Pondicherry Sewage Plant

and

Associated Ground Water Study Proposal

A Potential for Water Recycling

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Executive Summary

Currently 13 Million Litres per day (MLD) of sewage collected from the urban limits of Pondicherry is treated to primary quality in four large facultative oxidation ponds connected in series, and then discharged to an infiltration field or used to irrigate crops. It is believed that most of the discharge is directly recharging the groundwater at this point. Currently only basic information on the water quality of this discharge is available, with little understanding on the impact on the groundwater. A complicating factor is the presence of an operational solid waste dump adjacent to the ponds. Overflow from the ponds is mixing with the solid waste, and this leachate is infiltrating into the ground. Similarly there is no understanding as to whether this leachate is impacting the groundwater. During the monsoon there is a potential for substantial overflow with widespread dissemination of raw or partially treated sewage. Besides impacting ground and surface water, monsoonal runoff could impact a number of human settlements living very close to the sewage farm.

A new UASB Reactor followed by duck weed and fish ponds is about to come into operation, although it is only designed to treat 2.5 MLD, with the remaining 10.5 MLD continuing to be discharged as before. Due to population growth and increased investment in sewage collection, the volume of sewage received at the treatment facility is projected to increase to about 70 – 80 MLD over the next 30 years. At this stage no new treatment facilities are being built and therefore any increase in sewage will be added to the current four facultative ponds, and discharged. As a result retention time will decrease as water volume increases, with a concurrent decrease in primary treatment of the discharge.

Understanding the source, transport and attenuation of chemicals and human pathogens from a point source such as the Pondicherry Waste Water Treatment Plant is fundamental to effective management of the risks posed by these pollutants. This proposal details a new project by Center for Scientific Research & Auroville Water Harvest with the primary focus of quantifying the magnitude of the risk at the source, and secondly will begin the process of elucidating transport mechanisms, and broadly the larger impact on the groundwater. This second part is more difficult to quantify as transport and attenuation processes may cause substantial changes to the initial effluent discharged, for example dispersion, sorption and chemical or biological degradation of the chemicals. Such attenuation processes potentially act to mitigate the impact of chemicals and are a function of both the specific chemical and geologic domain around Pondicherry. This proposed study will allow Water Harvest to make substantial gains in its plan to implement its Integrated Water Management Plan for the Auroville/Tamil Nadu/Pondicherry bioregion.

This large volume of water represents a high scope for recycling, providing the sewage is treated at appropriate level. The present scenario of massive ground water infiltration of polluted water and irrigation of limited area while creating massive danger, can anyhow not scope with the increasing load the treatment facilities will handle soon. Larger usage in the surrounding can be done only on the area North of the treatment facilities as the area South is largely under rampant urbanization process. The North area is offering a large scope for irrigation but also groundwater depletion remediation.

In summary this project proposes to evaluate:

- Water quality of influent and effluent at the Pondicherry Sewage Treatment Facility
- The basic hydrology of groundwater under and around the Treatment Facility
- To identify and set up an appropriate borehole groundwater monitoring program to evaluate what impact recharge from the Waste Water Treatment Facility and associated Solid Waste Facility is having on groundwater.
- To rapidly identify the scope for recycling after proper processing of sewage

TABLE OF CONTENTS

Introduction

Auroville Centre for Scientific Research (CSR) is an international voluntary organization working towards a sustainable future. CSR is registered as a trust under the Auroville Foundation, which itself was constituted by an act of Parliament, Auroville Foundation Act no 54 1988. CSR was founded on January 6th, 1984. From April 1998 CSR was registered under two trusts - both operating under the Auroville Foundation; one for research activities, Auroville Centre for Scientific Research Trust, the other for commercial activities, Aurore Trust.

Under Csr Trust are functioning at present 8 units. During its 21 years of existence CSR has been instrumental in initiating applied research activities in the field of:

Appropriate building technologies: ferrocement and earth technology are two areas of widely acknowledged expertise.

Renewable energy, in the field of biomass, wind and solar.

Water, wastewater treatment and sanitation.

The transfer of the applied research achieved in these technologies takes place through regular training programs, workshops, seminars and publications.

CSR's involvement in water and sanitation has increased steadily over the last two decades. Activities and developments in the area of natural wastewater treatment systems took place from 1995 onwards, when CSR received a grant from the European Union, via BORDA (a German NGO), to build several wastewater treatment plants for study and demonstration of the viability of DEWATS (Decentralized Waste Water Treatment Systems). A second EU project with Borda-India took place from 2002 to 2004. Through partnership programs in China, Indonesia and India, the natural decentralized wastewater treatment technology is now fully developed for implementation in rural and semi-urban situations. Dewats treats domestic wastewater and industrial effluents with similar characteristics. CSR is part of the CDD (Consortium for Dewats Dissemination) which is a group of 27 diverse institutions working towards the wider promotion and implementation of Dewats in India and the South Asian region. At present more than 200 Dewats systems are operating within India.

