SELECTION AND DESIGN OF APPROPRIATE STP TECHNOLOGY FOR A TOWN IN TAMIL NADU

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree

of

MASTER OF TECHNOLOGY

in

CONSERVATION OF RIVERS AND LAKES

By

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CANDIDATE'S DECLARATION

I hereby declare that the work which has been presented in the dissertation entitled **"SELECTION AND DESIGN OF APPROPRIATE STP TECHNOLOGY FOR A TOWN IN TAMIL NADU"** in partial fulfillment of the requirements for the award of the degree of **Master of Technology in Conservation of Rivers and Lakes**, submitted in Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee, is an authentic record of my own work carried out during the period from July 2006 to June 2007 under the supervision of Shri.S.K.Singal, Senior Scientific Officer, AHEC, Indian Institute of Technology, Roorkee and Dr. A.A.Kazmi, Assistant Professor, Department of Civil Engineering and., Indian Institute of Technology, Roorkee.

The matter embodied in the dissertation has not been submitted by me for the award of any other degree or diploma.

Place: Roorkee
Date: 29th JUNE, 2007

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CERTIFICATE

This is to certify that the above statement made by the candidate is correct to the best of my knowledge and belief.

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ABSTRACT

There are many Sewage Treatment technologies available for the treatment and reuse of sewage in India. Sometimes, it is difficult to select a technology that is appropriate for the desired treatment in the specific region such as rural, urban or metropolitan area. The important factors affecting the selection of STP technology are the volume of daily flow, sewage characteristics, degree of treatment needed, disposal of the effluent, area of land required for the plant, capital cost of installation, power required for the treatment, annual operation and maintenance cost.

The Techno Economic Analysis tools such as Life Cycle Cost Analysis, Benefit Cost Ratio and Internal Rate of Return are used to take final decision. The study highlights the application of the Techno Economic Analysis tools for the selection of appropriate technology of sewage treatment and aims to provide guidance/methodology in the appropriate STP technology selection for urban planners and decision makers.

Kancheepuram a town in Tamil Nadu, a historic temple city is identified for the case study. Five municipal sewage treatment technologies that are mostly used in India are selected for analysis. Three major decision variables/parameters that affect the selection are taken into account for analysis; capital cost, annual maintenance cost, and land cost. The selection of technology is made by calculating the benefit cost ratio, assuming a discount rate of 10% and the cost benefit analysis or Life cycle cost analysis. It is found that the Waste Stabilization Pond is the most economical and cost effective technology to treat municipal sewage where the cost of land is below Rs. 62 Lakhs per ha (i.e., Rs. 62 per sqft or Rs. 620/sqm). Beyond Rs. 62 Lakhs to Rs. 190 Lakhs per ha the Upflow Anaerobic Sludge Blanket (UASB) with final polishing pond is economical. Above Rs. 190 Lakhs per ha Moving Bed Biofilm Reactor (MBBR), Sequencing Batch Reactor (SBR) & Activated Sludge Process (ASP) are found to be economical. For the Kancheepuram town the WSP is selected for the municipal sewage treatment as the land cost is Rs. 1.50 Lakhs per ha. (i.e., Rs. 1.5 per sqft or Rs. 15/sqm). The WSP is designed for actual conditions and the cost estimation been worked out.

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ABBREVIATIONS AND NOTATIONS

AHEC	Alternate Hydro Energy Centre
AM	Annual Maintenance
ASP	Activated Sludge Process
BCR	Benefit Cost Ratio
BOD	Biochemical Oxygen Demand
C	Centigrade
CETP	Combined effluent treatment plant
CPCB	Central Pollution Control Board
CPHEEO	Central Public and Health Environmental Engineering Organisation
COD	Chemical Oxygen Demand
CI	Cast Iron
CO_2	Carbon dioxide
DO	Dissolved Oxygen
EB	Electricity Bill
EIA	Environmental Impact Assessment
FAB	Fluidized Aerobic Bed
FC	Feacal Coliform
FPP	Final Polishing Pond
GHG	Green House Gas
GOI	Government of India
ha	Hectares
HP	Horse Power
HRT	Hydraulic Retention Time
IRR	Internal Rate of Return
IITR	Indian Institute of Technology Roorkee
km	kilometer
lpcd	Liters per capita per day
MBBR	Moving Bed Biofilm Reactor
Mg/l	Milligram per liter
MoEF	Ministry of Environment and Forest

MPN	Most Probable Number
MPS	Main Pumping Station
ml	Milli liter
MLD	Million Liter per Day
MLSS	Mixed Liquor Suspended Solids
MSL	Mean Sea Level
NRCD	National River Conservation Directorate
NEERI	National Environmental and Engineering Research Institute
NPV	Net Present Value
OHT	Over Head Tank
O&M	Operation and Maintenance
PCMC	Pimpiri Chinchuwad Municipal corporation
PLC	Programmable Logic Controller
ROI	Return On Investment
Rs	Rupees
SBR	Sequencing Batch Reactor
SS	Suspended Solids
STP	Sewage Treatment Plant
SVI	Sludge Volume Index
sqft	Square Feet
sqm	Square meter
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
TWAD	Tamil Nadu Water Supply and Drainage Board
UASB	Upflow Anaerobic Sludge Blanket
UGSS	Under Ground Sewerage Scheme
UNEP	United Nations Environment Programme
VIT	Vellore Institute of Technology
Vs	Versus
WHO	World Health Organization
WSP	Waste Stabilization Pond

CHAPTER-1

INTRODUCTION

1.1 BACKGROUND

The total fresh water resource available in India is 1850 km^3, which is only 4 % of World's fresh water resources, whereas the country's population is 16% of World's population. 70% of all available surface waters of India are polluted. Domestic wastewaters constitute upto 80% of the total volume of wastewater causing water pollution (Pannirselvam, 2005). The effect of pollution on society is recognized by most citizens and has resulted in a national commitment for the environmental clean-up. In India most of the Rivers, Lakes and other water bodies are polluted due to the indiscriminate discharge of untreated wastewater by the municipalities and industries. Also the rivers has no adequate flow due various reasons such as decrease in rainfall, Global Warming, Deforestation, Climate Change, GHG emission, Ozone depletion, and so on. The assimilating capacity or the carrying capacity of rivers is also not able to meet the enormous pollutant load. Rapid industrial growth, uncontrolled and unplanned urbanization and increasing population are also the reasons for the degradation of the water quality in the rivers and other water bodies.

The government of India has taken so many steps to control pollution through various legislations, Water Act, Environmental Protection Act and Action plans such as Ganga Action Plan, Yamuna Action Plan and other River Action Plans. Even then the pollution of rivers and the water quality in the rivers has not yet improved to the expected level. The reasons are the lack of Public Participation in planning, execution and post implementation stages. The various stakeholders were not involved in planning, selection of technology and decision making processes.

For the success of any project, the following steps are to be followed.

- Secure public support, cooperation and commitment from all levels of society, community, and governments (Local, State, Central).

- Integrated approach of water supply and sanitation and solid waste management to address the environmental impacts.
- Demand driven approach with effective cost recovery should be ensured.
- Long term planning to ensure financial stability and sustainability.
- Select appropriate indigenous technologies, which are cost effective, user friendly and eco-friendly, socially acceptable, financially viable, and technically feasible.
- Involve all stakeholders from the project planning stage; ensure accountability, transparency in management, and decision-making process.

