WATER MANAGEMENT

14th-15th February 2003
at the Centre for Urban Research in Auroville.

PRESENTATIONS

- **Presentation by Harald Kraft, Expert on Water & Wastewater Management from Berlin, Germany**

  The presentation focused on the pre-feasibility study on water management made by the speakers as part of the Asia-urbs project IND-015 and on some other projects executed under his supervision in Germany and in developing countries.

  First he recounted his experience of a lake project in Berlin. He explained that the proposed lake had an overflow to recharge the ground water. To pump the water, solar and wind energy were made use of. From there the water would flow into an artificial river that feeds the lake, there a community house exists. This community house would be used for child care, weddings, training, festivals and social gatherings. This lake captured only rain water & has been operational since 1993. Only once, during unusually torrential rains the year before & there was a problem as it rained much more than the system was designed for and the pump failed.

  Afterwards he made a presentation of the water management study done until then in the framework of the Asia-urbs project IND-015. He said that the site for Auroville, a city for 50,000 inhabitants, could not be built where a reliable water or food source did not exist. An interesting conclusion was drawn; the rainwater was the key! Rain in Auroville amounts to about 25 million cubic meters every year, sufficient for 50,000 people, therefore there is enough water even in a dry year. This is four times more water than Berlin in an average year. The problem was the storage of this water.

  Water kept in big lakes and ponds percolates and evaporates. The cheapest & best storage is underground and the geology of Auroville is favourable. There is a clay layer just beneath the Auroville premises sliding down to the sea. The water that seeps into Auroville goes through the city into the sea. But the best place to infiltrate the water is just opposite the highest point: the Matrimandir Gardens.

  The water running off the streets would be dirty. Converting it to drinking water would be a long process. When drawn from the lake, the water is fit for drinking. If the system is good for Germany which has strict quality control, the same could be applied here in India. The final treatment of the dirty water should be pumped and passed through the lake, in the process getting purified and percolating into the ground. So before it leaves the city and flows into the sea, the water would be collected.

For example in the implementation of a 30 hectares settlement for 2000 people, the roofs would be connected to 4600 cubic meters of a common system of a row of houses and a places for private roads. All the houses would have their own systems ranging from small systems of 50 cubic meters to big systems of 300 cubic meters. All the roads would have surfaces from where the water could infiltrate into the ground and would be treated. The treatment can be done with root zone systems.

An artificial basin is created and all the water flows by the gravity into the lake. For 3 years this would be Auroville landscape scenario with the lake completely sealed and only the overflow to be controlled. The lake would be only three and a half meters deep because the ground water exists and this water is crystal clear and only the storm water run-off goes into it.

Then some slides were shown exhibiting the working of the system. Storage, infiltration, drains from the side of the roads to green corridors into the green belt. A mention was made of the use of surface drains, an idea that is practical and economical here in India.

One slide showed an aerial view of the lake projected lake model where the roofs are visible, plants on top of the roof help to reduce the rainfall directly on top of the roof, and an under construction storage facility for storm water. Also visible is the inlet of the waste water into the green belt prior to the start of operation .The flow goes from here to the pond and from there to the households.

The slides showed also plans for a treatment plant in Berlin, with storm water harvesting, artificial lake, wind mill, solar pump, the whole water course, the public house in the lake, the crystal clear water, storage, infiltration, green rooms, small and large infiltration basin with a capacity of 250 cubic metres. Some slides focused on an underground filter and pressure system, where one third of the whole area, all the systems of this are connected to this unit and from there we have the supplier filter that pressurizes the rain water. Surface rain water could be seen going through the pipes. The outflow, inflow and biological filters are also seen. One can also see a well filled with water works and the flooding test. The clarity of the water was also evident.

The same water management scheme as to be applied in Auroville:

The Problem

At the inauguration the hill was barren. Only a few palmyras had survived the centuries of deforestation. During the monsoon season, the sea was dyed blood red with eroded earth. The rains have carved two canyons, 20 m deep and 100 m

wide in places, from the crown of the hill down to the sea. Only a very small portion of the rainwater that falls on the plateau remains in the ground, which allows for only two meagre harvests per year.
The water table lies 30m below the compacted surface, where it can only be tapped in small quantities, and even that is difficult. A layer of red laterite covers the entire hill and slopes gradually towards the sea. Under it lays strata of limestone, through which the groundwater flows out from within the soil. Adequate aquifers are found only at 100 m and 200-300 m depths.