Auroville Water Harvest is a unit under Auroville Centre for Scientific Research Trust.

The technical facility of Auroville Water Harvest started in 1986 (then called Auroville Water Service), progressing with its main activities of drinking water supply and sanitation, concentrated in Auroville and the nearby ten villages.

Since 1995 salt water intrusion has been monitored in the coastal aquifers, mostly as a consequence of over-pumping of ground water and the decay of the monsoon harvesting tanks. The impending environmental problems motivated AWS to embark on a strategy to control the ecological damage, and devise an integrated water management for the bioregion. The environmental, social, technical and economical challenges are all interconnected, hence “AUROVILLE WATER HARVEST” an integrated development agency was launched on 15th August 1996.

Today Auroville Water Harvest has evolved into a Center for Water Resource Management with multidisciplinary project teams tackling a broad array of water issues. Major projects include: Rainwater harvesting, Tank Rehabilitation, Ground Water Resource Investigation, Environmental awareness & education, Community Mobilization, among others.

As part of CSR-Auroville Water Harvest's Integrated Water Management program a new project is proposed here to evaluate the impact of the Pondicherry Waste Water Treatment Plant on the groundwater.

Understanding the source, transport and attenuation of chemicals and human pathogens from a point source such as the Pondicherry Waste Water Treatment Plant is fundamental to effective management of the risks posed by these pollutants. This proposal details a new project by CSR-Auroville Water Harvest with the primary focus of quantifying the magnitude of the risk at the source, and secondly will begin the process of elucidating transport mechanisms, and broadly the larger impact on the groundwater. This second part is more difficult to quantify as transport and attenuation processes may cause substantial changes to the initial effluent discharged, for example dispersion, sorption and chemical or biological degradation of the chemicals. Such attenuation processes potentially act to mitigate the impact of chemicals and are a function of both the specific chemical and geologic domain around Pondicherry. This proposed study will allow CSR-Auroville Water Harvest to make substantial gains in its plan to implement its Integrated Water Management Plan for the Auroville/Tamil Nadu/Pondicherry bioregion.

Scope for cooperation

It is our understanding that MIT together with the Smithsonian Institute has developed a technique to clean water with the help of algae. It is also our understanding that this has been tested in temperate climate only, at pilot scale in continuing process, at large scale in continuous process and in batch process as well in a bay where the water is polluted by large amounts of fertilizers and pesticides.

It is not yet known how the technique will function in tropical conditions and to a certain extent how it performs in treating sewage water. We at Auroville are interested in principle to assist you with investigations at pilot scale to treat sewage under tropical conditions. For this a pilot scheme at the Pondicherry wastewater Treatment Plant could be proposed where we have established a good basis for cooperation.

CSR-Auroville Water Harvest is very much interested to work MIT and the Smithsonian Institute on the development of this technique and would like to establish communication with these institutes directly in order to work out mutually agreeable conditions for cooperation.

Concerning the pollution aspect and related impact, CSR-Auroville Water Harvest plan to develop a partnership with Hydron Flevoland, Netherlands. Water Harvest will collect and prepare all water samples. Some preliminary water quality studies will be done in India while the more sophisticated analysis of metals and organic constituents will be done at Hydron Flevoland. Analysis and report writing will be done by Water Harvest in consultation with Hydron Flevoland.

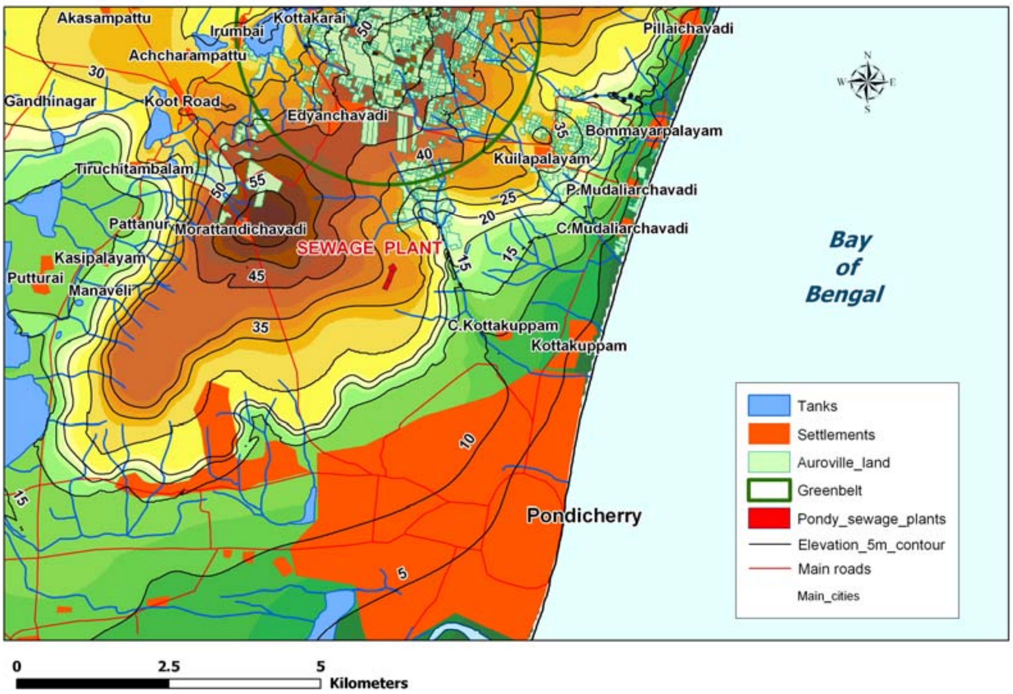
Through Auroville's work in the area in waste water and the contacts established for the purpose of the integrated water resources study, the relationship between Auroville and the Pondicherry Public Work Department, in charge for WWTP, is very good. Regularly visits are made by Auroville experts in waste water and data has been exchanged. Support is agreed upon from this authorities and should be worked out in a formal way.

