the options available are severely limited owing to lack of water and/or money (for flush-and discharge systems) and lack of space and/or difficult ground or groundwater conditions (for drop-and-store systems). The Millennium Development Goals will spur on the building of millions of toilets in the developing world over the next few decades. But the tendency will be to fall back onto conventional practices if eco-san is not promoted. Modifying these installations so that they do not contaminate the subsoil and groundwater requires capacity building that remains to be developed. The ecosan options are in general affordable to the poor and have almost no recurrent costs for operation and maintenance. In most cases eco-toilets require no excavation; do not depend on water and pipe networks; can be used even in congested areas; and, as the units have no odor when properly looked after, can be placed anywhere (even inside a house and on upper floors). Ecosan is an inexpensive and attractive alternative to expansion of sewerage systems.

Sophisticated solutions like vacuum toilets are now in use in many places in Europe at cluster level.

Finally, eco-san systems allow, even favor, decentralized urban waste-to-resource management. The burden for guaranteeing a well functioning urban sanitation system is taken from the municipal government and transferred to the neighborhood level where citizens can monitor conditions and take direct action when necessary. The role of municipal government then becomes regulatory with the goal of safeguarding public health.

7.4 A vision for the future

Ecological sanitation, while showing a great scope for the future in Auroville's context, is today at early stages of development.

The future of ecological sanitation lies in seeing its potential and investing further in its research, development and infrastructure. We cannot easily imagine the ecosan systems that may exist 10 or 30 years from now. They will no doubt be much more sophisticated than those available actually.

However, even in the future, the ecosan principles of containment, pathogen destruction and recycling of nutrients may remain much the same, as these are biological principles. The need for recycling is already well understood in Auroville and can only develop further.

With such an emphasis brought on sustainability, innovation and researches, it seems natural than planners and architects will detail Auroville master plan and building designs on ecological principles, including ecological sanitation.

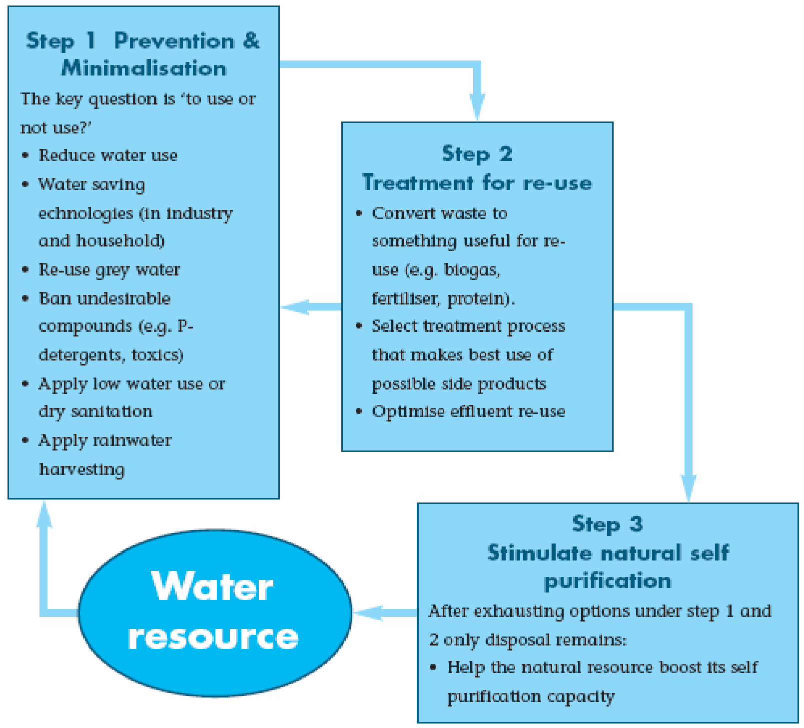
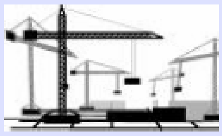
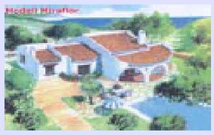


Figure: 3-step approach to select sanitation technology

Basic types of ecosan-projects

Project-type / Characteristics	A	B	C	D
	 rural upgrading	 urban upgrading	 new urban development areas	 non-residential (tourism, schools ...)
• User of sanitation facilities	household	household / neigbourhood	household / neigbourhood	tourists, employees, pupils ...
• User of the end products (Range: in house / other)	household	household (partly) / farmer, external user (partly)	household (partly) / farmer, external user (partly)	user-institution (partly) / farmer, external user (partly)
• Level of initiative and Decision (min / max)	micro / macro	micro / macro	macro	micro / macro
• Considered resources (minimum / optimum)	faeces + urine only / plus greywater, rainwater harvesting, organic waste	faeces + urine + greywater only / plus rainwater harvesting, stormwater management, organic waste	faeces + urine + greywater + stormwater-management / plus rainwater harvesting, organic waste	faeces + urine + greywater + stormwater-management / plus rainwater harvesting, organic waste
• Service provision for operation, transport, treatment and marketing (Range: in house / other)	household	household / public/ private service provider	household / public/ private service provider	user institution / public/ private service provider

The emerging experience of Auroville in ecosan options to rural communities and new settlements as alternatives to today's conventional approaches based on drop-and-store or flush-and-discharge is a promising start, which should be carried further through supportive experiments in new developments.

The most demanding ecosan challenge in the coming years is to develop and implement systems (design operation and maintenance) for urban areas. Around the world there are already examples of eco-san applied to urban areas and densely built-up villages, but the projects are small and scattered. The first major effort to implement a fairly large, comprehensive pilot urban eco-san project in a new town is under way in Erdos municipality (300,000 inhabitants) in Inner Mongolia, China.

Urban or rural – the basic ecosan approach, sanitize-and-recycle, remains the same. The differences are in the technical solutions required for multi-storey buildings, difficulties of reaching large, fluctuating populations with information, the challenges of communal collection systems, and the need to store, transport and treat large volumes of urine, faeces and grey water on-site or within the neighborhood.

8 Integrated Wastewater Management for Auroville

8.1 Basic parameters

8.1.1 Population

The following table has been developed based on Indian population census 2001, projections of population growth for Tamil Nadu (3.5% per year) and the final projected Auroville's population of 50,000 inhabitants and equivalent population as per *Auroville Master plan – Directions for growth*. It is based on the most optimistic figure of entire Auroville population reached by 2026 as planed by Aurofuture.

The projected villages population in Auroville greenbelt is included here as well as the equivalent population related the services nodes and utilities. These figures were not part of the Harald Kraft's study. As well, the projected population for the larger area of the study is presented.

The present population in the villages close to Auroville can only because of the attraction Auroville is creating economically but also for other reasons. The government starts to conduct land acquisition in order to develop new settlements and private investors are looking at this area with a lot of interest.

While not included under this study, the villages surrounding Auroville will most probably attract many activities, institutional, commercial and industrial, in relation to Auroville, and hence will increase the water demand and wastewater generated. As well, the coastal area is planned to host tourist attractions, institutions (Kalapet), but also a growing urban tissue with the related population. In the absence of a proper set of information on these issues, it is decided to limit the parameters to average predicted growth, for far it may be from ground reality in this particularly attractive context. It is recommended to conduct a socio-economic study on this aspect to consolidate the evaluation of the population finally present at term.

	Area	Inhabitants (a)	Equivalent population for commercial and industrial uses (b)	Total
1	**Residential Zone**	40,000	500	40,500
3	**Industrial Zone**	1,800	10,000	11,800
4	**Cultural Zone**	600	3,500	4,100
2	**International Zone**	600	1,500	2,100
5	**City Centre**	5,000	1,500	6,500
6	**Green Belt**			
	Auroville's population	2,000		2,000
	Services Nodes & Utilities (c)		*2,000*	2,000
	Villages population (c)	*25,000*		25,000
	Total for Auroville's area	***75,000***	***19,000***	***94,000***
7	***Other area of the study (c)***	*110,000*		110,000
	Total	**185,000**	**19,000**	**204,000**

Note: EP = Equivalent population
a- According to Auroville's Master Plan
b- as per Harald Kraft's study
c- Not mentioned in previous studies – Based on Indian population survey 2001 and 3.5% population growth.

It should be mentioned that the added population for commercial and industrial uses does not reflect the common values for public services usually developed close to residences, like creches for small children, medical facilities etc, as well for other public facilities which should be highly present in Auroville context to create the required social tissue and interactions between members of the City: collective kitchen, laundry etc. mentioned in *Auroville Master plan – Directions for growth.* As mentioned earlier, such facilities will greatly help to reduce the water demand. The study below must be understand in that perspective and cannot be considered as fully valid in this context.

The proposed consumption for additional water demand, similar to H.Kraft's study, is questionable as it refers to a definition of the activities and related requirements for each area, which is not available for the time being. It is anyhow kept as it is for comparative purpose.

8.1.2 Basic water parameters

8.1.2.1 Auroville

- The water consumption is evaluated to 150 liters per day and per capita: **150lcd**
- The Equivalent Population (EP) is based on the water demand amounting to equivalent volume **150lcd**.
- The wastewater generated is fixed as 85% of the water consumption or **128lcd**.
- By implementing water saving devices systematically, it is evaluated that the water consumption will fall to **120lcd**, while the wastewater generated would be **100lcd** only.

Considering that the technology is already available for a similar cost than conventional ones, that saving water has a huge impact on resources but also on infrastructure, operation and maintenance costs, the following calculation will give the two sets of figures, with and without water saving. The latest will be applied for more detailed calculation on wastewater generation.

8.1.2.2 Villages

- The water consumption is evaluated to **65lcd**
- The wastewater generated is evaluated to 60% of the initial flow or **40lcd**

8.1.2.3 Urbanized and institutional areas

- The water consumption is evaluated to **120lcd** as per Indian standards
- The wastewater generated is evaluated to 75% of the initial flow or **90lcd**.

8.1.3 Potential wastewater flow from various areas

The wastewater flow from areas further than the Greenbelt is not included in the following tables because of the little possibility of direct control to such large and diversified area but also the difficulty to forecast realistic population growth and Land Use pattern. Anyhow the management concept will be discussed in the following section.