The primary objective of wastewater treatment plant design is to provide treatment at a minimal cost while satisfying specific requirements. Wastewater treatment is necessary to preserve our natural/manmade water resources. Wastewater treatment systems have been established allover the world to prevent or control pollution. To restore the water quality in natural water bodies this provides a healthy ecosystem for aquatic life, wildlife, and provides recreation in the water bodies. During the last two decades wastewater treatment design emphasized treatment to control BOD, SS etc. Now the treatment design strategies were developed for the removal of Nitrogen, Phosphorous, and Feacal Coliforms. The latest innovative and technological developments are the changes in process design, which incorporate energy conservation, resource recovery such as nutrient, energy and water for reuse. Even though there are many Sewage Treatment technologies available, it is difficult to select a technology that is appropriate for the desired treatment. The study highlights the application of the Techno Economic Analysis tools for the selection of appropriate technology of sewage treatment and aims to provide guidance/methodology in the appropriate STP technology selection for urban planners and decision makers.

1.2 STUDY AREA

It is decided to select a historical town lying along a river which has a population of more than 1 lakh and having good water supply. Kancheepuram lying on the banks of Vegavathi River a tributary of River Palar which is running 4 km away from the city. It is famous for historical temples and silk sarees also attracts a large number of tourists. It is located in South West direction at 76 km from Chennai. The population as per 2001 census is 1, 52,984. The index map of the study area is given at fig1.1.

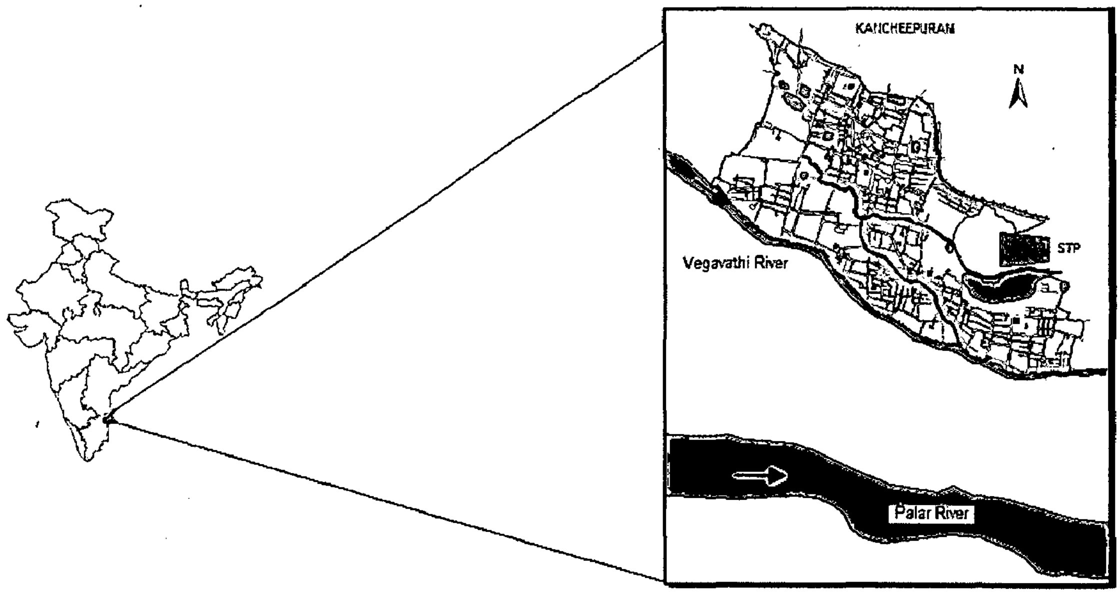


Fig 1.1 Index Map of study area

1.3 TECHNOLOGIES CONSIDERED

There are number of treatment systems that are applied for sewage treatment in India. The treatment systems that have been used are mostly biological and have their own merits and demerits. In order to arrive at the best feasible sewage treatment option from a techno-economic point of view, broadly following criteria has been adopted for selection of the sewage treatment options for evaluation.

- High power consuming wastewater treatment options has to be discounted.
- Removal efficiencies of the treatment system to be sufficient enough to meet effluent discharge standards.
- The treatment option should be simple to construct, easy to operate and have low operation and maintenance cost over a longer run; and
- The treated effluent is reused effectively for irrigation, industrial and other non-potable purposes.

Based on the above guidelines, the following technologies were proposed to be considered in this study.

- Waste Stabilization Pond (WSP).
- UASB Technology with post treatment final polishing pond (UASB+FPP).
- Activated Sludge Process (ASP).
- Moving Bed Biofilm Reactor (MBBR).
- Sequencing Batch Reactor (SBR).

The standards for the effluent disposal as per NRCD in India are given below in Table 1.1

Table 1.1 Standards for effluent disposal

PARAMETER	INTO WATER BODY	ON LAND
BOD, in mg/L	30	100
TSS, in mg/L	50	200
Feacal coliform, in MPN/100ml	1000(Desirable) 10000(Maximum)	-------

1.4 OBJECTIVES

The Objectives of the study are:

1. To develop a procedure/methodology for the selection of appropriate Sewage Treatment Plant (STP) technology for the Kancheepuram town in Tamil Nadu.
2. Design and cost estimation of the selected sewage treatment plant.

CHAPTER-2

LITERATURE REVIEW

2.1 GENERAL

Wastewater treatment systems are generally capital-intensive and require expensive, specialized/skilled operators. Therefore, before selecting and investing in wastewater treatment technology, it is always preferable to investigate whether pollution can be minimized or prevented. For any pollution control initiative an analysis of cost effectiveness needs to be made and compared with all conceivable alternatives. (WHO/UNEP, 1997).

The technology that is more appropriate in terms of technical acceptability, economic affordability and social attractiveness has to be considered. In developing countries where capital is scare and poorly skilled workers are abundant, solutions to wastewater treatment should preferably be low technology oriented. This means the technology chosen is less mechanized and has a lower degree of automatic process control, and that construction, operation and maintenance aim to involve locally available personnel rather than imported mechanized components. Such technologies are rather land and labour intensive, but capital and hardware extensive.

Technology selection eventually depends upon wastewater characteristics and on the treatment objectives as translated into desired effluent quality. Effluent quality control is typically aimed at public health protection, preservation of the oxygen content in the water, prevention of eutrophication, prevention of sedimentation, preventing toxic compounds from entering the water and food chains and promotion of water reuse.

The selection technologies should be environmentally sustainable, appropriate to the local conditions, acceptable to the user, and affordable to those who have to pay for them. Simple solution that are easily replicable, that allow further upgrading with subsequent development, and that can be operated and maintained by the local community, are often considered the most appropriate and cost-effective. (WHO/UNEP, 1997).