Climatology

The normal annual rainfall in the Pondicherry region is 1205mm. The wind speed ranges from 5.7 to 9.3 km per hour. Pan evaporation ranges from 12.5 to 29.2 cm per month depending on the season. Ambient temperature in Pondicherry ranges from 26 °C to 38.2 °C.

Geographical Location of the Project

Pondicherry Union Territory lies to the south of Chennai and is comprised of four regions: Pondicherry, Karaikal (surrounded by Tamil Nadu), Mahe (surrounded by Kerala) and Yanam (surrounded by Andhra Pradesh). It covers 293 km^2 in total while the Pondicherry urban limits cover 24.3 km^2. Its population is about 1.6 million (2001 census). The Pondcherry Waste Water Treatment lies to the north of Pondicherry and to the south of Auroville.



Pondicherry Waste Water Treatment Plant

Sewage collection and treatment falls under the jurisdiction of the Public Works Department of the Government of Pondicherry. There has been considerable development and increase in population density in and around the urban centre of Pondicherry. While there has been a concerted effort to set up water supply systems in many of these urban and sub-urban limits, there has been very little in the way of underground sewage facilities with appropriate sewage treatment. Generally there is a reliance on isolated septic tanks without proper sewage disposal systems, resulting in widespread unhygienic conditions. Currently the Government of Pondicherry is looking into a long term plan to provide extensive underground drainage system with some form of treatment. Presently the volume of sewage received at the WWTP is about 13 MLD (or about 25% of the daily sewage generated from Pondicherry), but this is expected to increase to 70-80 MLD over the next 30 years.