8.1.3.1 From Population

	Population	Water demand cum/d	WW cum/d	Water demand with waster saving devices cum/d	WW cum/d
Residential Zone	40,000	6,000	5,100	4,800	3,840
International Zone	600	90	77	72	58
Industrial Zone	1,800	270	230	216	173
Cultural Zone	600	90	77	72	58
City Center	5,000	750	638	600	480
Green Belt	2,000	300	255	240	192
Total for Auroville's own population	***50,000***	***7,500***	***6,375***	***6,000***	***4,800***
Green Belt- Villages population	25,000	1,625	1,138	1,625	1,138
Total	**75,000**	**9,125**	**7,513**	**7,625**	**5,938**

8.1.3.2 From Equivalent population for commercial and industrial uses

	Population	Water demand cum/d	WW cum/d	Water demand with waster saving devices cum/d	WW cum/d
Residential Zone	500	75	64	60	48
International Zone	1,500	225	191	180	144
Industrial Zone	10,000	1,500	1,275	1,200	960
Cultural Zone	3,500	525	446	420	336
City Center	1,500	225	191	180	144
Green Belt	2,000	300	255	240	192
Total	**19,000**	**2,850**	**2,423**	**2,280**	**1,824**

8.1.3.3 Total

	Population	Water demand cum/d	WW cum/d	Water demand with waster saving devices cum/d	WW cum/d
Residential Zone	40,500	6,075	5,164	4,860	3,888
International Zone	2,100	315	268	252	202
Industrial Zone	11,800	1,770	1,505	1,416	1,133
Cultural Zone	4,100	615	523	492	394
City Center	6,500	975	829	780	624
Green Belt	29,000	2,225	1,648	2,105	1,522
Total	**94,000**	**11,975**	**9,935**	**9,905**	**7,762**

8.2 *Concept*

Generally speaking, the concept of wastewater management for Auroville and the surrounding area should follow the frame of sustainable sanitation.

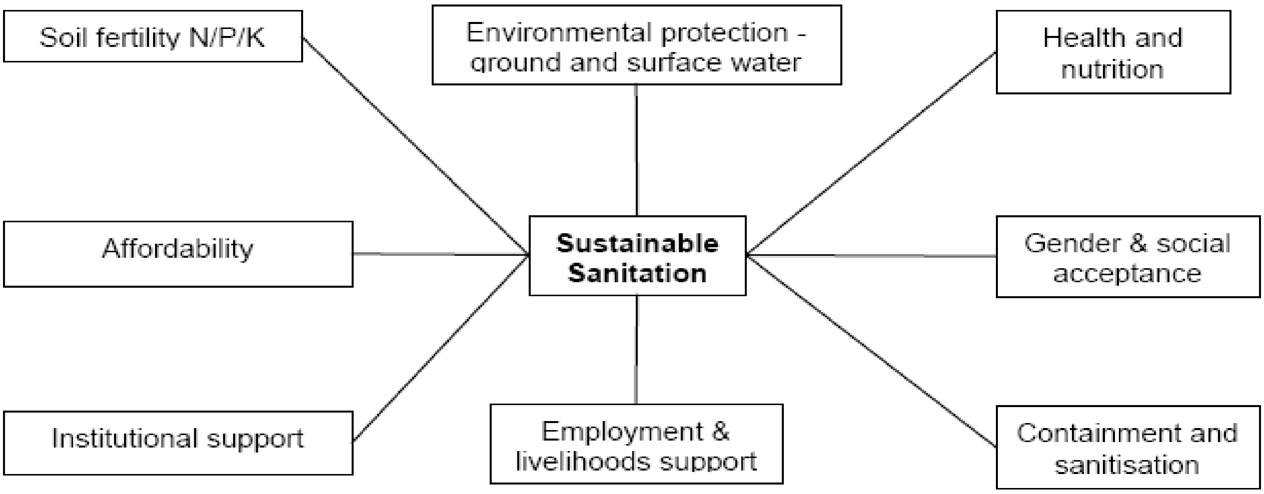


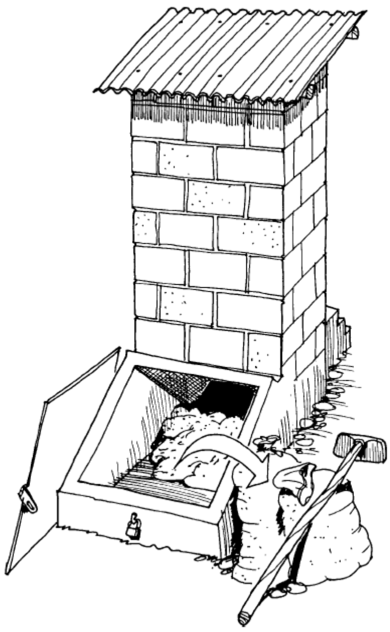
Figure: Components of sustainable sanitation – Source: EcoSanRes Programme Phase 2

8.2.1 The villages

At this stage and looking at the present of experience of Auroville in this domain, the support of the government, the positive response of the population as well as the multiple benefit it generates, it is highly recommended to promote 100% ecosan coverage in the villages.

It can consist of:

- Ecosan household toilets
- Ecosan public toilets in schools, public buildings, community spaces, economic activities etc
- Ecosan community based sanitation (toilets and laundry) close to community village farm lands
- Greywater recycling in kitchen garden wherever possible



Moreover, solid waste must be fully included in the village waste management system.

It can consist of:

- Separation of compost/ non degradable waste
- Household composting
- Community based composting
- Cow dung collection
- Biogas unit for processing of cow dung and part of the degradable waste (digested cow dung through biogas unit does not create weeds proliferation while non properly composted one do).
- Solid waste separation room and dumping yard
- Recycling of compost from toilet, sludge from biogas, other compost and urine for either kitchen garden or field fertilization.
- Selling of non- degradable waste for self financing of the activity.

Accordingly, the various composts digest sludge from biogas units and urine can be collected and recycled either directly in kitchen garden or as a manure source for field cultivation.

Selling of these products and of non degradable wastes can ensure a proper operation of the entire process by income generation

8.2.2 Auroville

8.2.2.1 Fitting with potentials, constraints and demand

Through the combination of several techniques, the effluent can be treated at various degrees, this allowing for appropriate discharge control (chemical, bacteriological, odors) but also to fit to various constraints and demand.

As per WHO standards and Indian standards, the wastewater can be discharged with different level of processing according to the site conditions, the risk of contamination, the potential contact with various kind of population but also the potential for recycling.

For example, if the wastewater is to be recycled close to an area where children are playing, where body contact may occur, or close to housing, some strict control on hygienic aspect but also odors is necessary. If the water is to be used to irrigate fields or greenery, then it can be advantageous to use a relatively organically loaded water which then will act as a fertilizer.

These are the reasons why various standards exist.

Practically, it translated in various technical or combination of technical solutions, which then translate in space requirement etc.

The economical aspect will follow a similar pattern.

It makes then a lot of sense to valorize the infrastructure cost by developing appropriate treatments and recycling at appropriate location.

One must note that an important part of the entire wastewater flow generated in Auroville will come from commercial units, administrations, schools, public facilities and the like. It is there practical and easy to integrate straight forward some of the components of the ECOSAN approach, like waterless urinal. As seen above in this study, the pollution load brought by urine is not negligible while it is easy and sage to handle and very interesting as a fertilizer. By diverting the urine through waterless urinal the space required to treat the wastewater can be reduced, with a related saving on investments.

Indicatively, a DEWATS system for 1000 people will have the following characteristics.

	Full wastewater flow – 120lcd				**With urine separation (Waterless urinal) – 100lcd**				**For Greywater only**			
	m2/ EC	Cost/ EC	m2/ m3	Cost/ m3	m2/ EC	Cost/ EC	m2/ m3	Cost/ m3	m2/ EC	Cost/ EC	m2/ m3	Cost/ m3
CPCB lower standard requirement	0.3	1,800	2.3	15,000	0.3	1,500	2.4	15,000	0.2	800	1.2	8,000
CPCB higher grade	0.4	2,600	3.3	22,000	0.3	1,900	2.9	19,000	0.2	1,400	1.7	15,000
A fully hygienic and odorless discharge would require an extra 0.40m2/EC with the present techniques in use (no mechanical part, no pump, no chemical input)	0.8	3,800	6.7	32,000	0.8	3,300	7.7	33,000	0.6	2,400	5.5	26,000

Note: The costs are for treatment facilities only, without sewer lines and further equipment. The second and 3 series are including the costs for collection equipment of urine or faeces which anyhow remains marginal for such large volume.

8.2.2.2 Future possibility

Concerning other aspects of Ecosan technology (like composting toilets or vacuum line), one cannot conclude at this stage about the pertinence it may present in the future wastewater management of Auroville as it generate many questions not easy to integrate in large building design at this stage. One can only recommend to develop a proper follow-up and trials on this emerging approach, as it will surely generate very interesting solutions in the coming years, completely in line with Auroville's concern for sustainability and innovation.

We would like to underline other techniques which will be play a growing role in wastewater management in the near future.

One is membrane technology. While it is a power demanding technology with rather high investment and O&M costs, it is a fast developing technology for this new field of wastewater treatment. New and cost effective solutions emerge actually, and systems of all sizes are now developed.

An other one, related to integrated development, is roof gardening. In this technology, the greywater is pumped to the roof which is equipped with a planted filter. As greywater is slightly polluted if to compare to black water, appropriate treatment can be achieved with relatively little space. While space at ground level is kept free from such relatively large infrastructure, it is also creating a very interesting effect on the building as it regulates very effectively the temperature inside the building by avoiding overheating in summer and hot climate, and reduce heat lost during winter and cold climate. This concept can even be adapted to vertical walls by using a new approach of vertical landscape called green wall. In the latest case, the entire atmosphere of the building can be regulated for temperature and humidity, creating a very pleasant inner space.

8.2.2.3 Sewer lines

A very important part of the investment and operation and maintenance costs in regard to sewage management is linked to sewer network. Sewers are costly and are usually sized and installed for full capacity, even at very initial stage of development, in order to avoid further damage to roads and other infrastructures. This means heavy immobilization of funds and the risk to waste money because the delay between planning and on the ground development may see the emergence of new concepts or new technical solutions, more appropriate, where such infrastructure may simply be obsolete. This kind of problem is very common in infrastructure development and cannot be underestimated while planning for financial resources mobilization.

The technical solutions available through decentralized technology may help to reduce tremendously this burden by:

- Suppressing the usual network: full treatment and on-site recycling or
- Recycling on-site part of the flow: reduction of sewer size and total volume to treat at pipe ends or
- Conducting part treatment on-site: minimized sewer system

In the last case, the wastewater can be processed until it does not have anymore settling particles. The sewers and related equipments (pumps etc) can then follow the standard designs for water supply and usual water supply pipes. This in turn implies a very important reduction in investment, in running cost, in operation and maintenance, but also a much easier scalability of the entire network.

8.2.2.4 Effluent characteristics

Auroville's core objectives as defined through its Charter is highly connected to highest human ideals where man and nature work together and where the highest human values are nurtured in a close sense of mutual benefits, of sustainability in its deepest sense, of constant progress.

Accordingly, activities harmful to environment or to public health will not find place here, while the individual and social activities and the usual impact they generate must be evolved to promote such concerns.

One can safely assume that Auroville will as much than possible not generate harmful pollutants, and that the wastewater will generally be of domestic characteristics.

Some economic activities or some services may anyhow generate some more difficult to process or potential harmful stuff like hospital or food processing units, cosmetic units etc. Considering that this is definitively specific and limited cases, this cannot be treated within such study.