2.2 SELECTION CRITERIA

The general criteria for technology selection comprise:

- *Average or typical efficiency and performance of the technology.* This is usually the criterion considered the best in comparative studies. The possibility that the technology might remove other contaminants than those that were the prime target should also be considered an advantage. Similarly, the pathways and fate of the removed pollutants after treatment should be analyzed, especially with regard to the disposal options for the sludges in which micro pollutants tend to concentrate.
- *Reliability of the technology.* The process should, preferably, be stable and resilient against shock loading, i.e. it should be able to continue operation and to produce an acceptable effluent under unusual conditions. Therefore, the system must accommodate the normal inflow variations, as well as infrequent, yet expected, more extreme conditions. This pertains to the wastewater characteristics (e.g. occasional illegal discharges, variations in flow and concentrations, high or low temperatures) as well as to the operational conditions (e.g. power failure, pump failure, poor maintenance). During the design phase, "what if" scenarios should be considered. Once disturbed, the process should be fairly easy to repair and to restart.
- *Institutional manageability.* In developing countries few governmental agencies are adequately equipped for wastewater management. In order to plan, design, construct, operate and maintain treatment plants, appropriate technical and managerial expertise must be present. This could require the availability of a substantial number of engineers with postgraduate education in wastewater engineering, access to a local network of research for scientific support and problem solving, access to good quality laboratories, and experience in management and cost recovery. In addition, all technologies (including those thought "simple") require devoted and experienced operators and technicians who must be generated through extensive education and training.
- *Financial sustainability.* The lower the financial costs, the more attractive the technology. However, even a low cost option may not be financially sustainable,

because this is determined by the true availability of funds provided by the polluter. In the case of domestic sanitation, the people must be willing and able to cover at least the operation and maintenance cost of the total expenses. The ultimate goal should be full cost recovery although, initially, this may need special financing schemes, such as cross-subsidisation, revolving funds, and phased investment programmes.

- *Application in reuse schemes.* Resource recovery contributes to environmental as well as to financial sustainability. It can include agricultural irrigation, aquaculture and pisciculture, industrial cooling and process water re-use, or low-quality applications such as toilet flushing. The use of generated sludges can only be considered as crop fertilisers or for reclamation if the micro-pollutant concentration is not prohibitive, or the health risks are not acceptable.
- *Regulatory determinants.* Increasingly, regulations with respect to the desired water quality of the receiving water are determined by what is considered technically and financially feasible.

2.2.1 Selection of Technology

The technology selection process results from a multi-criteria optimization considering technological, logistic, financial and institutional factors within a planning horizon of 10-20 years. Key factors are:

- The size f the community to be served
- The characteristics of the sewer system
- The sources of wastewater
- the future opportunities to minimize pollution loads
- The discharge standards for treated effluents
- the availability of local skill; for design, construction and O&M
- Environmental conditions such as land availability, geography and climate.

For the sustainability of any project, special attention has to be given to the selection of appropriate technology with participatory approach. Appropriate technology must be:

- A cost-effective technology that provides adequate treatment
- Affordable in capital cost and operation and maintenance
- Operable at a reasonable cost and with locally available labour
- Reliable enough to consistently meet effluent quality requirements.

All the stake holders should be actively involved from the project formulation stage and technology selection process. Such a selection should be based on knowledge of initial capital investment, land requirement, energy consumption, treatment efficiency and reliability and operation and maintenance costs of different technological options used for treatment of wastewater.

The important parameters that are used in the selection of biological treatment methods are land, power requirements and their performance. The expected BOD removal efficiency is not the only parameter to be considered. In several instances, equally careful attention has to be paid to the required removal of nutrients, nitrogen and phosphorous and to the micro organism like coliforms, helminths etc. Foul odour potential, sludge handling and disposal difficulties, other operational characteristic and dependability of performance are the other factors that need to be addressed.

The choice of a treatment system depends on various other factors which can be grouped under three key words: *affordability, acceptability and manageability. Affordability* depends on the financial ability of the community to be served and the requirement of the process in terms of power and land requirements. *Acceptability* mainly depends on performance of the treatment system. The acceptability generally depends on two groups of individuals: i. the pollution control authorities who have to approve the treatment method proposed and ii. the riparian public who have to live near the treatment facility. *Manageability* refers to both the routine operations of the plant and its maintenance and repairs when needed. If the three key tests of *affordability acceptability* and *manageability* are met by a process or treatment method, it could be considered for adoption as an appropriate technology. Appropriate technology is also most likely to be a sustainable one.

The factors that affect the choice of treatment method are its design criteria and related requirements such as the following.

- Waste water flow and its characteristics.
- Degree of treatment required
- Performance dependability.
- Other process requirements

  Land

  Power consumption

  Operating equipment requirement and its availability

  Availability of skilled staff

  Nature of maintenance problem

  Extent of sludge production and its disposal

  Loss of head expected

  Easy of stage wise extension of plant with time

Between land and power requirements a trade-off is often possible, based on actual cost of the two items. This could be well exploited to get an optimum solution for meeting treatment requirements and giving a dependable performance.

The extent of mechanization adopted should generally be the minimum possible so as to ensure sustainability. As far as possible, the operating equipment and its ancillary control equipment should be easy to operate and maintain. Conversion of waste to energy (by methane gas collection, scrubbing to remove hydrogen sulphide from the gas, wherever necessary and its conversion to electricity) imposes a requirement of higher level of skills of operation and maintenance. Wherever possible, during the site selection stage itself, the option of gas collection with direct supply to a nearby industry or area should be favored over conversion to electricity. (Arceivala, 2007)

2.2.2 Energy Conservation

Equally in developing and developed countries, energy conservation and reduction methods now need to be given attention when designing all waste treatment facilities. Wastewater treatment plants firstly minimize their power requirement and then look for power from either biogas or other renewable sources (wind and solar energy) so that they are independent of urban supplies.

In this regard, the approach that needs to be considered is to adopt every feasible method to conserve energy without adding to the costs or complexities of the treatment process. For example:

1) A judicious selection of equipment and processes that require minimum amount of power to operate, and
2) An emphasis on good engineering and architectural design a (without bringing in exotic technology) so as to benefit from the prevailing climate and conserve electric power.
3) Adopt more advanced power – recovery and other devices on a cost/ benefit basis, provided the mechanization so introduced is within the technological competence of the people concerned.

Among the methods that could be easily included in the above approaches are the following: Select, as far a possible the least energy – intensive processes capable of meeting effluent quality requirement. Power requirements are nil for waste stabilization ponds, relatively low for USAB systems, higher for facultative aerated lagoons and highest for extended aeration system. Moreover, aerobic digestion always needs more power than anaerobic digestion. Thus, if a more energy- intensive process is selected, there should be strong justification for it, such as the need for very high BOD removal efficiency, or the need for nitrification, or the need for reliability in operation.

The important factors in selection of the treatment processes include constituents to be treated effluent standard limitations, proximity to buildup area, hydraulic requirements, sludge disposal, energy requirements and plant economies. The collective arrangement of various treatment processes is called a flow scheme, a flow sheet, a process diagram, or a process train. Choice of proper treatment processes and development of the flow scheme requires understanding of the unit operations and processes, operational capabilities, and environmental effects of various treatment components than are rearranged to develop the process train for a desired application. (Qasim, 1999)

2.2.3 Equipment Selection

To select the treatment processes and the corresponding types of equipment for achieving the desired results a review of the design standards, design procedure and design assumption; preliminary design calculation and careful study of the manufacturers' catalogue may be necessary in advance.

2.2.4 Plant Layout and Hydraulic Profile

During early planning and design stages, careful consideration must be given to the existing conditions at the selected site of the proposed wastewater treatment plant. Condition such as topography, available land area, proximity to the developed areas, access roads, flood condition, need for future expansion, available head, and so on should all be considered in unit selection and layout.