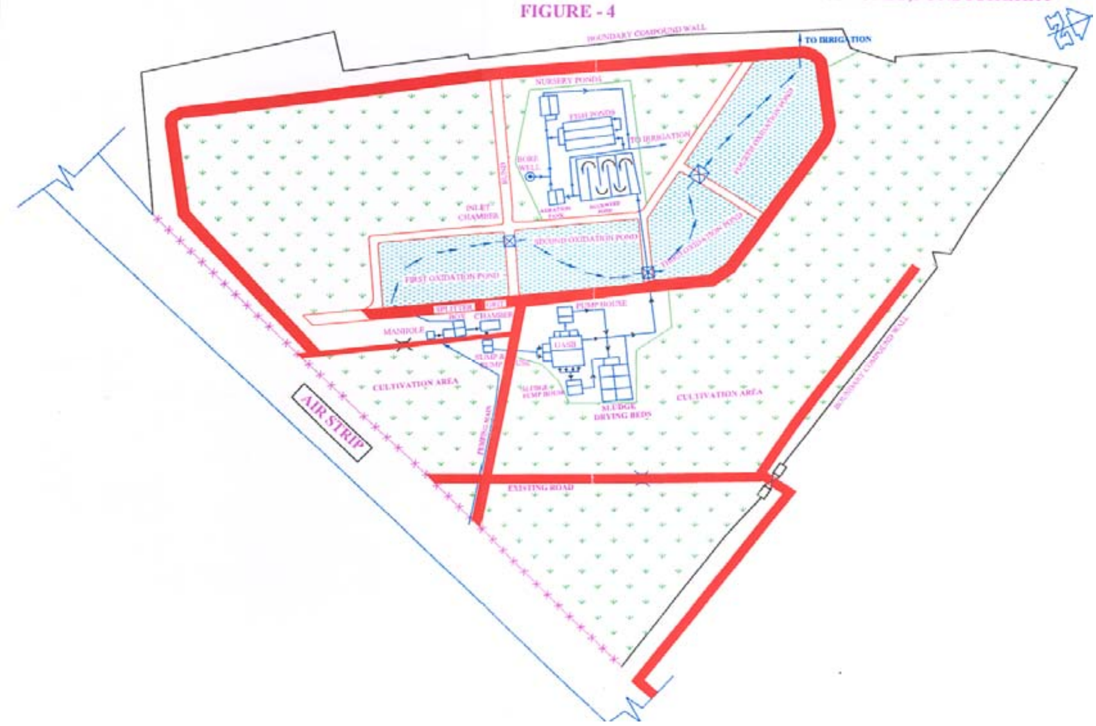
Sewage Collection

The sewer system in Pondicherry consists of a mixture of under and above ground collection mechanisms and is divided into 9 zones. Zone I is the main city area and measures 203 ha. Sewage from zone I is collected at the Kuruchikuppam Main Pumping Station from where it is pumped to the sewage plant 6 km north of Kuruchikuppam. The zone II sewer system flows to the Main Pumping Station at Kuruchikuppam. In zone III (Mudaliarpet), construction on the sewer system has been started. The zone IV (Nellithope) sewer system was commissioned in April 2003 and is connected to the systems of Zone I and II. In the remaining parts of the city there are open sewers. Isolated septic tanks are being constructed in many new development areas. The Public Works Department envisages an extension of the underground sewer system in the near future.

Waste Water Treatment Plant (WWTP)

The Pondicherry WWTP is located at Lawspet (north of Pondicherry) and was originally established during the 1980's when the first underground drainage system at Pondicherry was commissioned. The total area of the sewage farm is 125 acres and contains four large facultative oxidation ponds connected in series, as well as 44 acres under cultivation. The sewage collected is believed to be mostly domestic, but home industries, a common practice in urban India, and their related pollution can not be discounted. Similarly runoff containing fertilizers and pesticides could also be inadvertently collected. The four treatment ponds were constructed in 1980, 1991, 1997, and 2001 and have capacities of 2.9 MLD, 2.9 MLD, 2.2 MLD, and 4.8 MLD respectively. The general layout of the oxidation ponds, treatment units and the sewage farm is given in the figure below:

FIGURE - 4



The four facultative oxidation ponds have been designed for a per-capita sewage flow of 110 L and with a retention time of five days. The depth of the ponds at 1.2 m is designed to optimize biological oxidation demand (BOD) reduction through metabolization by algae and bacteria. The treatment capacity is reported to be 15 MLD, while it currently runs at 13 MLD. Presently influent BOD is reduced from about 200 mg/L to about 100 mg/L in the oxidation ponds before discharging into an infiltration field of an area of about 30,000 m^2 also localised within the Sewage Farm compound, or utilized to irrigate land. The linked ponds usually discharge at one point, but may also be diverted on the opposite side. Here however the discharge comes into close contact with un-separated solid wastes dumped daily from Pondicherry. The impact of sewage mixed with solid waste leaching is unknown at this stage.

A photograph of two of the facultative oxidation pond is shown below:

The pictures below show the main discharge point (left) and infiltration field (right). Note the high volume of foaming from detergents in the waste water.

The following two pictures show the distribution channels used for irrigation and one of the irrigation fields. Cultivation includes coconut, cotton, cashew, bamboo, gova, suppota, mango, fodder crops and fuel trees. Note once again the high volume of foaming here too.

The next two pictures show how close the solid waste dump is to the facultative oxidation ponds (left) and the extent of the dump (right).

New Construction - Upflow Anaerobic Sludge Blanket Reactor

Due to the poor treatment in the facultative oxidation ponds, the Government of Pondicherry is in the process of building an alternate method of treatment based on UASB (Upflow Anaerobic Sludge Blanket) Reactor followed by duck weed and fish ponds. It is intended to split the 13 MLD of sewage received into 2.5 MLD and 10.5 MLD. The 10.5 MLD will be treated in the existing four oxidation ponds, which will continue to be operated as cells in series and discharges as before, while the remaining portion of 2.5 MLD of sewage will be subjected to the new treatment. If the performance of the UASB is satisfactory it is planned to add one more, or another kind of treatment facility, in order to handle the increasing flow of wastewater.

Water Chemistry of Effluent and Groundwater

Water Harvest has very little data on water quality at the Pondicherry WWTP to make substantive claims about pollution impacts. It is for this reason that this project has been identified. Data on water quality from Mar 2003 and Sept 2005 collected by Water Harvest on influent and effluent is shown in Table 1 below.