The Groundwork
City life will become possible on this site only if the area can once more be made fit for human habitation. The first step in this process is to protect the ground. The annual loss of soil and water can only be halted by creating "bunds", banks and dykes which slow down and divert runoff, and by terracing and strengthening of canyon walls. These measures must be undertaken throughout the entire city.
The second step is to cover the surface with a layer of vegetation that will hold the soil together, as well as open it up so it can absorb the rainwater that falls on it.
The third step is to reforest the entire area. Pioneer plants which survive in extreme conditions will be planted first, followed by plants which recover the subtropical rainforest.

Over the last thirty years, this process of regenerating topsoil, retaining rainwater to restore the groundwater table, and modifying the micro-climate by providing shade, moisture and protection from wind and rain, has gradually brought the land back to life. The diversity of insect, bird, and animal species, has consistently increased, further supporting the process of renewal.

Water Supply: the conventional solution
Drinking water for the city could be conventionally supplied by one or two central pumping stations, drawing groundwater from the aquifers at depths of 100 to 300 m. In this scenario, however, a large lake at the highest point of the city may not serve as a practical solution since it would have to be filled with groundwater drawn from great depths, which would required a lot of energy and be very expensive.
To cover the other water needs of the city and its surrounding agricultural areas, a separate irrigation system supplied by deep bore wells would have to be established.

The city receives an average annual rainfall of 1200 mm, occurring within two rainy seasons, during which extreme downpours of up to 300 mm in 24 hours are not uncommon. Runoff could be channelled into the canyons, and sewage could be collected in a conventional drainage system, purified in a conventional sewage plant, and carried away through the canyons to the sea.

The Water Demand

The city is situated near the coastline, where the ground water flows into the sea. All of the other users with access to the aquifers at 100 - 300 m depth have already been taking what they need. With powerful pumps, at subsidised electricity rates, agricultural users in the surrounding area, even the narrow strip directly along the coast, are removing groundwater to cultivate crops at a very high rate. In addition, a rapidly expanding industrial sector is making extravagant demands on the precious water supply

The first signs of salt water intrusion into the aquifers in Pondicherry, in and near Auroville, are already evident.. South of the city, many square kilometres of coastal land have become infertile due to salination. Providing for the water needs of the city and its surrounding agricultural areas by desalinating sea-water is technically possible, but too costly to be affordable by the residents. Salination of the groundwater will mean the end of the city.

The Alternative Solution

Even in drought years, precipitation over the city area corresponds to more than ten times the amount of drinking water needed. But the rainy season lasts only a few months. Collecting and storing all this rainwater would require huge tanks that would not only be expensive to construct, but would require a lot of space.

However, one needs to reflect on the vision and try to view the apparent disadvantages of the site as potentially useful to the city. The upper layer of relatively impermeable laterite, together with the uppermost aquifer, form the entire plateau on which the city stands, and both slope gently towards the sea. Therefore, all of the water that percolates within the city area moves gradually above sea level towards the coast.

Now, instead of the terrain and soil being seen as a disadvantage for the city, they become blessings. The groundwater is prevented from flowing downwards or towards the sea too quickly. Although the rate of infiltration through the surface is slow, the best place for surface water to infiltrate in order to increase the groundwater supply is at the highest point, the centre of the city. From this point of view, a large lake can be seen as the ideal technical solution to this problem.

Rainwater falling on roofs can be collected in cisterns and used for drinking water and various household and gardening purposes.

The surface runoff from roads, tiled surfaces, and open areas, can be collected and stored in reservoirs within the greenbelt up to the boundaries of the city. After filtration, the stored rainwater can be slowly pumped up into the central lake, a distance of no more than 20-30 m, by means of solar energy. From here, percolation into the groundwater table will take place. In this manner, the water level of the lake will be kept constant, providing optimal conditions for high quality landscaping and park areas, along with desirable climatic effects.

Sewage from the densely developed areas can be centrally purified in the greenbelt, and then be re-used for irrigation purposes. Sewage, as well as secondary runoff if necessary, from the less densely developed areas can be purified in root-zone treatment plants and reused on site for irrigation.

In this way, the geological and geographical “disadvantages” of the city’s site, make a regime of rainwater conservation possible which would provide a plentiful water supply for both drinking and irrigation, even if the underlying groundwater becomes completely salinated. The average rainfall is not only sufficient enough to support vigorous tropical vegetation, but would provide enough surpluses to supply the surrounding areas. However, this will be successful only if the residents of the city protect the first aquifer from contamination.
The upper strata of earth beneath the city functions as a reservoir, and must therefore be protected. Drinking water can be obtained from wells in the greenbelt which tap the groundwater before it flows beyond the city limits towards the sea.
The extreme degradation of life’s basic elements through over exploitation of this area’s natural resources, has threatened the existence of human settlements. This water management concept enables the residents of the city to live unaffected in the midst of a degraded environment, so long as they, themselves, avoid polluting the ground and the water which together form the basis for their survival.