2.2.5 Energy and Resource Requirements

Because of the recently increased concern about the limited resources available to meet our energy needs, the project planning and design must also include energy conservation. Primary energy is the energy used in the operation of the facility, while secondary energy is needed to manufacture chemicals, other consumable materials, and construction material such as concrete and steel. Waste treatment alternatives that substantially conserve energy are considered innovate. Therefore, process energy utilization and conservation should be of particular value throughout the planning, project formulation and preliminary engineering design.

2.2.6 Plant Economics

As an integral part of the wastewater treatment plant planning and design a cost – effective analysis must be performed to ensure that the construction and the operation and maintenance are reasonable and appropriate for the planned level of treatment and process train. A cost effective solution is one that will minimize total costs of the resources over the life of the treatment facility. Resources costs include capital (land plus construction), operation, maintenance and replacements, and social and environmental costs. Benefits from sludge and effluent sale or reuse will partly offset the resources costs.

2.2.7 Environmental Impact Assessment

The environment impact assessment must evaluate all impacts –beneficial and adverse, primary and secondary that may result from the construction of a waste water treatment facility. The primary impacts are those directly associated with construction and operation of the treatment works. The secondary impacts are indirect, resulting from the plant or the change in land use induced or facilitated by the construction of the plant or its associated sewers.

2.2.8 Waste water Treatment process Alternatives and Alternative selection

Once the size and scope o the water pollution problem is defined develop various alternatives for wastewater treatment, effluent disposal and sludge processing and disposal. Screen systematically each alternative to determine those that can meet the federal, state and local criteria. Then review the principal alternative to identify those that have cost effective potential. Develop cost data for the principal alternatives and then evaluate them critically for environmental consequences along with the cost benefit analysis. (Qasim, 1999)

2.3 TREATMENT METHODS

Sewage treatment is a combination of unit processes put together to achieve a desired effluent quality. Many combinations are used to achieve the same degree of treatment. The design engineer has to carefully select the suitable combination of unit processes that gives the desired output. The methods of sewage treatment include

- Primary or Physical treatment
- Biological or Secondary treatment
- Tertiary or advanced treatment

The separation of solids from the sewage can be done in one or two steps, so that the BOD gets reduced and DO content brought to normal levels. The solids may be organic or inorganic. Most of the organic solids undergo degradation and they serve as food for the microorganisms. Inorganic solids are inert and do not undergo degradation. Further the solids are classified into

- floating
- settleable
- colloidal and
- dissolved

Because of the differing properties of each type of these solids, it is not possible to remove them in a single unit. The first two types could be removed in a primary treatment unit by virtue of their physical properties through screens, grit, skimming and sedimentation chambers.

The removal of colloidal and dissolved solids involves the addition of chemicals. Addition of chemicals for sewage treatment is not resorted to for economical reasons. However in biological treatment units, the microorganisms bring about the conversion of such solids into settleable or stabled materials. These units are very efficient and economical.

2.3.1 Physical or primary treatment

The principal unit operations and their functions applied to primary treatment of sewage are given in the Table 2.1 as below.

Table: 2.1 Unit operations of primary treatment and their functions.

Unit operation	Functions
Bar racks and Screens	Removal of floating and settleable solids those are larger than the size of opening in screens. To render the other units aesthetics and to prevent damage to the downstream mechanical equipments, valves, to make aeration, disinfection and distribution of sewage very effective.
Grit chamber	Removal of inert inorganic heavy and tough particles such as grit, sand, stones, etc. which will otherwise affect the pumps and other downstream equipments.
Skimming and grease trap	Removal of lighter floating solids including grease, soap, cork, wood, vegetable debris etc...
Sedimentation	Removal of settleable solids and scum

2.3.2 Biological or Secondary treatment

The objective of biological treatment is to coagulate the non settleable colloidal solids and to stabilize the organic matter. The various biological processes used for sewage treatment are

- Aerobic
- Anaerobic
- Aerobic and Anaerobic in tandem
- Pond Systems
- Natural Treatment Systems

Aerobic Processes

Suspended Growth	Attached Growth	Both combined
Activated Sludge process Sequencing Batch Reactor Aerated Lagoons Extended Aeration	Trickling Filter Rotating Biological Disc	Fluidized Aerobic Bioreactor (FAB)

Anaerobic Processes

Suspended Growth	Attached Growth
Upflow Anaerobic Sludge Blanket UASB Anaerobic Baffled Reactor	Expanded Bed Fluidized Anaerobic Bed (FAB)

Aerobic and Anaerobic in tandem

- Biofilter

Pond Systems

- Waste Stabilization Ponds (Anaerobic, Facultative and Maturation ponds)
- Oxidation Ponds (Facultative and Maturation ponds)
- Duck Weed Ponds

Natural Treatment Systems

- Slow Rate Treatment
- Rapid Infiltration
- Overland Flow
- Constructed Wetlands
- Aquaculture

2.3.3 Tertiary or Advance treatment

The need for tertiary or advanced treatment is based on a consideration of one or more of the following factors.

- The need to remove organic matter and total suspended solids beyond what can be accomplished by above processes to meet more stringent discharge or reuse standards.
- The need to remove residual total suspended solids to condition the treated effluent for more effective disinfection.
- The need to remove nutrients beyond what can be accomplished by above processes to limit the eutrophication of sensitive water bodies.
- The need to remove specific inorganic (heavy metals) and organic constituents to meet the reuse standards.

Advanced treatment systems

- Depth filtration
- surface filtration
- membrane filtration
- carbon adsorption
- reverse osmosis
- chemical precipitation
- chemical oxidation
- electro dialysis
- distillation
- ultra filtration

2.4 SELECTION OF SEWAGE TREATMENT TECHNOLOGY

The selection of suitable method for sewage treatment for a given situation depends up on the following factors: volume of daily flow to be treated, area of land required for the installation of the plant, the method of supply of oxygen to the microorganisms, mechanical equipment involved in the method, ease of operation and maintenance, capital cost for the installation of the plant, and annual operation and maintenance cost etc. The amount of sludge produced by each technology and the cost of its disposal also can be considered.

As the sewage treatment technology is a combination of various unit operations and processes, the following important factors must be considered when evaluating and selecting the unit operations and processes. (Metcalf Eddy, 2007)

Table: 2.2 Factors to be considered in evaluating and selecting the unit operations and processes.

Process applicability	The applicability of a process is evaluated on the basis of past experience, data from full-scale plants, published data, and from pilot-plant studies. If new or unusual conditions are encountered, pilot-plant studies are essential.
Applicable flow range	The process should be matched to the expected range of flow rates. For example, stabilization ponds are not suitable for extremely large flow rates in highly populated areas.
Applicable flow variation	Most unit operations and processes have to be designed to operate over a wide range of flow rates. Most processes work best at a relatively constant flow rate. If the flow variation is too great, flow equalization may be necessary.
Influent wastewater characteristics	The characteristics of the influent wastewater affect the types of processes to be used (e.g., chemical or biological) and the requirements for their proper operation.
Inhibiting and unaffected constituents	What constituents are present and may be inhibitory to the treatment processes? What constituents are not affected during treatment?