8.2.2.5 Concept

The wastewater management in Auroville should follow the following criteria.

- Treatment should ensure safe and comfortable discharge as per site constraints
- Recycling must be systematically practiced and valorized
- In-building recycling (toilet flushing) must be integrated in administrations, high density habitats (line of forces) commercial units and collective facilities whenever possible
- Treatment facilities must be steady, reliable, cost effective and long lasting
- Operation and maintenance should be simple and cost effective
- Power demanding solutions must be avoided if not of superior value, all criteria considered
- Chemical inputs must be avoided if not of superior value, all criteria considered
- Mechanical systems and pumps must be avoided if not of superior value, all criteria considered
- Biological beneficial input like EM can be fully part of the process
- Scalability must be part of the concept
- Treat the water close to source when demand is there
- Sewer should be seen as the last options, or in line with large demand (agricultural activities)
- On-site treatment must be studied as a way to reduce size and cost of sewer network.
- Urine separation must be integrated in collective facilities and commercial units.
- Wastewater must be considered and therefore valorized as a resource better than a burden.
- Consultancy, involvement and participation of the population

8.2.2.6 Proposed wastewater management strategy

It is proposed to adapt the solution to the context.

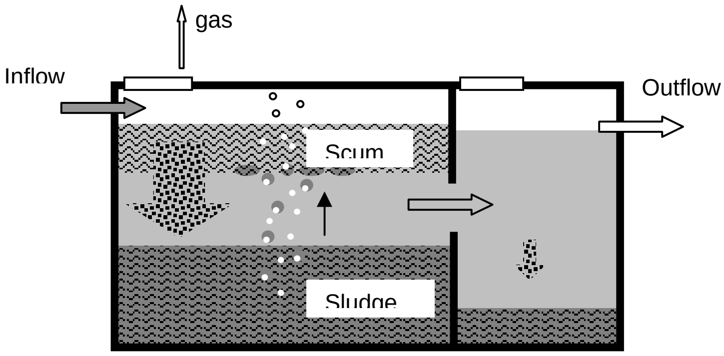
For example:

- It is on principle better to recycle wastewater when available for watering greenery, where and when necessary, than to use fresh water resources.
- In-house recycling, providing hygienic concern is secured, could be of interest in densely populated areas as the necessary double piping it requires is then easy to integrate, while it may raise difficulties, important extra cost and risks for lower density.
- It is better to infiltrate processed wastewater when others recycling are covered if the leftover volume is meager and if the cost of connecting to a sewer line is comparatively not economic.
- Some areas show a relatively important slope which should be used to optimize the design of the system and reduce costs.

8.2.2.7 Proposed components of the treatment systems

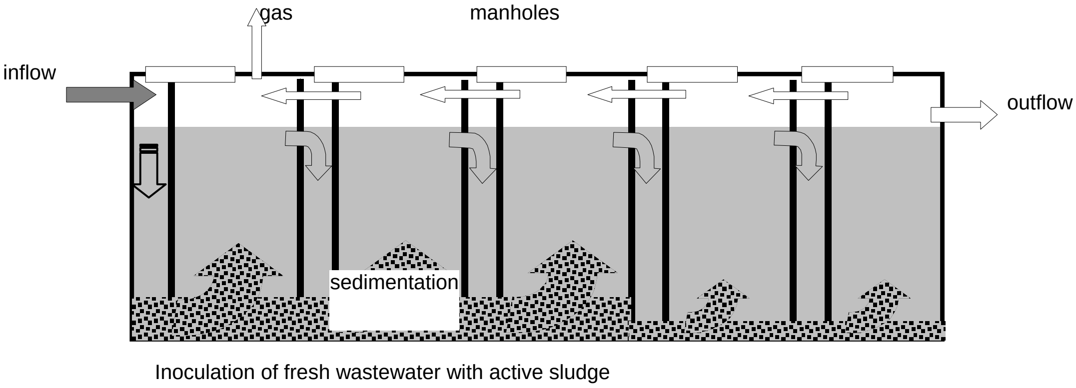
It is proposed to design the treatment systems using DEWATS technology as follow:

1. Collection system
2. Preliminary treatment if necessary (screen, grit trap, grease trap etc)
3. Pre treatment: 2 chambers settlers



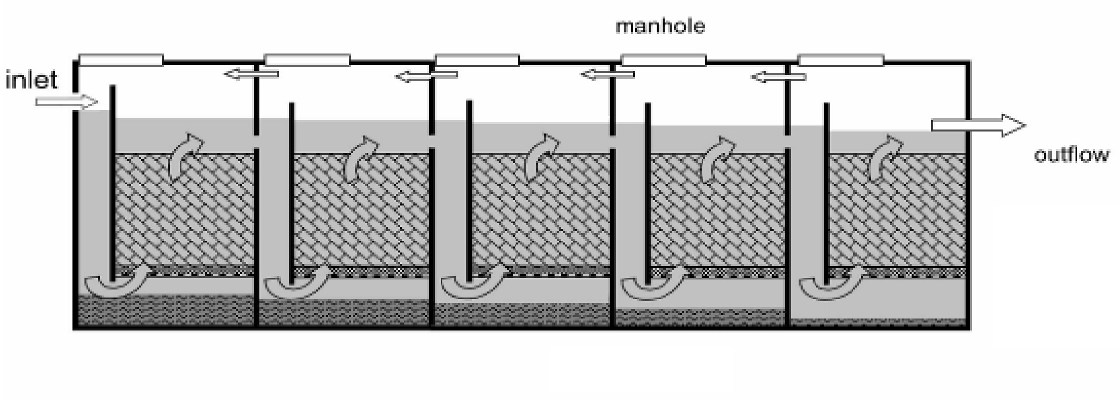
Typical Section of a Settler

4. First treatment: baffled tank reactor



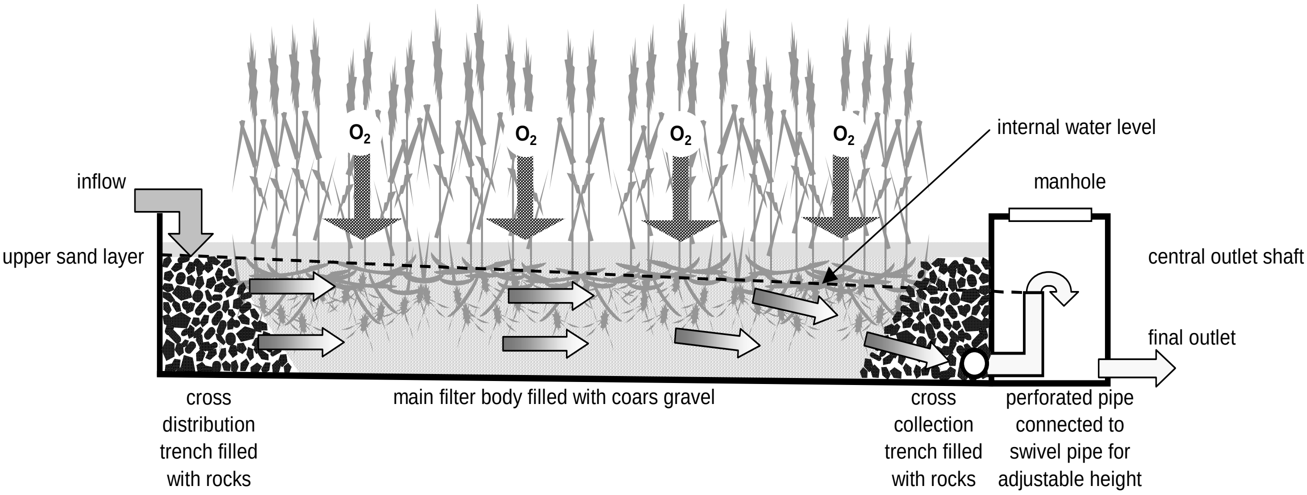
Typical section of an Anaerobic Baffled Reactor

5. Second treatment: anaerobic filter



Typical section of an Anaerobic Filter

6. Third treatment, planted gravel filter



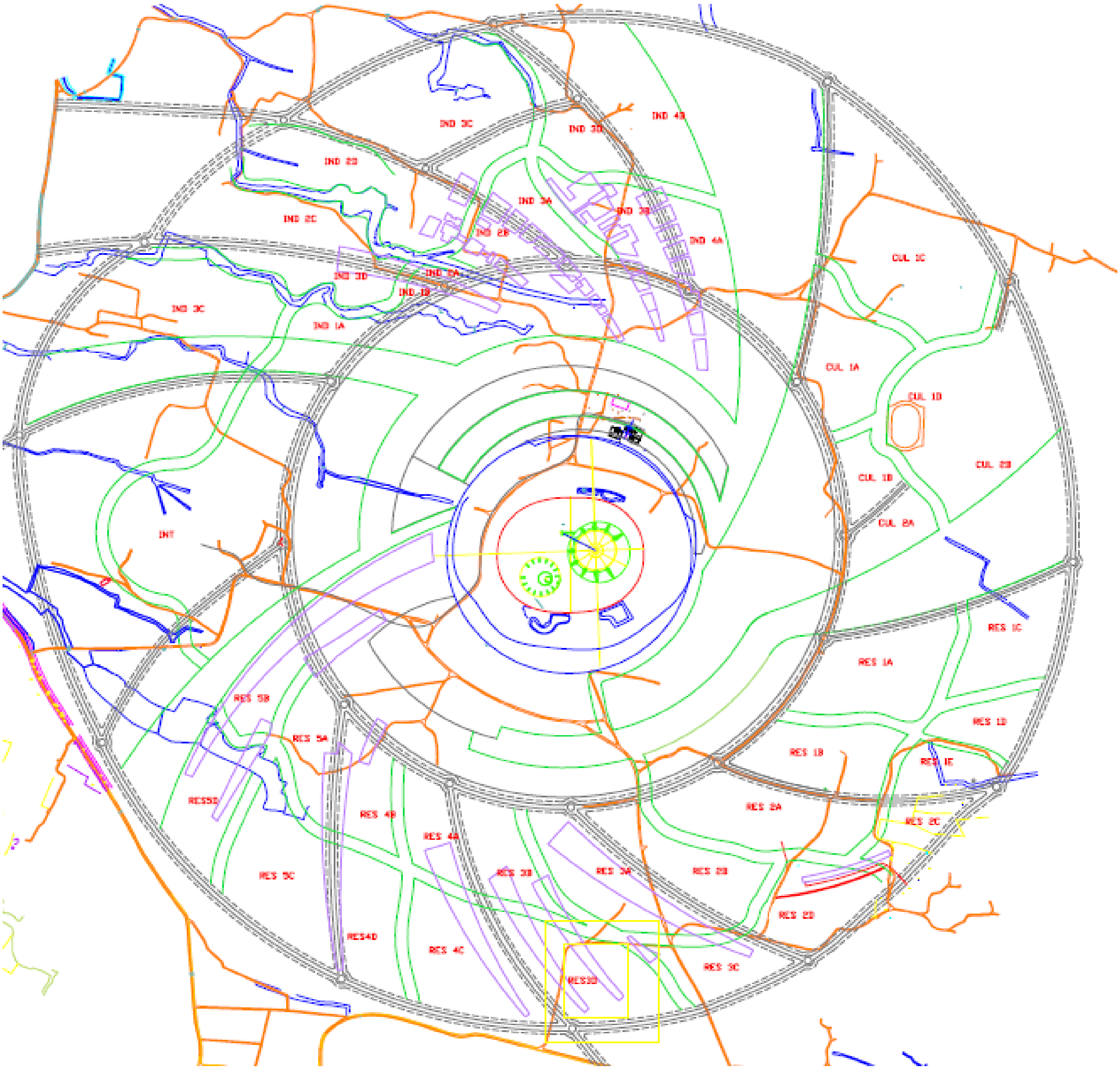
Typical section of Planted Filter

8.2.2.8 Sub-sector analyses

The analyze below is based on sub-sector break-up.