Table 1: Water Quality Test Results From Pondicherry Sewage Farm

Parameter	**Units**	**Sept 2005**	**Mar 2003**	**Mar 2003**
Influent/effluent	-	Effluent	Influent	Effluent
pH (at 25°C)	-	7.2	7.3	7.4
Electroconductivity (25°C)	µS/cm	1350	1412	1367
TDS (at 103-105°C)	mg/l	764	866	824
TSS	mg/l	54	140	138
Total Alkalinity (as CaCO3)	mg/l	340	-	-
Chloride (as Cl)	mg/l	215	-	-
Sulfate (as SO4)	mg/l	80	-	-
Fluoride (as F)	mg/l	1.9	-	-
Kjeldhal Nitrogen (as N)	mg/l	36	-	-
Total phosphorus	mg/l	-	4.4	1.1
Total Sodium (as Na)	mg/l	117	-	-
Arsenic	mg/l	-	ND	ND
Total Lead (as Pb)	mg/l	0.5	0.1	0.05
Total Cadmium (as Cd)	mg/l	<0.5	ND	ND
Total Chromium (as Cr)	mg/l	6.8	ND	ND
Total Mercury (as Hg)	mg/l	<0.001	-	-
Zinc	mg/l	-	0.4	ND
Detergent (as MBAS)	mg/l	3.9	-	-
Phenols (as C6H5OH)	mg/l	1.5	-	-
Oil and Grease	mg/l	1.0	-	-
COD	mg/l	220	400	320
BOD	mg/l	142	219	122
Total Coliforms	N/100ml	-	93×10^8	46×10^6
E.coli	N/100ml	27000	93×10^8	46×10^6
Salmonella	-	-	Present	Present
Pseudomonas	-	-	Present	Absent
Pesticides	-	-	Lindane trace	ND

It is difficult to make an analysis on such a small data set, although the following can be highlighted (with Indian standards for land irrigation in parenthesis[1]):

- BOD is a little high at 122 to 142 mg/l (100 mg/l)
- Chromium is high at 6.8 mg/l (2 mg/l)

Importantly Water Harvest does not have a long term record of basic water quality showing variations in water received, variations in treatment efficiency (i.e. seasonal), and influence of the monsoon, etc. In addition our ability to measure the metal

[1] Current standards can be found at http://www.cpcb.nic.in/standard32.htm

contamination is limited and organic contamination is essentially non-existent (especially at the low levels necessary to properly measure impact).

Pondicherry is well-supplied with medical facilities, and Indian urban residents have easy access to pesticides for households use (against termites, cockroaches, rats etc). Pondicherry's domestic sewage is likely to contain substantial residues from these sources. The presence of Lindane in the data above indicates the potential for widespread contamination. Current EPA standards set drinking water limits for Lindane at 0.2 parts per billion. The fact that it is not detected in the table above is most likely due to detection limits rather than it not being there.

Furthermore there is substantial risk of effluent containing chemical effluents from unidentified and unregistered industrial activities at the household level, such as battery recycling and electroplating. The high chromium level of 6.8 mg/L is indicative of this. It is therefore a matter of urgency that the effluent at the WWTP is fully characterized, both in metals and organics, especially in the light of the fact that this effluent is freely discharged to the environment.

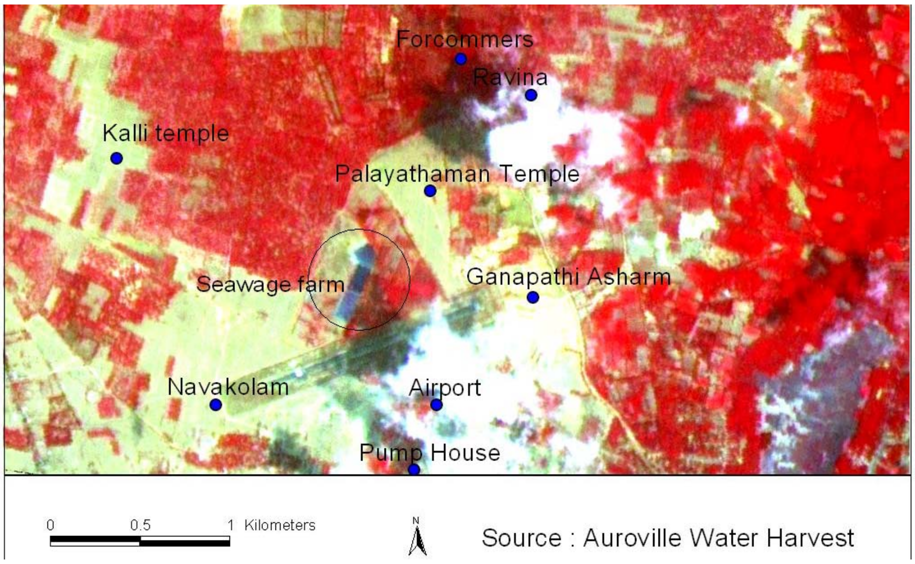
To investigate possible impact of the infiltrating effluent on regional groundwater, samples from several surrounding wells have been taken and analyzed. The data from this investigation are shown in Table 2 below. These are from samples taken in Sept 2005.