Climatic constraints	Temperature affects the rate of reaction of most chemical and biological processes. Temperature may also affect the physical operation of the facilities. Warm temperatures may accelerate odor generation and also limit atmospheric dispersion.
Process sizing based on reaction kinetics or process loading criteria	Reactor sizing is based on the governing reaction kinetics and kinetic coefficients. If kinetic expressions are not available, process loading criteria are used. Data for kinetic expressions and process loading criteria usually are derived from experience, published literature, and the results of pilot-plant studies.
Process sizing based on mass transfer rates or process loading criteria	Reactor sizing is based on mass transfer coefficients. If mass transfer rates are not available, process loading criteria are used. Data for mass transfer coefficients and process loading criteria usually are derived from experience, published literature, and the results of pilot-plant studies.
Performance	Performance is usually measured in terms of effluent quality and its variability, which must be consistent with the effluent discharge requirements.
Treatment residuals	The types and amounts of solid, liquid, and gaseous residuals produced must be known or estimated. Often, pilot-plant studies are used to identify and quantify residuals.
Sludge processing	Are there any constraints that would make sludge processing and disposal infeasible or expensive? How might recycle loads from sludge processing affect the liquid unit operations or processes? The selection of the sludge processing system should go hand in hand with the selection of the liquid treatment system.

Environmental constraints	Environmental factors, such as prevailing winds and wind directions and proximity to residential areas, may restrict or affect the use of certain processes, especially where odors may be produced. Noise and traffic may affect selection of a plant site. Receiving waters may have special limitations, requiring the removal of specific constituents such as nutrients.
Chemical requirements	What resources and what amounts must be committed for a long period of time for the successful operation of the unit operation or process? What effects might the addition of chemicals have on the characteristics of the treatment residuals and the cost of treatment?
Energy requirements	The energy requirements, as well as probable future energy cost, must be known if cost-effective treatment systems are to be designed.
Other resource requirements	What, if any, additional resources must be committed to the successful implementation of the proposed treatment system using the unit operation or process being considered?
Personnel requirements	How many people and what levels of skills are needed to operate the unit operation or process? Are these skills readily available? How much training will be required?
Operating and maintenance requirements	What special operating or maintenance requirements will need to be provided? What spare parts will be required and what will be their availability and cost?
Ancillary processes	What support processes are required? How do they affect the effluent quality, especially when they become inoperative?
Reliability	What is the long-term reliability of the unit operation or process being considered? Is the operation or process easily upset? Can it stand periodic shock loadings? If so, how do such occurrences affect the quality of the effluent?

Complexity	How complex is the process to operate under routine or emergency conditions? What levels of training must the operators have to operate the process?
Compatibility	Can the unit operation or process be used successfully with existing facilities? Can plant expansion be accomplished easily?
Adaptability	Can the process be modified to meet future treatment requirements?
Economic life-cycle analysis	Cost evaluation must consider initial capital cost and long-term operating and maintenance costs. The plant with lowest initial capital cost may not be the most effective with respect to operating and maintenance costs. The nature of the available funding will also affect the choice of process.
Land availability	Is there sufficient space to accommodate not only the facilities currently being considered but possible future expansion? How much of a buffer zone is available to provide landscaping to minimize visual and other impacts?

The selection of an appropriate sewage treatment technology is a method or a technique, which provides a socially and environmentally acceptable level of service or quality of project with full health benefits and at the least economic cost. The factors to be considered in technology selection are

i. Common scale to compare the overall performance of alternatives.
ii. The progressive aspiration of the community, and
iii. The effects of inequalities in the levels of society and technology

The technology should be least cost, hygienically sound, structurally permanent and aesthetically acceptable and maximum convenience in use with least negative effect on environment. (Shahalam, 1982)

The most important factors that should be borne in the mind before the selection and design of any sewage/ wastewater treatment system are: (Sulabh Envis Newsletter, 2007)

Engineering Factors

- Design period, stage wise population to be served and expected sewage flow and fluctuations.
- Topography of the area to be served, its slope and terrain; tentative sites available for treatment plant, pumping stations and disposal works.
- Available hydraulic head in the system upto high flood level in case of disposal into a river or high tide level in case of coastal discharges.
- Groundwater depth and its seasonal fluctuations affecting construction, sewer infiltration.
- Soil bearing capacity and type of strata to be met in construction.
- On site disposal facilities, including the possibilities of segregating sullage and sewage and reuse or recycling of sullage water within the households.

Environmental Factors

- Surface water, groundwater and coastal water quality where wastewater has to be disposed after treatment
- Odour and mosquito nuisance which affects land values, public health and well being.
- Public health considerations by meeting the requirements laid down by the regulatory agencies for effluent discharge standards, permissible levels of microbial and helminthic quality requirements and control of nutrients, toxic and accumulative substances in food chain.

Process considerations

- Wastewater flow and characteristics.
- Degree of treatment required.
- Performance characteristics.
- Availability of land, power requirements, equipments and skilled staff for handling and maintenance.

Cost considerations

- Capital costs for land, construction, equipments etc.
- Operating costs including staff, chemicals, fuels and electricity, transport, maintenance and repairs etc.

"Appropriate technology" can be defined as the technology that is affordable and operable by the user and that reliably provides the required treatment. Other criteria are that the technology be financially sustainable by the local community and use a holistic approach. "Sustainability and Wastewater Treatment" looks at wastewater treatment with a focus on environmental and cost appropriateness.

Choosing technologies for domestic waste disposal is a complex process involving many factors. To arrive at an appropriate technology for a given community the cost-effective technology that provides adequate treatment and that the local community has the finances and skilled labour force to operate and maintain. Selecting the most appropriate technology for a given community requires an analysis of cultural factors, a site evaluation, and a cost analysis. For a final selection, however, it must be supplemented with a detailed analysis for each community based on local factors and needs.

The main factors in choosing a domestic wastewater treatment technology are water availability, presence of a collection system, housing or population density, availability of skilled management and operating personnel, land availability, availability and cost of power, receiving water requirements, hydrogeologic conditions and climate, and availability of opportunities for effluent reuse.

2.5 ECONOMICS OF TREATMENT TECHNOLOGIES/METHODOLOGY FOR SELECTION

The following financial management tools are used for comparing the costs of various Sewage Treatment Technologies using net present value (NPV), internal rate of return (IRR), and benefit-cost ratio (BCR) calculations.

Annual Cash Flow Projections

Cash flows are the expenditures made and revenues received during the lifetime of a technology. By computing annual expenditures and revenues, a year-by-year cash flow projection is established.

Net Present Value or Present worth Method

This method uses compound interest factors to compound or discount all cash flows. Sewage Treatment technologies are then ranked by comparing the equivalent values at time zero of each alternative using the same interest rate and equipment lifetime. Net present value (NPV) is calculated as the difference between benefits and the discounted costs. The technology with the highest present worth is the best technology from an economic standpoint.

Capitalized Cost or Life Cycle Cost Method

In this method, the present worth of a technology assuming an infinite life is computed, i.e., the capitalized cost is the initial cost plus the present value of an infinitely lived technology. The technology with the lowest capitalized cost is the best technology from an economic standpoint.