The feasibility of the water management concept

Safe Water Yield from Precipitation

The precipitation over the urban area is, on the average, enough to cover the drinking water demand for the city (145 %). Only in a dry year is it possible that the water demand may not be completely satisfied (-22%). It is therefore necessary that all precipitation, which exceeds the long term average, be completely used for recharging the groundwater.

Safe Water Yield from Sewage

To cover the water demand for drinking and irrigation, urban sewage is to be completely fed back into the water cycle. The sewage is treated to the extent that it can be reused for irrigation (3,28 M m^3/yr.).

Water Balance

On the long-range average, the surplus available for groundwater recharge amounts to 0,64 M m^3/yr. In a year with above average precipitation, the surplus water amounts to 1,85 Mm^3/yr. In a dry year, however, the water supply for the city falls short up to 0,58 M m^3/yr

Drinking Water Supply

The drinking water demand for 50.000 inhabitants amounts to 3,65 M m³/yr. The runoff from rooftops, with 1,23 km² surface area, amounts to between 0,77 – 2,10 M m³/yr., or 1,44 M m³/yr. on average. All of the runoff is to be stored in cisterns, from where it is either directly used to subsidise drinking water or conveyed to the central infiltration facility. The specific cistern volumes would need to be at least 800 l/m² roof area, or better yet, 1.200 l/m² roof area. The total volume of all the cisterns in the city then amounts to 0,984 M m³ - 1,476 M m³. Approximately 40% of the drinking water demand could be satisfied from water stored in the cisterns. The remaining 60% can be satisfied with the surface runoff from the streets, open areas and green areas. This runoff amounts to 2,70 – 5,60 Mm³/yr., or 3,84 M m³/a on the average.

The surface runoff is intercepted by water courses within the greenbelt and then delivered to the city centre for groundwater recharge. From the central groundwater recharge facility, the groundwater needs a flow time of about 1 to 5 years to reach the city limits. From the recharged 1st aquifer, 60% of the drinking water demand can be drawn from 30 – 50m deep wells which are distributed throughout the entire greenbelt.

Sewage Disposal

In decentralised facilities located in the upper rim of the greenbelt, urban sewage (2,74 M m³/yr.) is to be biologically treated, purified, and be made available for irrigation in the agricultural areas.

Central Infiltration Facility

The surface runoff within the city limits is to be completely used for groundwater recharge.

The most appropriate location for the infiltration facility is the city centre, since from here, the flow path to the edge of city is maximised. The garden around the Matrimandir is, from a hygienic standpoint, by far the preferred location for the groundwater recharge facilities. Infiltration trenches along the most important routes would total in length to about 2.150 m. The maximum daily infiltration capacity amounts to approximately 74.000 m³/d. The required infiltration capacity depends on the allocated storage volume for the surface runoff in the greenbelt. In an average year, the maximum infiltration capacity during the NE monsoon amounts to approximately 20.000 m³/d, and during an above average NE monsoon, approximately 38.800 m³/d.

Storage Volume in the Greenbelt

The surface runoff from the city and the greenbelt is intercepted at the fringes of the city in water courses and continually transported to the city centre for infiltration.

The size of the water courses determines the size of the required daily infiltration capacity, as well as the size of the treatment plant and the retention time in the

central lake. The larger the water courses, the smaller the remaining facilities can be dimensioned.
The retention of the runoff towards the east is not a problem since only a few downstream water rights exist. More problematic is the retention of the flows towards the west and north since there exist old water rights for which compensation needs to be made. With a storage volume of 1,033 M m^3, a precipitation of up to 350 mm can be stored. The minimum required infiltration capacity would then be 33.600 m^3/d, and the retention time in the central lake would be 41 days. When the storage volume is 3,983 Mm^3, the discharge to the central lake can be reduced to only 13.300 m^3/d due to the equalisation of the flows. The inlet filters would need only to be 3.000 m^2, and the average retention time would be 104 days.