While the evaluation is based on the wastewater generated at this scale, it may be more advantageous to develop the treatment systems by combining or on the contrary by splitting areas.

With the level of information available so far (no detailing of the master plan) it is not possible to go further in details and the ground conditions and development span should dictate the final choices.



Map: Location of the sub-sectors in Auroville.

Note:

a. The areas defined in the table under Sub-sectors are the net areas and do not include the areas under the proposed Green Corridors, Radial & Crown Roads (Auroville Master Plan – Directions for Growth).

b. Water demand is based on 150lcd

c. Water demand with water saving practices is based on 120lcd

d. Wastewater generated is based on 85% of c.

e. On-site recycling demand represents the watering of 7% of the Area (a.) with 6mm height of water per day (evaporation loss compensation). Added to that is the wastewater recycled in-buildings when the density is high (Line of Force) and when the additional water demand is high.

f. Unused wastewater is the difference between d. and e. It is used in further tables to determined if this should be brought forward for other usage (irrigation mainly) or infiltrated on site and accordingly the kind and level of treatment to do.

g. Values in red in the “on-site recycling raw values demand” column indicate that the demand (for irrigation and flushing toilets if any) exceed the wastewater generated.

h. The column “Unused wastewater raw values” appears in the first tables and is corrected in the second one under the name “Unused wastewater “ In the former case, negative figures may appears because of excess demand , while in the latest case the deficits are compensated from sub-sector to sub-sector within the same sector in order to optimize the recycling of wastewater.

i. The space and cost requirement are extrapolated from detailed calculation for a treatment system of 100m3/d. Based on experience, economy of scale will play at least up to 1,000m3/d.

1. Residential Zone

Water balance

Sub-sector Name/ Code	Proposed Population	Area in Ha*	Gross Density PPHa	Additional water demand for commercial or industrial uses EP	Water demand cum/d	Water demand with water saving cum/d	Wastewater generated cum/d	On-site recycling demand cum/d	*Unused wastewater raw values cum/d*
SECTOR 1									
RES. 1A	200	6.89	29	2	30	24	21	29	-8
RES. 1B	327	5.69	57	3	50	40	34	24	10
RES. 1C	190	5.41	35	2	29	23	20	23	-3
RES. 1D	390	2.34	167	4	59	47	40	10	30
RES. 1E	393	2.31	170	4	60	48	40	10	31
SUBTOTAL	**1,500**	**22.64**	**66**	**15**	**227**	**182**	**155**	**95**	**59**
SECTOR 2									
RES. 2A	1,641	8.16	201	16	249	199	169	34	135
RES. 2B	300	4.56	66	3	45	36	31	19	12
RES. 2B (L.O.F.-2)	494	0.89	555	5	75	60	51	15	36
RES. 2C	215	2.23	96	2	33	26	22	9	13
RES. 2D	650	4.1	159	7	98	79	67	17	50
RES. 2D (L.O.F.-1)	200	0.35	571	2	30	24	21	6	14
SUBTOTAL	**3,500**	**20.29**	**172**	**35**	**530**	**424**	**361**	**101**	**259**
SECTOR 3									
RES. 3A	633	6.22	102	6	96	77	65	26	39
RES. 3A (L.O.F.-2)	600	0.91	659	6	91	73	62	18	44
RES. 3A (L.O.F.-3)	236	0.15	1,573	2	36	29	24	6	18
RES.3B	800	3.75	213	8	121	97	82	16	67
RES. 3B (L.O.F.5)	1,728	1.77	976	17	262	209	178	48	130
RES. 3C	2,171	3.31	656	22	329	263	224	64	159
RES. 3D	960	7.25	132	10	145	116	99	30	68
RES. 3D (L.O.F.-4)	872	1.11	786	9	132	106	90	25	65
SUBTOTAL	**8,000**	**24.47**	**327**	**80**	**1,212**	**970**	**824**	**233**	**591**
SECTOR 4									
RES. 4A	1,818	2.9	627	18	275	220	187	54	133
RES. 4B	3,037	3.38	899	30	460	368	313	85	228
RES. 4B (L.O.F.-7)	504	0.31	1,626	5	76	61	52	13	39
RES. 4B (L.O.F.-8)	2,310	2.99	773	23	350	280	238	66	172
RES. 4C	2,307	6.84	337	23	350	280	238	29	209
RES. 4C (L.O.F.-6)	924	1.33	695	9	140	112	95	27	68
RES. 4D	1,100	4.64	237	11	167	133	113	19	94
SUBTOTAL	**12,000**	**22.39**	**536**	**120**	**1,818**	**1,454**	**1,236**	**294**	**943**
SECTOR 5									
RES. 5A	3,110	3.19	975	31	471	377	320	86	235
RES. 5B	431	0.18	2,394	4	65	52	44	11	34
RES. 5B (L.O.F.-11	3,840	5.16	744	38	582	465	396	111	285
RES. 5B (L.O.F.-10	95	0.84	113	1	14	12	10	6	4
RES. 5C	4,901	7.4	662	49	743	594	505	145	360
RES. 5D	1,823	4.23	431	18	276	221	188	60	128
RES. 5D (L.O.F.-9)	800	0.8	1,000	8	121	97	82	22	60
SUBTOTAL	**15,000**	**21.80**	**688**	**150**	**2,273**	**1,818**	**1,545**	**440**	**1,105**
Total	**40,000**	**111.59**	**358**	**400**	**6,060**	**4,848**	**4,121**	**1,163**	**2,958**

Water treatment details

Sub-sector Name/ Code	Proposed Population	Gross Density PPHa	Additional water demand for commercial or industrial uses EP	Wastewater generated cum/d	On-site recycling demand cum/d	Irrigation m3/d	Flushing m3/d	Recharge m3/d	Unused waste water cum/d	On site treatment	On-site space requirement m2	Cost
SECTOR 1												
RES. 1A	200	29	2	21	29	29				4	141	741,744
RES. 1B	327	57	3	34	24	24				4	231	1,212,751
RES. 1C	190	35	2	20	23	23				4	134	704,657
RES. 1D	390	167	4	40	10	10		30		4_3	167	1,112,553
RES. 1E	393	170	4	40	10	10		31		4_3	168	1,118,894
SUBTOTAL	**1,500**	**66**	**15**	**155**	**95**	**95**	**0**	**61**	**0**		**842**	**4,890,599**
SECTOR 2												
RES. 2A	1,641	201	16	169	34	34			135	4_2	545	3,659,901
RES. 2B	300	66	3	31	19	19		12		4_3	170	983,322
RES. 2B (L.O.F.-2)	494	555	5	51	15	4	11	36		4_3	222	1,026,525
RES. 2C	215	96	2	22	9	9		13		4_3	106	656,759
RES. 2D	650	159	7	67	17	17		50		4_3	282	1,863,495
RES. 2D (L.O.F.-1)	200	571	2	21	6	1	5	14		4_3	90	415,120
SUBTOTAL	**3,500**	**172**	**35**	**361**	**101**	**85**	**16**	**124**	**135**		**1,415**	**8,605,121**
SECTOR 3												
RES. 3A	633	102	6	65	26	26			39	4_2	269	1,644,042
RES. 3A (L.O.F.-2)	600	659	6	62	18	4	14		44	4_2	223	930,528
RES. 3A (L.O.F.-3)	236	1,573	2	24	6	1	5	18		4_3	102	477,691
RES.3B	800	213	8	82	16	16			67	4_2	261	1,766,988
RES. 3B (L.O.F.5)	1,728	976	17	178	48	7	40		130	4_2	626	2,615,600
RES. 3C	2,171	656	22	224	64	14	50		159	4_2	807	3,368,270
RES. 3D	960	132	10	99	30	30			68	4_2	366	2,328,286
RES. 3D (L.O.F.-4)	872	786	9	90	25	5	20		65	4_2	320	1,336,300
SUBTOTAL	**8,000**	**327**	**80**	**824**	**233**	**103**	**130**	**18**	**573**		**2,974**	**14,467,704**
SECTOR 4												
RES. 4A	1,818	627	18	187	54	12	42		133	4_2	678	2,830,288
RES. 4B	3,037	899	30	313	85	14	71		228	4_2	1,105	4,617,328
RES. 4B (L.O.F.-7)	504	1,626	5	52	13	1	12		39	4_2	179	747,291
RES. 4B (L.O.F.-8)	2,310	773	23	238	66	13	54		172	4_2	849	3,543,712
RES. 4C	2,307	337	23	238	29	29			209	4_2	677	4,795,113
RES. 4C (L.O.F.-6)	924	695	9	95	27	6	21		68	4_2	342	1,427,615
RES. 4D	1,100	237	11	113	19	19			94	4_2	349	2,390,580
SUBTOTAL	**12,000**	**536**	**120**	**1,236**	**294**	**94**	**200**	**0**	**943**		**4,179**	**20,351,927**
SECTOR 5												
RES. 5A	3,110	975	31	320	86	13	72		235	4_2	1,127	482,328
RES. 5B	431	2,394	4	44	11	1	10		34	4_2	151	27,216
RES. 5B (L.O.F.-11)	3,840	744	38	396	111	22	89		285	4_2	1,414	780,192
RES. 5B (L.O.F.-10)	95	113	1	10	6	4	2	4		4	67	352,328
RES. 5C	4,901	662	49	505	145	31	114		360	4_2	1,821	1,118,880
RES. 5D	1,823	431	18	188	60	18	42		128	4_2	705	639,576
RES. 5D (L.O.F.-9)	800	1,000	8	82	22	3	19		60	4_2	289	120,960
SUBTOTAL	**15,000**	**688**	**150**	**1,545**	**440**	**92**	**348**	**4**	**1,101**		**5,575**	**3,521,480**
Total	**40,000**	**358**	**400**	**4,121**	**1,163**	**469**	**694**	**208**	**2,752**		**14,985**	**51,836,831**