Internal rate of return

The internal rate of return (IRR) is the discount rate which equalizes the present values of costs/expenditures and revenues, i.e., the value at which the NPV = 0

Return on Investment Method

The return on investment (ROI) is the ratio of annual profits to original investment. This may be used to compare the savings from Sewage Treatment technologies in relation to known costs. This method does not account for the time value of money and other factors..The technology with the highest ROI is the best technology from an economic standpoint.

Benefit cost ratio

It is the ratio of the total present value of benefits to the total present value of expenditures of any project. It should be greater than one. The benefit cost ratio (BCR) is calculated as:

$$BCR = \frac{\text{Present value of benefits}}{\text{Present value of expenditures}}$$

The technology with higher the Benefit cost ratio is the best technology from an economic standpoint.

2.6 COST

2.6.1 Capital Costs

Total capital cost should include all direct and indirect costs related to siting and installation as well as the equipment purchase cost. Some technologies require little site preparation and installation, while others involve significant installation requirements. The following list gives *direct costs* that need to be taken into account.

- Site preparation
- Demolition and disposal (e.g. removal of an old STP)
- Building (new construction or renovation)
- Foundation and supports
- Electrical service
- Piping including steam and water lines
- Pumping accessories
- Air compressor
- Lighting
- Sanitary sewer
- Sprinkler system
- Painting and insulation
- Handling and on-site fabrication
- Equipment purchase cost (including auxiliary devices, instrumentation, carts for transporting waste, monitoring equipment, freight, sales tax, etc.).

The following are *indirect costs* that should be considered:

- Project management
- Engineering
- Construction fees
- Permitting
- Regulatory testing

- Professional fees (including media fees to respond to public outcry, if the community does not like the technology choice)
- Start-up
- Performance testing
- Contingencies.

There are intangible costs that cannot be quantified, such as loss of good public perception if the chosen technology is unpopular in the community or among staff.

2.6.2 Annual Operating Costs

Annual operating costs are costs incurred every year due to the operation of the technology during the life of the equipment. Due to inflation, the magnitude of these costs may vary, but the same kinds of costs will be incurred.

Direct costs are those that are dependent on the throughput of the system, such as:

- Labor (operating and supervisory)
- Utilities:
- Electricity
- Consumables:
- Chemical disinfectants
- Maintenance (scheduled and unscheduled)
- Materials
- Replacement parts
- Maintenance labor
- Landfill disposal costs (including transportation and tipping fees)
- Cost of disposing wastes not treated by the technology
- Cost of treating waste during scheduled and unscheduled downtime.

Indirect costs are costs that are not proportional to throughput, such as:

- Overhead
- Administrative costs
- Insurance
- Annual regulatory permit fees
- Periodic verification or emission tests

CHAPTER 3

BACKGROUND OF THE STUDY AREA

3.1 PROFILE OF KANCHEEPURAM

3.1.1 LOCATION

Kancheepuram town is one of the historical and sacred cities in Tamil Nadu, India. It is famous for historic temples and Handloom silk sarees. It is a selection grade municipality and District Headquarters. It is located in the South West direction at a distance of 76 km from Chennai. It is situated at 12° 50' North Latitude and 79° 42' East longitude. The town has an average elevation of 83.82m above M.S.L. The area of the municipality is 11.72 Sq. km. The main land lies on the northern bank of the holy river Vegavathi, a tributary of the river Palar. The town is well connected by rail and road. The nearest Airport is in Chennai. The 4 Lane Golden Quadrilateral from Chennai – Bangalore- Mumbai passes through the outskirts on the northern side of the town. The town map is given in Annexure -1

3.1.2 CLIMATIC CONDITIONS

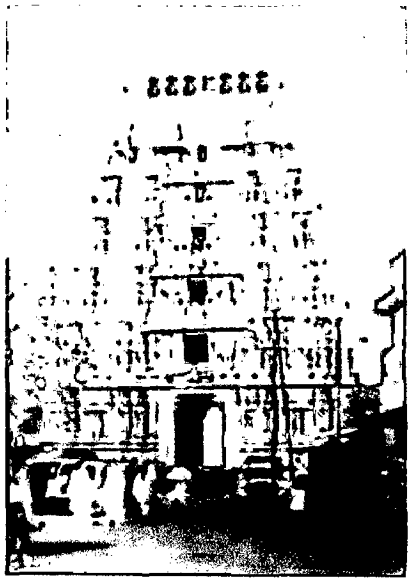
The temperature throughout the year is high, reaching a maximum of 37.5° C average in the month of April to July and recording of minimum average of 20.5° C temperature during the months of December to February. The prevailing wind direction is South West in the morning and south east in the evening. The town gets rains from both South West and North East monsoon. Average annual rainfall of the Town is 1125 mm.

3.1.3 SOIL

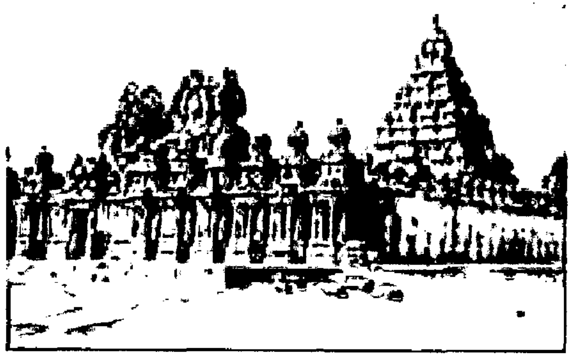
Predominant soil found in the town is Black, Red loam, Clay and Sand. The town has natural slope from West to East. The groundwater table varies from 2m to 6m during winter and 4m to 8.5m in summer seasons.

3.1.4 ECONOMIC BASE

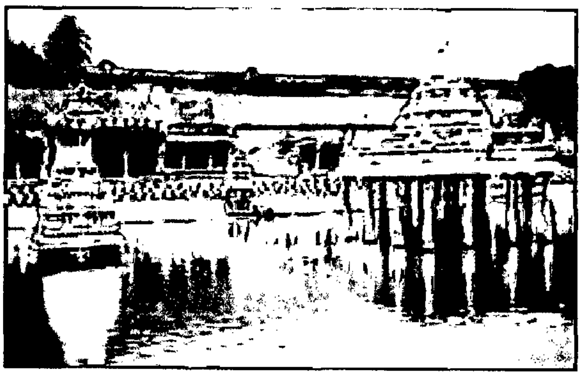
Kancheepuram is one of the most Sacred Towns of India having a Number of Ancient Temples which attract Tourists. It is also famous for Handloom Silk Sarees. It is the main business centre for the surrounding rural areas. In tourism, this town attracts 3% foreigners and balance tourists from allover India. Some photos on the beauty of temples that attracts tourists are shown in fig 3.1.



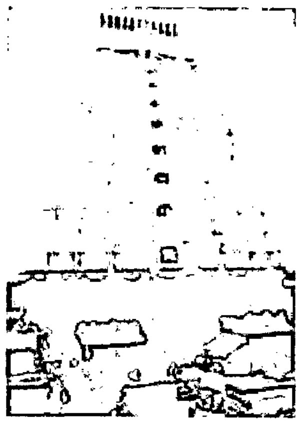
Kamatchiamman Temple



Ekambaranathar Temple



Temple Tank in Varadarajaswamy Temple



Ekambaranathar Temple

Fig 3.1 Historical Temples in Kancheepuram

3.2 WATER SUPPLY

Kancheepuram is provided with protected potable water supply scheme with Vegavathi River as the source in 1987. This project was designed for an ultimate population of 56,000 with a per capita supply of 75 lpcd. In the year 1961 another water supply scheme with Palar River as source was executed to improve the supply for which the headworks is located in Orikkai. The TWAD Board executed the World Bank assisted waster supply scheme with source in River Palar near Thirupparkadal (35 km from the town). Now daily 14 MLD of water is supplied from all the above water works for population of 1, 52,984 at the rate of 90 Lpcd.