Table 2: Groundwater quality results from a number of wells around Pondicherry Sewage Farm.

	Ravena	Forcomers	Palayathaman Temple	Kalli temple	Ganapathi Ashram	Pump House	Airport	Navakolam
pH	6.6	7.4	5.9	6.5	6.8	5.8	6.2	6.4
Conductivity[1]	638	437	390	147	946	676	963	283
TDS	378	385	176	86	657	406	567	190
TSS	1.0	1.0	1.0	1.0	1.0	6.0	1.0	1.0
Alkalinity	289	226	110	72	380	220	360	130
Chlorides	65	25	50	6	170	130	190	9
Sulphate	45	9	38	10	87	50	65	12
Fluoride	0.9	0.8	0.6	0.9	0.9	0.8	0.8	0.8
Ammonia	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
K-Nitrogen	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sodium	42	20	39	11	59	96	126	10
Lead	0.04	0.04	0.04	0.04	0.04	0.08	0.04	0.04
Mercury	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001
Cadmium	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Chromium	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Oil and grease	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Surfactants (as MBA's)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Phenolics	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
COD	4.7	3.6	3.0	3.0	6.0	8.0	5.0	18
E. coli [2]	4	12	0	0	28	0	8	10

Results are in mg/L except where indicated. (1 as µS/cm, 2 as N/100 ml)

The following a diagram indicates the locations of wells relative to the sewage farm:



Similarly to the effluent data these results are only a snapshot of potential impact and are limited by the low number of parameters investigated. Without a larger dataset and long term variations it is difficult to make any substantive claims about the impact of the sewage farm on groundwater. Traditionally, groundwater has been regarded as a relatively microbiologically safe source of drinking water in that it is shielded from the immediate influence of contamination by the overlying soil and unsaturated zones. It is now known that microbiological contamination of groundwater is more widespread than previously believed and that natural attenuation in the soil is not necessarily complete, or that channeling (rapid transport pathways) can occur with rapid infiltration into the groundwater. The presence of *E. Coli* in the data above implies human/animal impact on the groundwater – although this is not necessarily infiltration from the sewage farm as the well at Palayathaman Temple registered an *E. Coli* of 0 and it is intermediate between the sewage farm and Forecommers which registered an *E. Coli* count of 12.

Furthermore initial hydrology work suggests that the majority of the impact of the groundwater will be to the south of the Treatment Plant. The area shows a very high infiltration rate and the geological investigations indicate some weakness in continuousness of the strata.

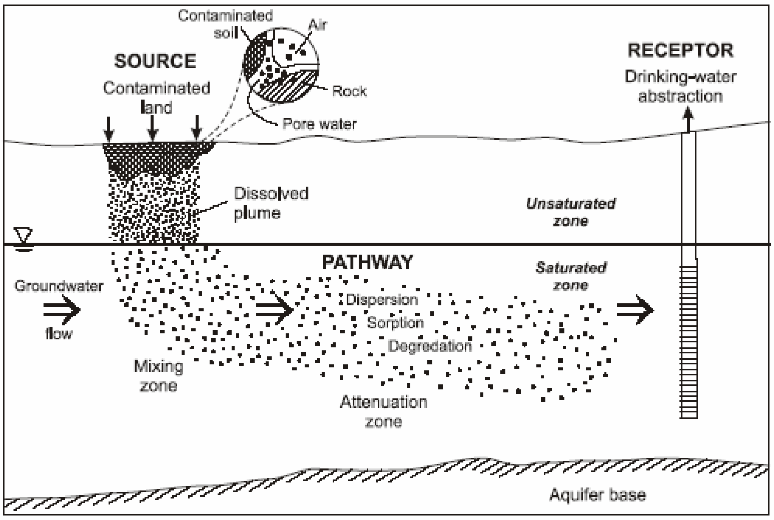
At this point we have no data on organic chemical contamination of the groundwater. Just as it is crucial to fully characterize the discharge from the WWTP, it is crucial to begin a groundwater monitoring program to investigate the impact of largely untreated sewage water on the groundwater. This project proposes to set up this groundwater monitoring program.

A growing concern in India and Bangladesh is the widespread natural occurrence of arsenic in groundwater[1]. As a side project Water Harvest will evaluate whether the Pondicherry/Tamil Nadu groundwater falls into this category of concern by extracting background arsenic concentrations from this study.