2. Industrial Zone

Water balance

Sub-sector Name/ Code	Proposed Population	Area in Ha*	Gross Density PPHa	Additional water demand for commercial or industrial uses EP	Water demand cum/d	Water demand with water saving cum/d	Wastewater generated cum/d	On-site recycling demand cum/d	*Unused wastewater raw values cum/d*
SECTOR 1									
IND. 1A	20	1.5	13	111	20	15	12	8	5
IND. 1A (L.O.F.- 12	-	1.1	-					5	
IND. 1B		0.17	-					1	
IND. 1B (L.O.F.- 13	-	1.06	-					4	
IND. 1C	50	9.49	5	278	49	37	31	43	-12
IND.1D	50	2.89	17	278	49	37	31	15	16
SUBTOTAL	**120**	**16.21**	**7**	**667**	**118**	**88**	**75**	**76**	**9**
SECTOR 2									
IND. 2A	-	0.21	-					1	
IND. 2B	350	1.68	208	1,946	344	256	218	29	188
IND. 2B (L.O.F.- 14	-	1.24	-					5	
IND. 2C	50	5.84	9	278	49	37	31	28	3
IND. 2D	150	7.4	20	834	148	110	93	41	53
SUBTOTAL	**550**	**16.37**	**34**	**3,058**	**541**	**402**	**342**	**104**	**244**
SECTOR 3									
IND. 3A	200	2.11	95	1,112	197	146	124	22	103
IND. 3A (L.O.F.- 15	-	0.64	-					3	
IND. 3B	250	3.34	75	1,390	246	183	155	30	125
IND. 3B (L.O.F.- 16	-	11.58	-					49	
IND. 3C	350	12.45	28	1,946	344	256	218	75	143
IND.3D	-	2.18	-					9	
SUBTOTAL	**800**	**32.30**	**25**	**4,448**	**787**	**585**	**497**	**187**	**371**
SECTOR 4									
IND. 4A	200	2.92	68	1,112	197	146	124	30	95
IND. 4B	130	8.75	15	723	128	95	81	48	33
SUBTOTAL	**330**	**11.67**	**28**	**1,835**	**325**	**260**	**205**	**78**	**128**
TOTAL	**1,800**	**76.55**	**24**	**10,008**	**1,771**	**1335**	**1,119**	**444**	**752**

Water treatment details

Sub-sector Name/ Code	Proposed Population	Gross Density PPHa	Additional water demand for commercial or industrial uses EP	Wastewater generated cum/d	On-site recycling demand cum/d	Irrigation m3/d	Flushing m3/d	Recharge m3/d	Unused wastewater cum/d	On site treatment	On-site space requirement m2	Cost
SECTOR 1												
IND. 1A	20	13	111	12	8	6	1			4	85	447,739
IND. 1A (L.O.F.- 12	-	-			5	5						
IND. 1B		-			1	1						
IND. 1B (L.O.F.- 13	-	-			4	4						
IND. 1C	50	5	278	31	43	40	3			4	213	1,119,348
IND.1D	50	17	278	31	15	12	3			4	213	1,119,348
SUBTOTAL	**120**	**7**	**667**	**75**	**76**	**68**	**8**	**0**	**0**		**511**	**2,686,435**
SECTOR 2												
IND. 2A	-	-			1	1						
IND. 2B	350	208	1,946	218	29	7	22		182	4_2	621	3,532,284
IND. 2B (L.O.F.- 14	-	-			5	5						
IND. 2C	50	9	278	31	28	25	3	3		4	213	1,119,348
IND. 2D	150	20	834	93	41	31	10		53	4_2	400	2,065,824
SUBTOTAL	**550**	**34**	**3,058**	**342**	**104**	**69**	**35**	**3**	**235**		**1,233**	**6,717,456**
SECTOR 3												
IND. 3A	200	95	1,112	124	22	9	13		100	4_2	378	2,119,644
IND. 3A (L.O.F.- 15	-	-			3	3						
IND. 3B	250	75	1,390	155	30	14	16		77	4_2	382	1,887,696
IND. 3B (L.O.F.- 16	-	-			49	49						
IND. 3C	350	28	1,946	218	75	52	22		134	4_2	819	4,291,308
IND.3D	-	-			9	9						
SUBTOTAL	**800**	**25**	**4,448**	**497**	**187**	**136**	**51**	**0**	**311**		**1,580**	**8,298,648**
SECTOR 4												
IND. 4A	200	68	1,112	124	30	12	13		95	4_2	389	2,146,464
IND. 4B	130	15	723	81	48	37	8		33	4_2	384	1,913,213
SUBTOTAL	**330**	**28**	**1,835**	**205**	**78**	**49**	**21**	**0**	**128**		**774**	**4,059,677**
TOTAL	**1,800**	**24**	**10,008**	**1,119**	**444**	**322**	**115**	**3**	**675**		**4,098**	**21,762,216**

3. Cultural Zone

Water balance

Sub-sector Name/ Code	Proposed Population	Area in Ha*	Gross Density PPHa	Additional water demand for commercial or industrial uses EP	Water demand cum/d	Water demand with water saving devices cum/d	Wastewater generated cum/d	On-site recycling demand cum/d	*Unused wastewater raw values cum/d*
SECTOR 1									
CUL.1A	100	5.66	18	583	102	82	70	30	39
CUL.1B	20	2.08	10	117	20	16	14	10	4
CUL.1C	425	15.18	28	2,478	435	348	296	190	106
CUL.1D	-	4.18	-					18	
SUBTOTAL	**545**	**27.10**	**20**	**3,177**	**558**	**447**	**380**	**248**	**149**
SECTOR 2									
CUL. 2A	30	2.57	12	175	31	25	21	13	8
CUL. 2B	25	8.07	3	146	26	20	17	36	-18
SUBTOTAL	**55**	**10.64**	**5**	**321**	**56**	**45**	**38**	**48**	**-10**
TOTAL	**600**	**37.74**	**16**	**3,498**	**615**	**492**	**418**	**296**	**139**

Water treatment details

Sub-sector Name/ Code	Proposed Population	Gross Density PPHa	Additional water demand for commercial or industrial uses EP	Wastewater generated cum/d	On-site recycling demand cum/d	Irrigation m3/d	Flushing m3/d	Recharge m3/d	Unused wastewater cum/d	On site treatment	On-site space requirement m2	Cost
SECTOR 1												
CUL.1A	100	18	583	70	30	24	7		39	4_2	299	1,561,203
CUL.1B	20	10	117	14	10	9	1	4		4	95	501,595
CUL.1C	425	28	2,478	296	190	64	126		89	4_2	1,505	3,888,655
CUL.1D	-	-			18	18						
SUBTOTAL	**545**	**20**	**3,177**	**380**	**248**	**114**	**134**	**4**	**128**		**1,899**	**5,951,453**
SECTOR 2												
CUL. 2A	30	12	175	21	13	11	2			4	143	752,393
CUL. 2B	25	3	146	17	36	34	2			4	119	626,994
SUBTOTAL	**55**	**5**	**321**	**38**	**48**	**45**	**4**	**0**	**0**		**262**	**1,379,387**
TOTAL	**600**	**16**	**3,498**	**418**	**296**	**159**	**138**	**4**	**128**		**2,162**	**7,330,840**

4. International Zone

Water balance

Sub-sector Name/ Code	Proposed Population	Area in Ha*	Gross Density PPHa	Additional water demand for commercial or industrial uses EP	Water demand cum/d	Water demand with water saving devices cum/d	Wastewater generated cum/d	On-site recycling demand cum/d	*Unused wastewater raw values cum/d*
SECTOR 1									
INT. 1A	25	2.91	9	63	13	11	9	13	-4
INT.1B	105	2.22	47	263	55	44	37	15	23
SUBTOTAL	**130**	**5.13**	**25**	**325**	**68**	**55**	**46**	**28**	**19**
SECTOR 2									
INT.2A	70	17.49	4	175	37	29	25	75	-50
INT. 2B	400	16.67	24	1,000	210	168	143	91	52
SUBTOTAL	**470**	**34.16**	**14**	**1,175**	**247**	**197**	**168**	**166**	**2**
TOTAL	**600**	**39.29**	**15**	**1,500**	**315**	**252**	**214**	**194**	**20**

Water treatment details

Sub-sector Name/ Code	Proposed Population	Gross Density PPHa	Additional water demand for commercial or industrial uses EP	Wastewater generated cum/d	On-site recycling demand cum/d	Irrigation m3/d	Flushing m3/d	Recharge m3/d	Unused wastewater cum/d	On site treatment	On-site space requirement m2	Cost
SECTOR 1												
INT. 1A	25	9	63	9	13	12	1			4	61	321,300
INT.1B	105	47	263	37	15	9	5	19		4	257	1,349,460
SUBTOTAL	**130**	**25**	**325**	**46**	**28**	**22**	**6**	**19**	**0**		**318**	**1,670,760**
SECTOR 2												
INT.2A	70	4	175	25	75	73	2			4	171	899,640
INT. 2B	400	24	1,000	143	91	70	21	2		4	978	4,203,252
SUBTOTAL	**470**	**14**	**1,175**	**168**	**166**	**143**	**23**	**2**	**0**		**1,149**	**5,102,892**
TOTAL	**600**	**15**	**1,500**	**214**	**194**	**165**	**29**	**20**	**0**		**1,467**	**6,773,652**

5. City Centre

No detailed break-up sub-sector wise is available. The evaluation is based on the entire population and presented in the Recapitulative.

6. Green Belt Zone

No detailed break-up sub-sector wise is available. The evaluation is based on the entire population and presented in the Recapitulative.

8.2.2.9 Recapitulative

Water balance

	Proposed Population	Area in Ha*	Gross Density PPHa	Additional water demand for commercial or industrial uses EP	Water demand cum/d	Water demand with water saving cum/d	WW cum/d	On-site recycling demand cum/d	*Unused wastewater raw values cum/d*
Residential Zone	40,000	111.59	358	400	6,060	4,848	4,121	1,163	2,958
Industrial Zone	1,800	76.55	24	10,008	1,771	1,335	1,119	444	752
Cultural Zone	600	37.74	16	3,498	615	492	418	296	139
International Zone	600	39.29	15	1,500	315	252	214	194	20
City Centre	5000	94.83	53	1500	975	780	663	531	132
Green Belt	2000	NA	NA	2000	600	480	408	41	367
Total	**50,000**	**360.00**	**466**	**18,906**	**10,336**	**8,187**	**6,943**	**2,669**	**4,368**

Water treatment details

	Proposed Population	Gross Density PPHa	Additional water demand for commercial or industrial uses EP	WW cum/d	On-site recycling demand cum/d	Irrigation m3/d	Flushing m3/d	Recharge m3/d	Unused wastewater cum/d	On site treatment	On-site space requirement m2	Cost
Residential Zone	40,000	358	400	4,121	1,163	469	694	208	2,752	4_3_2	14,985	51,836,831
Industrial Zone	1,800	24	10,008	1,119	444	322	115	3	675	4_2	4,098	21,762,216
Cultural Zone	600	16	3,498	418	296	159	138	4	128	4_2	2,162	7,330,840
International Zone	600	15	1,500	214	194	165	29	20	0	4	1,467	6,773,652
City Centre	5000	53	1500	663	531	398	132	0	132	4_2	3,939	19,099,130
Green Belt	2000	NA	2000	408	41	41	0	0	367	4_2	1,124	8,078,400
Total	**50,000**	**466**	**18,906**	**6,943**	**2,669**	**1,553**	**1,109**	**235**	**4,054**		**27,774**	**114,881,068**

Say 115,000,000 Rs, or 11.5 Crores of Rupees.