3.2.1 SOURCE AND LOCATION OF HEADWORKS

The Palar River is the main source of water supply to the town. There are two head works both in Palar River bed. One at Orikkai (4.5 KM from the town) and another at Thiruparkadal (35 KM from the town).

3.2.2 ZONING OF WATER SUPPLY

To have equitable supply and required uniform pressure, the town has been divided into 7 Zones for effective management of Water Supply and each zone has one Over Head Tank (OHT). Water from Orikkai head works is pumped to two overhead tanks (OHT) at bus stand and Rajaji Market and that from Thiruparkadal is pumped to five OHTs at Jawaharlal Market, Upperikulam, Mandapam street, Yathathakari Street and Pattalam Street. Vegathy Booster also pumps water directly to distribution mains, while the water distribution is on from OHT's . The location of OHTs, capacity, staging height and their source of supply are given in the Table 3.1 as below.

Table: 3.1 Location, Capacity and source of supply of OHTs

Location of OHT	Capacity (in Lakh liters)	Staging height in m	Source of supply
Jawaharlal Market – Zone 1	20	12	Thiruparkadal
Upperikulam – Zone 2	10	12	Thiruparkadal
Bus Stand – Zone 3	9	12	Orikkai
Mandapam Street -Zone 4	20	12	Thiruparkadal
Rajaji Market – Zone 5	11.25	7.5	Orikkai
Yathathakari St – Zone 6	20	12	Thiruparkadal
Pattalam Street – Zone 7	8	11	Thiruparkadal

Water is supplied from the OHTs through distribution mains to 45 wards of the town. The total length of Distribution networks is about 127.50 km which covers almost the entire town. The no of house service connections are 16058.

3.2.3 WATER TARIFF

The municipality has the following tariff for the water supplied to various purposes.

Domestic purpose: Rs. 30 / month

Commercial Purpose: Rs. 6 / 1000 liters

Industrial purpose: Rs. 9 / 1000liters

3.3 SEWERAGE

Underground sewerage Scheme is functioning in this town from the year 1975. The Government of India declared Kancheepuram as one of the hyper-endemic towns in the year 1970 and hence the present sewerage system in the town was provided. The sewerage scheme was executed in 1975, at a cost of Rs. 120 Lakhs by TWAD Board. The UGSS was designed for a population of 1.50 lakhs and to have an average flow of 9 MLD and a peak flow of 54 MLD. For managing the sewerage system, the town has been divided into East and West zones. The UGSS network covers 73.3 km out of a total road length of 110.91 km. There are 23426 sewerage connections out of 26057 property tax assessments. Now the average sewage generation is around 13.7 MLD. The sewage is collected in two zones by gravity to the collection sumps in the respective zone pumping stations. The sewage is then pumped to the ponds located at Thirukalimedu at a distance of about 3 km from the town. The treated effluent is used for grass farming and growing coconut trees. The extent of farming land is 112 acres.

3.3.1 DETAILS OF EXISTING SEWERAGE SYSTEM

West zone

The length of sewers in this zone is 45.1 km of sizes ranging from 150 mm to 450 mm. There are 4 main sewers in this zone. The sewage collected in this zone by gravity to the collection sump at P.S.K Street. (West zone pumping station). Sewage from the sump is pumped to the STP site by means of 2 nos of 100 HP submersible pumpsets through 500mm CI main. The flow is approximately 6.48 MLD

East zone

The East zone pumping station is located in a place called Thenambakkam. The length of sewers in this zone is 30.3 km. There are 3 main sewers in this zone. Sewage collected by gravity and pumped to STP by means of 2 nos of 75 HP Submersible pumpsets through 400 mm CI main. The flow is around 4.32 MLD.

3.3.2 Sewage treatment Plant

The STP is located in Thirukalimedu at a distance of about 3 km from the town. The area of the STP is 27.256 acres. The total area is 112 acres in which grass farming and coconut trees are grown. The treatment plant consists of the following units.

1. Anaerobic pond
2. Facultative pond
3. Maturation pond

3.3.3 Status of existing system

There is no proper mechanism for the maintenance of the STP. The Fig 3.2 is the existing STP inlet and ponds. The water hyacinths in the ponds were not removed. The sewage is pumped into the STP and the effluent is used for grass farms.

3.3.4 Manjal neer channel

The storm water drains in the town are connected to the Manjal neer channel which finally leads to Nathapettai Eri (Tank). The Rice mill wastewater and the dying unit wastewaters are also flowing into this channel. The fig 3.3 is the photograph showing the Manjal Neer channel. Fig 3.4 is the rice mill-soaking pit for the paddy. After soaking the wastewater will be let out into the open drain. Fig 3.5 is the dying unit wastewater. The wastewater from these rice mill and dying units are directly discharged into manjal neer channel.

3.4 Problems of Pollution

The following problems were noticed in the existing sewerage system.

- Inadequate capacity of the system due to increased population.
- Overloading of the existing sewer system due to Rice Mill (53 Nos) and Dying units (60 Nos) discharging their effluent/wastewater.
- Some portion of wastewater by these rice Mills and Dying units directly discharge effluent to the Manjal Neer Channel.
- Wastewater from unsewered and newly developed areas are discharged into Manjal Neer Channel
- Overflow from pumping stations due to inadequate pumping capacity.
- Pollution of Manjal Neer Channel and Vegavathi River.
- The inlet chambers in STP are damaged and leaking.
- Silt deposited in the ponds were not removed and the capacity of the pond reduced.
- No proper watch and ward in the STP.
- Efficiency of treatment reduced due to the poor Maintenance of STP
- Poor sewage treatment and disposal affects the health of the local population and the environment
- Children have been affected by helminthes, coliform, enteric and diarrhoeal diseases are the most common cause of infant mortality

Agriculture in adjacent villages has been affected due to the discharge of untreated or partially treated dye-effluents from cottage dyers into the Manjal Neer channel in Kanchipuram town. Raw sewage spills into the Vegavathi river at times and partially treated sewage flows down the Manjal Neer odai reaching Nathapettai tank and several tanks in the downstream, resulting in total stoppage of use of this tank for irrigation (the villagers use ground water, which also is being contaminated). Burgeoning population, too, has taken its toll. Soaring requirement of drinking water in urban areas complicated by falling water table due to over extraction of ground water for domestic and industrial use has raised the pressure on the river water resources to unprecedented levels that these ecosystems have come under heavy strain.

Many lakes receives untreated or partially treated sewage that is collected through open drains. Even where sewage treatment plants are in operation (as in Kancheepuram municipality), overloading due to the increase of sewage volume with passage of time and poor management of the system leading to unchecked spills of untreated sewage have led to contamination of irrigation water channels as well as ground water. The contamination often spreads downstream several tens of kilometres to villages through irrigation channels, often affecting agricultural land, productivity and thereby rural livelihoods. The net result has been the elimination of water harvesting bodies and the concomitant pollution of both surface and ground water.