[1] DPHE-Unicef arsenic mitigation program and WHO publication on groundwater: www.who.int/water_sanitation_health/resourcesquality/en/groundwater1.pdf

Scope of Proposed Work for Monitoring and Impact Evaluation

As this report highlights there is a potential for substantial impact of effluent from the Pondicherry Waste Treatment Plant and associated Solid Waste dump on the groundwater. This project proposes to evaluate the size of this impact by firstly quantifying the water quality received and discharged at the Treatment Plant (and if possible leachate from the solid waste dump), and secondly by setting up a groundwater monitoring program from water drawn from indicator wells around the Treatment Plant. Justification for a borehole monitoring program is based on the classic contaminate conceptual model. This model is shown in the figure below and is based on a point source where aqueous chemicals and pathogens move vertically downward. The plume penetrates below the water table to subsequently migrate laterally in the flowing groundwater. The discharge from the Pondicherry Treatment Plant since the 1980s has sufficient chemical mass to enable this site to act as a long-term generator of contaminated plumes; potentially impacting the groundwater. This conceptual model is widely accepted and is the one to which groundwater vulnerability and protection concepts, and groundwater risk-assessment models are most easily applied[1].



Potential for attenuation processes and pollution mitigation to occur varies within the various subsurface zones, i.e. soil, unsaturated and saturated zone. Associated attenuation processes are complicated and include dispersion and dilution, chemical reactions such as precipitation and complexation, and biodegradation. Attenuation processes can be more effective in the soil rather than aquifers due to higher clay contents, organic carbon, microbial populations and higher oxygen levels. An important question that will be looked at is the extent of soil attenuation processes at the infiltration zone, and to what extent channeling is occurring with rapid infiltration into the groundwater.

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[1] Note this model is not always applicable for organic chemicals having a wide range of affinities for water.

The data from both the discharge and groundwater wells will be collected and analyzed for wide variety of ater quality parameters, taking into consideration seasonal variations on treatment efficiencies/attenuation and monsoonal effects. In particular emphasis will be placed on quantifying the impact of heavy metals as well as indicator organic contaminants from both pharmaceutical and agricultural sources. The proposed lists of parameters to be investigated are listed in Appendix 1, although this might change based on availability.

The water quality data will be correlated with hydrogeology data Water Harvest is currently producing for the area. It must be stressed that this is only the first phase of a much larger project encompassing a full understanding of the transport and attenuation of chemicals in the subsurface, and the associated establishment of risks within in a greater Integrated Water Management Plan.

Phase 1

Identify full water quality parameters to be investigated as well as sampling protocol and frequency. Site visit to local laboratory, Environmental Monitoring Service, Auroville (EMS). Site visit to groundwater wells and evaluation of their relevance for a groundwater monitoring program. Identify a wells to be used as a control for background concentration of chemical constituents (or as close to background concentrations as possible).

Phase 2

Make contact with Hydron Flevoland in the Netherlands and if possible set up a partnership to work on this project together. Identify which water quality parameters can be tested at Hydron Flevoland's laboratories, clarify sampling protocols and shipping protocols. Additional testing will be done at EMS.

Phase 3

Begin collecting samples according to sampling plan and frequency. Quarterly intermediate reports

Phase 4

Final analysis of data and Final Report, including correlation with hydrogeology data, attenuation effects if any, etc. Proposals for further work.

Potential for Recycling of Processed Sewage

The volume sewage collected in the Pondicherry Sewage Treatment Facilities offer a large potential for recycling. The actual scenario is of heavy over extraction from groundwater resources due to agricultural activities and the resulting fast depletion of the aquifer system. This is creating an alarming situation on the coastal line but also further inland as sea water intrusion is already monitored in the vicinity.

Two scenarios, may be combined, can be imagine out of such large water resource.

The first one is to deliver processed water to the irrigated area. This would create a very large scope for larger area under irrigation, prolonged farming activities through the year and important reduction of extraction from the over tapped groundwater resources.

As such, the actual volume of sewage of 13Mld could be utilized to irrigate 650Ha at the minimum, while the final expected flow of 80Mld could be used to irrigate at least 4000 Ha all through the year. This is offering a tremendous scope for economical and social changes in this area where livelihood is still very precarious.

The second scenario will concern groundwater recharge. This could help to replenish the depleted aquifer, but also to maintain a positive barrier of fresh water along the coast, actually threaten by sea water intrusion. The yearly volume generated by the Pondicherry Sewage Treatment Facilities are larger that the actual extraction on this area and hence can play this role.

It should be noted that the Sewage farm is on high ground elevation if to compare to the surrounding. As per topographic investigations it is possible to carry the processed water to the suitable location for irrigation and for groundwater recharge with limited infrastructure development and without the help of pumps or other costly running systems.