Code:

0	No treatment
1	Settling only
2	CPCB lower grade - 100mg/l BOD
3	CBCB higher grade - 30mg/l COD
4	Hygienizing < 1000 e.coli/100ml

8.2.2.10 Explanation and comments

- The “Irrigation” column refers to the local demand (greenery and watering of gardens).
- All the wastewater is processed at least to level 2, in order to reduce the cost of transportation (sewers and pumps if any)
- All wastewater recycled on-site is processed at least to level 3 in order to avoid clogging of recharge devices if any
- All wastewater recycled in the city area for greenery or in-building (flushing) is processed at level 4.
- In some cases, part of the wastewater is recharged in the ground after appropriate treatment (level 3). This choice is linked to the relatively limited volume not used on site and/or to the important extra cost a sewer brought in the sub-sector or sector will represent. It is mainly the sector 1 and 2 of the Residential Zone.
- Concerning the space requirement evaluation, it is based on the proposed on-site treatments as specified.
- The cost evaluation includes the piping connection and related visiting boxes to the treatment, the pretreatments (screen, grease trap, grit trap) if any, the treatment facilities, and the storage tanks for recycling when and where necessary.
- The present evaluation does not include further expenses related to “Unused wastewater” which is planned to be brought to irrigated land, or practically the sewer network. It must be noted that no further treatment will be required down the line for recycling for agriculture purpose. As well, no pumping equipment will be required as the water can be transported by gravity to the irrigated areas.
- As no details are made available for the City Centre, the demand for recycling for local irrigation (greenery) is not consolidated.

8.2.2.11 Operation and maintenance

The proposed setup is working by gravity only and is showing very low maintenance demands.

- The systems do not needs pumps to function. Hence, no electrical charges are planed.
- The collection pipes, grit trap, screen, grease trap require regular maintenance for checking and cleaning. Say once in 6 months for the visiting boxes (which can be conducted during the visit to the main equipments), once a month for the screen and grit traps, and once a day for the grease trap. The latest will be present only close to large kitchen and restaurant and should be taken care of by the related staff. Hence no specific human resources or charges are related.
- The settlers are designed for a desludging interval of 2 years. For 100m3/d of wastewater, the sludge volume to be removed after 2 years will be of 43m3. Desludging should occur through a suction unit properly equipped. It is anyhow good to inspect the settlers twice a year.
- The baffled reactors can be desludged only once in 5 years if the settlers are properly maintained (desludged). For 100m3/d of wastewater, the sludge volume to be removed after 5 years will of 50m3. Desludging should occur through a suction unit proper equipped. It is anyhow good to inspect the baffled reactors twice a year.
- The anaerobic filters are located after the baffled reactors and do not present significant sludge accumulation through time if the former equipments are properly maintained. It is anyhow good to inspect the anaerobic filters twice a year.

- The planted gravel filters need to be cropped twice a year in order to clean the filter and enhance purification through vegetation growth. The same time period will be used for inspection.

The numbers of treatment systems is not defined at this level of study as no detailed planning is available yet.

Nevertheless, in order to come to an idea about the operation and maintenance cost of such proposal, once can assume that:

1. Each sub-sectors as defined above will be equipped with one system
2. The City Centre will be equipped with 5 systems localized as per wastewater flow and demand.
3. The Greenbelt will be equipped with say 15 main systems.

So, all together the entire city can be covered with 80 systems.

Accordingly, the operation and maintenance cost can be covered as follow:

	Period in annum				
	Regular visit	Main maintenance	**Main Operation**	**Cost per unit**	**Total cost per annum**
Grease trap	NA	NA	NA		
Screen and grit trap	1/12	1/12	Cleaning	2 man hour (50Rs/h/worker)	96,000
Visiting boxes	1/2	NA	NA		
Settler	1/2	2	Desluding of 43m3	1000Rs/m3	1,720,000
Baffled Reactor	1/2	5	Desluding of 50m3	1000Rs/m3	800,000
Anaerobic Filter	1/2	NA	NA		
Planted Gravel filter	1/2	1/2	Plants cutting	2 man day (400Rs/d/worker), 2500Rs transport charges	528,000
Through the year man power				2 workers (400Rs/d/worker)	292,000
Unforseen				*10%*	315,000
				Total	**3,751,000**

8.2.2.12 Conclusion and recommendation

8.2.2.12.1 General conclusion

<u>Scalability</u>

As described above, the proposed solution can be developed in a modular and scalable way. This is allowing for maximum flexibility in adjusting with constraints, space availability, discharge, capital mobilization and span of development

<u>Investment</u>

The present study demonstrates that it is possible to treat all the wastewater flow generated by Auroville through decentralized means in a cost effective way.

By applying judicious on site treatment, recycling related to specific demands, site conditions and other infrastructure development costs, one comes to the conclusion that the wastewater can be treated integrally for an investment cost of **11.5 Crores** of Rupees (about **2.1M€** at a rate of 55Rs/€) or 43,000Rs per m3.

Note: Comparatively to Harald Kraft's study, the investment cost for the present proposal is **24%** (without sewer lines).

<u>Space requirement</u>

The space requirement for the proposed system is of about **28,000 m2**.

In some sub-sector evaluation, chiefly in residential zone, the space requirements come to more than 1000m2, which may be difficult to integrate. While it is not possible at this stage of study to come to a final conclusion, it is easy to install the treatment facilities on the direct external area of the concerned sector without major cost increase.

Note: Comparison with space requirement in Harald Kraft proposal.

Description of the Treatment Plant West		**m2**
Inhoff Tanks	3 units of w/l/h: 11 m x (2 x 8m) x 16,9 m	528
trickling filter	(1 unit of Æ/h: 15,6 m x 4,2 m; 2 unit of Æ/h: 16,2 m x 4,2 m)	768
Dortmund Tank	(1 unit of Æ/h: 11,5 m x 10,3 m; 2 unit of Æ/h: 12,0 m x 10,7 m)	420
Root Zone Treatment Plant (RZTP)	5 ha	50,000
Storage of treated waste water for re-use	storage tank of 5.800 m³ for domestic waste water and 2.100 m³ for the industrial waste water	*3,634*
	Total	**55,350**

Description of the Treatment Plant East		
Imhoff tank	(1 units of w/l/h: 11 m x (2 x 8m) x 16,9 m)	176
trickling filter	1 unit of Æ/h: 16,2 m x 4,2 m	262
Dortmund Tank	1 unit of Æ/h: 12,0 m x 10,7 m	144
Root Zone Treatment Plant (RZTP)	17.000 m².	17,000
Storage of treated waste water for re-use	storage tank of 2.600 m³	*1,196*
	Total	**18,778**

Total space requirement	**74,129**

Hence, the space requirement for the present proposal is 38% of H.Kraft's one.

Operation and maintenance

It is evaluated that the entire operation and maintenance of the treatment facilities can be covered by 2 workers. Regular visit, desludging, cleaning, grass cutting etc, will generate extra operation costs.

A total of **3,800,000 Rs/a** is estimated for this entire program.

Note: H.Kraft's proposal shows a O&M cost of 36.466.000 RS/a. Hence the present proposal has a O&M cost of 10% of the H.Kraft one.

8.2.2.12.2 Matrimandir

Matrimandir Gardens

It must be noted that all the water demand for the Matrimandir Inner Gardens (around 200m3/d) can be covered by the wastewater generated by the area actually planed for immediate development and so-called Administration-Habitat area. It is highly favorable, cost effective and highly sustainable to tap this resource to irrigate the garden better than to extract groundwater for such purpose.

Matrimandir Lake

Moreover, it is evaluated that 132m3/d (48,270m3/y) of wastewater will be generated from the City Centre and unused. When considering that the Matrimandir lake with its 160,000m2 will have a net water lost (evaporation minus rainfall) of about 70,000m2/y, it is very interesting to recycle this unused wastewater, after adequate processing of course, as it will greatly help to compensate the deficit for a negligible cost.

8.2.2.12.3 Other Recommendations

Waterless urinal

While the technology is mature enough the above evaluation does not include waterless urinal because of not enough details available. It can easily be included in some buildings (schools, collective kitchen, administrative setup, factories etc) as mentioned earlier which will reduce further the investment cost, the space requirement and the water demand.

It is recommended to include it while going through detailed planning.

Other Ecosan solutions

Considering the large effort conducted worldwide to develop enhanced wastewater management practices and integrated sanitation solutions, such technology is bound to evolve very fast.

It is hence essential to keep alert about emerging concept and new technical solutions.

Membrane technology

Membrane technology is a fast moving sector. One can predict that it will play a major role in the future management of wastewater all over the world. One should keep an eye on this promising but power consuming technology to see if it can fit with sustainable factors and other particular concerns for Auroville's development.