Central Lake
With a central lake of 181.000 m^2 surface area, and a maximum depth of 10 m, the average depth would be 7,60 m, and the storage volume would be 1.376.000 m^3
The minimum retention time, with a maximum capacity of 34.400 m^3/d, would be approximately 40 days. The surface area of the lake sealant is 185.800m^2. The loss due to infiltration through the clay seal (vacuum sealed natural clay) amounts to approximately 15.450 m^3/yr. The loss due to evaporation amounts to approximately 54.300 m^3/yr. on the average. The retention time in the central lake should be several months since the lake will be used for natural treatment of the surface water.

Filters
The polluted surface water stored in the greenbelt is to undergo extensive treatment before conveyance to the central lake. For this purpose, large capacity slow sand filters are planned. From all of the storage facilities within the greenbelt, the retained surface runoff is to be continually passed through the inlet filter before entering the central lake. The inlet to the lake is to be designed so that an optimal distribution of inflow results and no disruption to the flow can develop. The outlet occurs as overflow through inlet structures of various depths located on the other side of the lake from the intake point to maximise flow times. The outflow is to be cleaned from algae and other filterable materials before it reaches the infiltration trench by means of an outlet filter, which is planned as a rapid filter.

Power Requirement for the Conveyance of Surface Runoff
From the water courses in the greenbelt, the surface water is to be conveyed by means of pressure conduits to the filter at the central lake. With an average vertical rise of 25 m, and an annual output of 2,07 – 5,6 M m^3/yr., the power requirement amounts to 277.423 kWh/yr. – 750.517 kWh/yr.

WASTE WATER TREATMENTS IN AUROVILLE

After illustrating the work made for the supply of drinking water, Mr Kraft analysed the present waste water treatment practices in Auroville which include a number of decentralized waste water treatment systems. When Auroville started to grow, many settlements started to build sanitary installations, without realizing the need for a survey
He pointed out that wastewater that was treated in the best treatment plants was still unhygienic. Cloriform bacteria in a modern treatment plan is reduced by 90-95 percent but, since the process eliminates the indicator bacteria, and not the types of viruses, they are very resistant to a normal treatment processes. The problem is how to get rid of them. The solution of heavy chlorination and heavy radiation and ozonizaton is very costly and very dangerous. Therefore, not feasible for Indian standards. He spoke about the Root Zone Treatment of waste water initiated in Germany, which according to him was quite successful. This is a system where the water flows underground, through the roots of certain plants and the soil. If the waste water percolates through a living soil, the reduction of the bacteria and pollutants is best, so the idea was to select very specific plants capable of doing that. For the proposed lake in Auroville one needs to know a lot about plants, soil and hydraulics and finally wastewater.

Research on waste water treatment has been carried out by major research institutes in Germany, producing very detailed studies on bacteria and germs in treatment processes when exposed to ultra violet radiation. Ultra Violet radiation is very effective in killing trace bacteria but doesn't touch other pathogens at all. The indicators are eliminated which allowed one to check if intestinal bacteria are still present in the drinking water. They found a number of germs in the roots of the treatment plants. There are bacteria killing bacteria and bacteria killing viruses, so you have bacteria that are very harmless, indicating the need to be careful to see that ultra violet radiations do not eliminate the pathogens. He spoke of a separate line to flush the toilet to reduce the consumption of water, for example, when a filter is used in the out flow of the tap, most of the water goes in the flush (British system) 8-9 litres. Instead a toilet that would use only 6 litres was being developed. The Swedes have developed a method that uses only 4 litres where the valve opens only when the siphon is full of water. The water is needed to flush the pipes and to flush the main sewers. So, what they did was a simple 20 litres container with a siphon which when filled releases the water that will flush directly into the sewer, the reduction was remarkable.

Regarding BOD the main parameters is around 135 mg/litre. In the final effluent the BOD is around 25 mg/litre at 25 degrees C. Case studies were proposed by the Centre Pollution Control Board, India, to perform tests on the treatment units for selected places. One of them was for Aspiration & Invocation, residential settlements, and Auromode - a garment industry. The final effluent point range was between 8 & 31.

Another system designed by Mr. Harald Kraft, has 3 chambers, and is a complete system, that doesn't use a pond. It uses a kind of Imhoff tank, and has been functioning well since 3 years. At Sangamam Village Model Project, there is a bore well and an innovative water tank designed in a series of three water tanks. The top container is for the ground water from the nearby bore well, the middle tank is for treated waste water after recycling and pumping back and the bottom contained harvested rain water. The water supply system for every house has three pipe lines that run parallel, one for domestic use, one for harvested rain water and one for the treated waste water, the last one aided by CPCB, a decentralized waste water treatment system which is an up-flow anaerobic reactor.