Appendix 1: Water Quality Parameters

General	Primary Metals	Aromatic hydrocarbons[1]	Pesticides[2]
pH	Arsenic	Benzene	Alachlor
BOD	Cadmium	Toluene	Atrazine
COD	Chromium	Ethylbenzene	Carbofuran
Conductivity	Copper	Xylene	Chlordane
TDS	Lead		2,4-D[3]
TSS	Mercury	Chlorinated Hydrocarbons[4]	DBCP[5]
Alkalinity	Nickel	dichloromethane	Dioxin[6]
Chlorides	Sodium	trichloromethane	Dinoseb
Sulphate	Selenium	tetrachloromethane	Endothall
Fluoride	Uranium	trichloroethene	Endrin
Phosphorus		tetrachloroethene	Glyphosate
Ammonia		vinylchloride	Heptachlor
Nitrate	Secondary Metals[7]	Cis 1,2-dichloroethane	Lindane
Nitrite	Aluminum	Trans 1,2-dichloroethane	Methoxychlor
Total Nitrogen	Antimony	1,2-dichlorobenzene	Picloram
Oil and grease	Barium	1,1-dichloroethene	Simazine
Surfactants	Beryllium	Cis 1,2-dichloroethene	
	Iron	Trans 1,2-dichloroethene	Other[8]
Faecal indicator[9]	Magnesium	1,4-dichlorobenzene	PAHs
Total Coliform	Manganese		PCBs
E. Coli	Silver	Pharmaceutical Indicators	PCPs
	Thallium		

[1] Collectively known as BTEX these are among the most common organic groundwater contaminants

[2] Pesticides represent a wide range of compounds used mostly as insecticides, herbicides, and fungicides. Many are environmentally persistent and pose long term problems. The following list is one recommended by the US EPA, however local use needs to be taken into consideration.

[3] 2,4-dichloro-phenoxy-acetic acid

[4] Chlorinated hydrocarbons are used in a variety of industrial and home industrial activities, including degreasing, textiles (dry cleaning) and animal/leather hides, metal stripping, and are widely used as cleaners, paint removers, etc. The following list is recommended by WHO for groundwater monitoring, all may not apply in this case.

[5] 1,2-dibromo-3-chloropropane

[6] Due to regular burning of solid waste theire might be dioxin contamination

[7] Quantification of these secondary metals would be useful for long term studies.

[8] The concentration of the polynuclear aromatic hydrocarbons (PAHs), the polychlorinated biphenyls (PCBs) and pentachlorophenol (PCP) should be quantified. These compounds have very low solubility in water and are highly sorptive, hence dissolved-phase plumes in groundwater tend not to be large. However they are very persistent in the environment and are therefore indicators of long term groundwater pollution. Furthermore PCBs and PCPs could be generated from the solid waste dump.

[9] In the long term it would be appropriate to look at a broader range of biological contamination

Appendix 2 : Water Quality Report

ENVIRONMENTAL MONITORING SERVICE

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Waste Water Examination Report

Customer name: Harvest, Auroville. Received: 19/06/06

Sample ID: Composite Effluent (Karuvadikuppam) Completed: 26/06/06

Sample collected: by customer Lab ID: 097

Sl. No.	Parameters	Units	Results
1.	pH (at 25° C)		7.6
2.	Electrical conductivity (at 25° C)	µS/cm	1516
3.	Total Hardness (as $CaCo_3$)	mg/l	340
4.	Calcium (as Ca)	mg/l	96
5.	Magnesium (as Mg)	mg/l	25
6.	Fluoride (as F)	mg/l	0.8
7.	Total Sodium (as Na)	mg/l	170
8.	Total Potassium (as K)	mg/l	26
9.	Total Iron (as Fe)	mg/l	0.9
10.	Total Manganese (as Mn)	mg/l	1.0
11.	Total Copper (as Cu)	mg/l	< 0.2
12.	Total Zinc (as Zn)	mg/l	0.4
13.	Total Aluminium (as Al)	mg/l	1.5
14.	Total Antimony (as Sb)	mg/l	< 0.25
15.	Total Arsenic (as As)	mg/l	0.07
16.	Total Lead (as Pb)	mg/l	< 0.2
17.	Total Cobalt (as Co)	mg/l	< 0.3
18.	Total Cadmium (as Cd)	mg/l	< 0.1
19.	Total Chromium (as Cr)	mg/l	3.6
20.	Hexavalent Chromium (as Cr^{6+})	mg/l	0.5
21.	Total Nickel (as Ni)	mg/l	< 0.4
22.	Total Selenium (as Se)	mg/l	< 0.01
23.	Total Silver (as Ag)	mg/l	< 0.1
24.	Total Mercury (as Hg)	mg/l	0.001
25.	Detergents (as MBAS)	mg/l	2.0
26.	Phenols (as C_6H_5OH)	mg/l	0.04

Analyst _______ Lab executive _______

Appendix 3: Overview of sewage farm from high resolution satellite imagery


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Google
Pointer 11°58'24.05" N 79°49'18.66" E elev 30 m
Streaming |||||||||| 100%
Eye alt 5.62 km

Appendix 4 : Topography and preliminary study for outflow diversion by gravity