ANNEXE

Standards for Discharge of Environmental Pollutants: Effluents
Central Pollution Control Board

SN	Parameter	Inland surface water	Public sewers	Land for irrigation	Marine/coastal areas
	2		3		
	.	(a)	(b)	(c)	(d)
1	Colour and odour	See 6 of Annexure-1I		See 6 of Annexure-1I	See 6 of Annexure-1I
2	Suspended solids mg/l, max.	100	600	200	(a) For process waste water (b) For cooling water effluent 10 per cent above total suspended matter of influent.
3	Particle size of suspended solids	shall pass 850 micron IS Sieve	-	-	(a) Floatable solids, solidsmax. 3 mm (b) Settleable solids, max 856 microns
4	pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
5	Temperature	shall not exceed 5°C above the receiving water temperature			shall not exceed 5°Cabove the receiving water temperature
6	Oil and grease, mg/l max,	10	20	10	20
7	Total residual chlorine, mg/l max	1	-	-	1
8	Ammonical nitrogen (as N),mg/l, max.	50	50	-	50
9	Total kjeldahl nitrogen (as N);mg/l, max. mg/l, max.	100	-	-	100
10	Free ammonia (as NH3), mg/l,max.	5	-	-	5
11	Biochemical oxygen demand BOD (3 days at 27oC), mg/l, max.	30	350	100	100
12	Chemical oxygen demand COD, mg/l, max.	250	-	-	250
13	Arsenic(as As).	0.2	0.2	0.2	0.2
14	Mercury (As Hg), mg/l, max.	0.01	0.01	-	0.01
15	Lead (as Pb) mg/l, max	0.1	1	-	2

16	Cadmium (as Cd) mg/l, max	2	1	-	2
17	Hexavalent chro-mium (as Cr + 6),mg/l, max.	0.1	2	-	1
18	Total chromium (as Cr) mg/l, max.	2	2	-	2
19	Copper (as Cu)mg/l, max.	3	3	-	3
20	Zinc (as Zn) mg/l, max.	5	15	-	15
21	Selenium (as Se)	0.05	0.05	-	0.05
22	Nickel (as Ni) mg/l, max.	3	3	-	5
23	Cyanide (as CN) mg/l, max.	0.2	2	0.2	0.2
24	Fluoride (as F) mg/l, max.	2	15	-	15
25	Dissolved phos- phates (as P),mg/l, max.	5	-	-	-
26	Sulphide (as S) mg/l, max.	2	-	-	5
27	Phenolic compounds (as C6H50H)mg/l, max.	1	5	-	5
28	Radioactive materials: (a) Alpha emitters micro curie mg/l, max. (b)Beta emittersmicro curie mg/l	$10.^{-7}$ $10.^{-6}$	$10.^{-7}$ $10.^{-6}$	$10.^{-7}$ $10.^{-6}$	$10.^{-7}$ $10.^{-6}$
29	Bio-assay test	90% suivival of fish after 96 hours in 100% effluent	90% suivival of fish after 96 hours in 100% effluent	90% suivival of fish after 96 hours in 100% effluent	90% suivival of fish after 96 hours in 100% effluent
30	Manganese	2 mg/l	2 mg/l	-	2 mg/l
31	Iron (as Fe)	3mg/l	3mg/l	-	3mg/l
32	Vanadium (as V)	0.2mg/l	0.2mg/l	-	0.2mg/l
33	Nitrate Nitrogen	10 mg/l	-	-	20 mg/l

Valuing Decentralized Wastewater Technologies

Financial planning and financial risk: The small unit size of decentralized system allows closer matching of capacity to actual growth in demand. Decentralized capacity can be built house-by house, or cluster-by-cluster, in a “just in time” fashion. This provides a number of important benefits. It moves capital costs of capacity to the future, typically reducing the net present value of a decentralized approach. The result is often a more economical approach than building centralized treatment capacity or extending sewers (depending on many other factors). Spreading out capital costs also typically means that a community needs to incur less debt, compared to the borrowing requirements of a large up-front capital investment in capacity. This can reduce the financing costs for the community. The “build-as-you-go” aspect of decentralized systems also means that if less growth occurs than first predicted, the community is not stuck with overbuilt capacity and a large debt load that must be spread across fewer than expected residents. Making decentralized investments over time also means that a community can easily adjust its technology choices as improved or cheaper technologies become available. Further, expensive nutrient removal technologies can be targeted to only the locations that are nutrient sensitive, as opposed to upgrading treatment of all the community’s wastewater at a centralized plant. Some potential financial disadvantages of decentralized systems are that the large number of systems can increase design, permitting, financial, and other transaction costs of a wastewater service strategy. Also, lenders may perceive individual and small wastewater system debt as riskier investments compared to municipal borrowing, so the unit costs of debt may be higher. Decentralization also concentrates the financial risks of individual system failures on individuals or clusters of residents, in contrast to the insurance-like spreading of risks of failure across large numbers of users that centralized systems can provide. For both centralized and decentralized systems, it is very important that financial planning provides for depreciation and eventual replacement of wastewater assets.

Community and watershed impacts: Decentralized options expand the toolbox of growth management strategies available to communities. In particular, small-scale wastewater systems enable cluster-style development, which has many economic, environmental, and social benefits. On the other hand, in communities without adequate planning and zoning in place, decentralized systems can result in costly haphazard growth. Decentralized systems can also help a community avoid unwanted annexation or regional sewer extensions, thus maintaining the community’s autonomy and character. In terms of water quality, smaller wastewater systems may have more or fewer negative impacts on the surface water environment than larger systems, depending on many factors. The same is true of risks to public health presented by wastewater systems. Hydrologically, decentralized systems can avoid drawdown of water tables and reductions in stream base flow that can occur because of infiltration and inflow and other alterations to a watershed water budget caused by sewers. Decentralized systems can also address fairness and equity issues in communities: they are less likely to raise questions over the distribution of costs and benefits of wastewater investments, and they avoid the “double-payment” penalty that occurs when sewers replace recently installed onsite systems. Finally, decentralizing infrastructure tends to reduce the economic stakes involved in wastewater planning, which can help avoid breakdown of relationships and trust within a community.

Onsite and neighborhood impacts: While centralized wastewater systems are essentially out of sight and mind for most property owners (excepting payment of sewer bills), onsite and cluster systems require greater awareness and participation, with attendant non-monetary costs. With respect to aesthetic issues such as visual impacts and odors, centralization tends to create substantial impacts on small areas (around treatment plants), while decentralization tends to widely distribute impacts that are individually less significant. Aesthetic impacts can be mitigated through technology and design choices, but this has costs that may affect the relative economics of wastewater options. System scale may affect how a building can be located on a property, or affect other ways the property can be used. This has impacts on property values. In retrofit and repair/replacement situations, upgrading decentralized systems generally requires less disruption to properties and neighborhoods than construction of sewers.

Capital and O&M (operation and maintenance) costs: Smaller systems lose the advantages of economies of scale that are possible in wastewater treatment capital costs and O&M costs. However, smaller systems also avoid diseconomies of scale that are inherent in sewer systems. Given that collection system costs can be 80 percent or more of total systems costs, collection diseconomies of scale can overwhelm treatment economies of scale, resulting in decentralized systems being the more economical choice. However, high effluent standards tend to favor centralization, although it is possible to produce high quality effluent with some decentralized technologies. Some of these technologies, such as small-scale constructed treatment wetlands, may be more land-intensive.

Integration with other infrastructure: By avoiding the capital and operational expenses of large redistribution networks, decentralized wastewater systems provide opportunities for cost-effective reuse of water at the site and neighborhood scale. However, onsite and cluster systems do not provide the quantities of water necessary for large water users such as industrial facilities and large landscapes, which in some communities will be the most cost-effective application of reclaimed wastewater. Integration of stormwater systems is also possible in some wastewater reuse schemes, typically at medium to larger system scale.

Management: Management activities generally exhibit economies of scale, which can be attained either by centralized systems or “centralized management of decentralized systems.” In some cases management requirements for decentralized systems are simpler and less costly than those for centralized systems.

Reliability, vulnerability, and resilience: Wastewater system reliability, vulnerability to natural hazards and inadvertent or deliberate disruption by humans, and resilience once disturbances have occurred, depend on many factors that can vary with or be independent of system scale. On average, the risks and costs of wastewater system failure are probably less for decentralized systems than centralized systems, because the consequences of small, widely distributed failures are limited while the consequences of large, concentrated failures can be severe.

Decentralization Benefits, Costs, and Considerations

Decentralization benefit: Where smaller scale tends to produce a benefit or save on a cost relative to larger scale.
Decentralization cost: Where smaller scale tends to produce a cost relative to larger scale, or fails to obtain a benefit available at larger scale.
Decentralization consideration: Where there is no clear tendency for smaller scale to be beneficial or costly relative to larger scale. Rather, the relative benefits and costs of different scale systems depend very strongly on the specific nature of the situation and the available wastewater options.

Financial Planning and Financial Risk

Decentralization benefit

- By (typically) moving capacity costs to the future, the net present value of costs for decentralized systems is reduced compared to centralized systems of similar or even somewhat higher nominal costs.
- Decentralized systems can reduce the net present value of wastewater system costs by deferring or downsizing the need for replacement systems.
- Decentralized systems can help extend the useful service life of existing conventional infrastructure.
- The small unit size of decentralized systems allows closer matching of growing demand for wastewater capacity; therefore, less money is tied up in overbuilt capacity.
- Decentralized systems can shorten project lead time—e.g. the construction period—further reducing the cost of tying up funds unproductively.
- In cases when future demand fails to meet expectations, additional scheduled increments of decentralized capacity can be foregone, avoiding the cost of overbuilt centralized capacity.
- The flexibility of decentralized resources allows managers to adjust capital investments continuously and incrementally, more exactly tracking the unfolding future, with continuously available options for modification or exit to avoid trapped equity.
- Modular, short-lead-time technologies valuably temporize: they buy time, in a self reinforcing fashion, to develop and deploy better technologies, learn more, avoid premature decisions, and make better decisions. The faster the technological and institutional change, the greater the turbulence, and the more uncertain are future needs, the more valuable this time-buying ability becomes.
- Smaller, quick-to-build units of decentralized wastewater capacity offer flexible options to planners seeking to minimize regret, because capacity can be added or foregone to match actual demand.
- Shorter lead-time and smaller size reduce the planning horizon, consequently decreasing the amplification of errors in forecasting demand with the passage of time.
- Because decentralized systems often cost less to plan and design than centralized systems, they generate less exposure to lost costs if a plan is turned down by voters or regulators.
- Short lead-time units of decentralized wastewater infrastructure expose a utility to the financial costs of construction delays and capital cost escalations far less than large, slower-to-build treatment plants and major collection system expansions.
- The low operating costs of many decentralized technologies expose a utility and system users to less financial risk from variation and escalation in energy and other operating costs.
- Even when per unit operating costs of decentralized systems are higher, overall system costs may be less susceptible to inflation and other cost escalations when decentralized systems carry less excess capacity than centralized systems.
- A decentralized strategy for capacity expansion is less likely to result in sunk costs in older technologies and instead allows for rapid response to technological change.
- Decentralized systems may allow upgrades to be focused on a small subset of a community’s capacity, saving substantial capital costs.
- Decentralized systems, by spreading costs over time rather than concentrating costs up front, are more likely to not require borrowing, or to require less borrowing, than centralized systems.
- By reducing borrowing increments, decentralized systems strain a utility or community’s financial resources less, thereby improving its financial indicators, which may lead to better terms on debt (e.g. as a result of better bond ratings).

Decentralization cost

- Decentralized systems may increase the transaction costs of upgrading facilities.
- Decentralization concentrates the direct financial risks (e.g. replacement costs) of system failure or inadequacy on individuals and small groups, in contrast to the insurance-like spreading of these financial risks in centralized and regional systems. This concentration of risk can impose catastrophic costs on users.
- To the extent decentralized systems require a community to increase the number of times it borrows funds, they may increase the "transaction costs" associated with borrowing.
- To the extent decentralized systems shift borrowing from a community or utility to entities with smaller assets and revenue sources (e.g. individual homeowners for onsite systems, homeowners' associations for cluster systems), lenders may perceive debt as a riskier investment and the cost of debt, for instance, the interest rates, may increase.

Decentralization consideration

- Because cluster systems tie-up more time and money in permitting and implementation than do conventional onsite systems, developers may favor onsite systems and the potential benefits of cluster systems may be foregone.
- Real impacts of failure, exposure to liability for harm to others or to penalties under law, and the financial resources to survive a finding of liability for a wastewater system failure vary in unclear ways with system scale.
- Some technologies used in decentralized wastewater systems may allow a project to be reversed and downsized more easily than typical centralized systems, which have a higher proportion of assets in custom-constructed components or buried in the sewer network. However, centralized treatment systems may have greater value for in-situ reuse, and the market for used conventional wastewater treatment plant components is probably stronger than that for used decentralized system components.
- Decentralized systems may be more or less eligible than conventional systems for certain grants, low-interest loans, and other alternative financing.
- Decentralized systems allow a community to shift project costs and financing costs to developers or private property owners.
- Financial planning for any scale of wastewater system must provide for depreciation and replacement of assets.

Community and Watershed Impacts

Decentralization benefit

- Decentralized wastewater systems expand the toolbox of strategies to manage growth and promote "smart growth": they can help avoid sewer-induced sprawl and help direct the location and form of growth as desired by the community.
- Through reduced density or improved site layout (e.g. with cluster development), decentralized systems can help reduce the proportion of impervious surface in a landscape, thereby cutting pollutant loading to surface water bodies and maintaining groundwater recharge.
- Smaller systems can help a community resist unwanted annexation or regional sewer extensions, thus maintaining the community's character, independence and control over other services.
- Decentralized systems likely keep more money circulating within a local economy—supporting local income and creating local jobs—than centralized or regionalized systems of similar lifecycle cost.
- Decentralized systems avoid the hydrologic impacts that centralized collection systems can cause or contribute to. These include lower water tables, drawdown of aquifers, and reductions in stream base flow.
- Installation and operation of decentralized systems are likely to cause less disturbance to riparian zones than larger sewer systems.
- Smaller systems are less likely to raise questions over the distribution of their costs and benefits.
- Maintaining decentralized systems as permanent solutions avoids the "double payment" problem sewers can create.
- Centralization increases the expertise required of system managers and operators, and therefore the compensation required to retain them, perhaps to a point that generates ill will in some small communities.
- Decentralizing infrastructure units tends to reduce the political and economic "stakes" involved in a wastewater facility decision. This can reduce community conflict and its associated costs.

- By breaking borrowing needs into smaller amounts that occur periodically as a community grows, decentralized systems can help avoid mistrust and rate shock brought on by large borrowing for capacity that will not be fully used for years.
- Smaller systems lend themselves to local decisions, enhancing public comprehension and legitimacy.

Decentralization cost

- In communities without adequate planning, zoning, and other growth management tools in place, decentralized systems can result in haphazard growth and its attendant costs.

Decentralization consideration

- Direct stream flow augmentation from any scale system may be beneficial or detrimental.
- Smaller wastewater systems may have a more or less impact than larger systems on surface water chemistry and ecology, and thereby create economic implications for communities, depending on many factors.
- Smaller wastewater systems may generate greater or lesser public health risks than larger systems, depending on regulations, enforcement, technology, design and construction, O&M, and other factors.
- Occupational health and safety risks and hazards to the public vary by technology and system scale and should be considered when system choices are made.

Onsite and Neighborhood Impacts

Decentralization benefit

- Centralization intensifies undesirable system characteristics that induce public resistance and loss of value for neighboring properties.
- Odor control is typically less of a concern with smaller systems.
- Decentralization allows for preservation of open space and its attendant values without the costs of unnecessary infrastructure.
- Advanced decentralized systems may allow the development of otherwise undevelopable property, thereby creating or maintaining property value.
- In retrofit and repair/replacement situations, decentralized systems generally require less disruption of properties and neighborhoods.

Decentralization cost

- While centralized wastewater systems are essentially out of sight and mind for most property owners (excepting payment of sewer bills), onsite and cluster systems require greater awareness and participation, with attendant non-monetary costs.
- The greater the degree of decentralization, the greater the limit on development density. Where higher density is desirable, this may result in an inability to maximize property value.

Decentralization consideration

- Visual impacts of wastewater systems on sites and neighborhoods may occur with any scale system.
- Both centralized and decentralized systems can be noisy or quiet, depending on the technology chosen.
- Serving areas with decentralized systems rather than sewers can affect the affordability of properties.
- System scale may affect how a building or set of buildings can be located on a property, which may impact development costs and property value.
- Some wastewater systems may increase the value of the subject property or adjacent properties because of a perception that the system is particularly novel, sustainable, or valuable environmentally.
- Decentralized systems displace and constrain other uses of a site to a lesser degree than centralized systems. The cumulative impact of dispersed, lower impacts of decentralized systems in this respect, versus more intense and concentrated opportunity costs of centralized systems, is not clear.

Capital and O&M Costs

Decentralization benefit

- Smaller systems avoid diseconomies of scale in wastewater collection systems.
- Smaller systems can avoid the high costs of installing large pipes and can take maximum advantage of alternative technologies that cost less to install.
- Smaller systems have shorter pipe lengths per connection served.

- Smaller systems have a lower ratio of large pipes versus small pipes, thus reducing the use of more expensive large pipes.
- Smaller systems may need fewer manholes or none at all.
- Smaller systems often have lower requirements for pumps than larger systems.
- Decentralization resulting in different technology choices may dramatically shift the nature and frequency of required O&M activities, in some cases reducing O&M costs below that of a centralized system serving the same area.
- To the extent that a sewer system adds to property value, using instead an onsite system results in lower property tax payments.

Decentralization cost

- Smaller systems miss economies of scale in wastewater treatment systems.
- Very small wastewater facilities require higher capacity per capita in order to manage variability in hydraulic loads produced per connection.
- High effluent standards tend to favor centralized treatment.
- Smaller treatment systems typically require more material per unit of capacity.
- Because of the large number of treatment units and effluent discharge points inherent in decentralized systems, capital costs of equipment for monitoring equivalent to that undertaken at centralized wastewater treatment plants would be substantially higher.
- Smaller systems lose economies of scale that are possible in wastewater system operation and maintenance.
- For a given technology, labor costs exhibit economies of scale; decentralizing that treatment technology will result in increased labor costs per unit of capacity.
- Because decentralized treatment systems are dispersed, they probably require more travel for inspection, operation, and maintenance than more centralized systems.
- Because of the large number of treatment units and effluent discharge points inherent in decentralized systems, costs for ongoing monitoring equivalent to that undertaken at centralized wastewater treatment plants are substantially higher.
- In the specific case of ownership of onsite systems by a private responsible management entity, the onsite system becomes a taxable asset, and the taxes become an additional cost in comparison to a publicly owned sewer system.

Decentralization consideration

- As system scale decreases, per unit costs of treatment plant construction typically increase.
- Smaller systems are more likely to use alternative sewers that do not require extra treatment plant capacity to manage infiltration and inflow loads typical of gravity sewer systems.
- Minimum design flow requirements may result in onsite and cluster systems that are underloaded, affecting their ability to function properly.
- Decentralization can be used to isolate waste generators that produce high hydraulic or mass loads (e.g., BOD loads of restaurants, hydraulic and pollutant loads of industrial facilities) in order to reduce the capacity and treatment needs such facilities place on public systems.
- Land area requirements and siting constraints may favor or disfavor smaller systems.
- Smaller systems are more likely to use “off the shelf” technologies, while larger systems tend to require more sophisticated, customized engineering. However, smaller systems may require more sensitivity to site conditions throughout a service area. A decentralized approach may have greater up-front planning costs.
- The sum of permit fees paid to entities outside the community may be less or greater for decentralized systems than centralized ones. Transaction costs to obtain permits may push decisions toward more or less decentralization.
- Depending on the treatment technology chosen, monitoring capital costs per capita may be lower or higher for decentralized systems than for centralized systems.
- Decentralization usually results in different technology choices, which may have lower or higher labor costs per unit of capacity across the whole system than a more centralized system would.
- Decreasing treatment plant size for a given technology will tend to lose economies of scale from bulk purchase of chemicals, but many decentralized technologies require no chemicals or less than those required for some centralized systems.
- Decentralized systems may require more or less routine parts and materials replacement than centralized systems serving the same population.

– Technologies used for decentralized systems tend to generate lower quantities of biosolids or require less biosolids handling. This may reduce the per capita costs of residuals management.
– Periodic permit fees and other fees paid to government bodies in order to operate a wastewater system can range from nonexistent to substantial and may or may not be significant on a per capita basis.
– Depending on the technology chosen, ongoing monitoring costs per capita may be lower or higher for decentralized systems than for centralized systems.
– Insurance to cover the costs of repairing or replacing a failed system or system component would constitute an operating cost if chosen, but is only just beginning to be available to wastewater system owners.

Infrastructure Synergies: Benefits of Integration

Decentralization benefit

– By avoiding the capital and operational expenses of large re-distribution networks, decentralized wastewater systems provide opportunities for cost-effective reuse of water at the site and neighborhood scale.
– Decentralized systems allow for closer control of sources contributing to biosolids, which may provide benefits in improved biosolids quality. Further, new approaches to dry or ultra-low-water sanitation systems based on urine/feces separation offer opportunities for improved capture and use of nutrients in human waste.

Decentralization cost

– Onsite and cluster systems do not provide the quantities of water necessary for large water users such as industrial facilities and large landscapes, which in some communities will be the most cost-effective application of wastewater reuse.
– Decentralized systems do not provide the necessary control and scale to cost-effectively produce energy through sewage sludge digestion and combustion of the resulting methane.

Decentralization consideration

– Integration of wastewater and stormwater systems can be considered, under particular conditions, across a range of scale.
– Additional opportunities for integration of wastewater and other systems may be favorable for decentralized systems, while others may be more appropriate for centralized systems.

Management

Decentralization consideration

– Management activities generally exhibit economies of scale, which can be attained either by centralized systems or “centralized management of decentralized systems.” In some cases management requirements for decentralized systems are simpler and less costly than those for centralized systems.
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Reliability, Vulnerability, and Resilience

Decentralization benefit

– On average, the risks and costs of wastewater system failure are probably less for decentralized systems than centralized systems, because the consequences of small, widely distributed failures are limited while the consequences of large, concentrated failures can be severe.

Decentralization consideration

– System reliability depends strongly on the inherent reliability of the chosen treatment processes and on proper operation and maintenance—factors that can vary with or be independent of system scale.
– As a whole, decentralized systems may be somewhat less vulnerable to natural hazards and deliberate sabotage, but are perhaps more vulnerable to system misuse and inadvertent interference. Much depends on the particular technology, local conditions, and prevention and mitigation measures.
– Diversity of treatment units, ease of repair, and other factors may make decentralized systems more resilient than centralized ones, but technology choices and local conditions will affect comparative resilience.