3.5 Need for sewage treatment

In view of the above problems on environmental, social, economical, agricultural, there is an urgent need to address these problems. There is an increasing awareness and demand among citizens to keep the environment clean. Therefore, providing and maintenance of urban environmental infrastructure facilities in order to keep the environment clean and healthy, which essentially is one of the traditional functions of the local Governments. However, the local Governments in India have not been able to fulfill the promise of adequate civil infrastructure to their rapidly increasing number of citizens mainly due to lack of institutional capabilities and financial resources. The result of the cities in overcrowding and ill-equipped settlement with high-polluted environment prone to frequent epidemics. The sewage from domestic and industrial sources in the cities has been polluting rivers and other water bodies situated nearby. The provision of appropriate sewage treatment will solve most of the above problems.

3.6 Benefits of sewage treatment

The sewage treatment will provide he following benefits

- Provide good living environment,
- Improvement in the public health,
- Prevention of pollution of water bodies,
- Prevention of groundwater pollution, and
- Prevention of fish kills.

3.7 Sewerage Tariff

At present, the municipality has the following tariff structure for the sewerage connection charges as per the byelaw are as detailed below.

House with plinth area upto 100 sqft:	Rs.100 / year
Commercial/Non-Residential Purpose upto 100 sqft:	Rs.500 / year
For every additional plinth area of 250 sqft:	Rs. 50 / year (Residential)
For every additional plinth area of 250 sqft:	Rs. 100 / year (Non-Residential)

Fig 3.2 Photo showing the existing STP Inlet (left) and Pond (right)

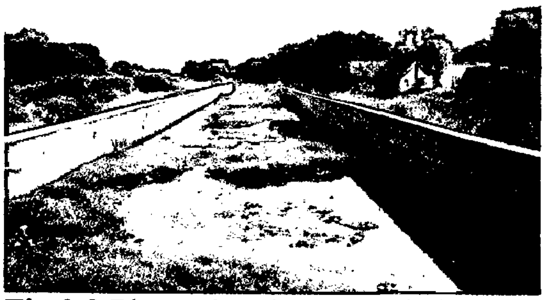


Fig 3.3 Photo showing the existing Manjal neer channel

Fig 3.4 Rice mill-Paddy soaking pit

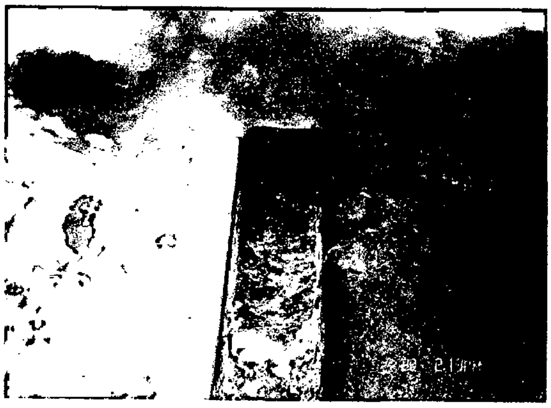


Fig 3.5 Dying unit wastewater

CHAPTER 4

RESULTS & DISCUSSION

4.1 DATA COLLECTION AND ANALYSIS

The collection of data is an important function for any work based on which one can do further analysis and inferences can be drawn from the analysis. Data can be either primary data or secondary data or both. The data should be realistic one and the data that are not consistent has to be eliminated from analysis.

For the selection and design of any sewage treatment plant the following data are very important.

- Population
- Quantity of water supply and wastewater generation
- Wastewater characteristics such as BOD, COD, TSS, TDS, Heavy metals, Faecal coliform, sulphates, etc...
- Availability of land
- Treatment level required to satisfy the national regulatory standards
- Effluent disposal to land or water bodies
- Drainage pattern and slope
- wind direction and intensity
- Temperature
- Rainfall details
- Type of soil and geology
- Ground Water Table levels
- Climatic conditions
- Location details with reference to latitude and longitude
- Industries

Most of the data are secondary in nature and obtained from the Municipality and other Govt. Departments.

4.2 POPULATION FORECAST AND SEWAGE GENERATION

The population growth of Kancheepuram town and the percentage variation since the year 1901 is given in the Table 4.1. The population forecast was carried out to find out the design population by graphical method using the trend line (Fig 4.1). The design population expected in the year 2017 is 181,763. The per capita water supply is 90 lpcd. The sewage quantity generated is worked out as 80% of water supply. An infiltration of 15% is assumed and added to the design flow. The total sewage flow is 15.05 MLD. The peak factor is 2.25. The peak flow is 33.86 MLD.

Table 4.1 Population Growth

S.No	Year	Population	% variation
1	1901	46,164	------
2	1911	53,864	16.68
3	1921	61,376	13.95
4	1931	65,258	6.32
5	1941	74,685	14.37
6	1951	84,810	13.65
7	1961	92,714	9.32
8	1971	1,10,657	20.53
9	1981	1,31,013	18.4
10	1991	1,44,955	10.64
11	2001	1,52,984	5.54

(Source: Census of India 2001)

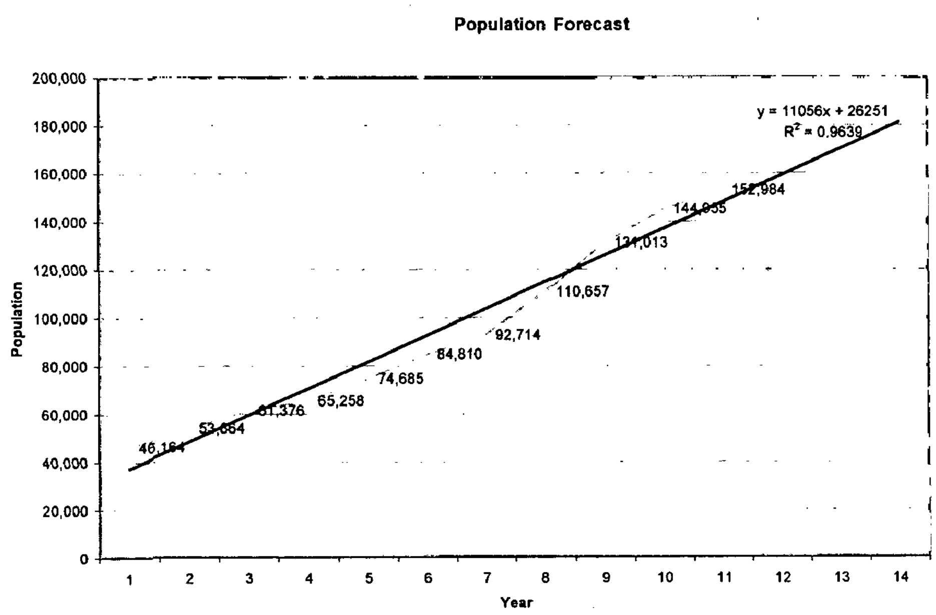


Fig 4.1 Population Forecast by Graphical Method

4.3 SEWAGE SAMPLING AND ANALYSIS

Sewage sample collected from the main pumping station and analyzed for the wastewater characteristics. The wastewater from modern rice mill and dying unit also collected and analysed. The results of wastewater analysis are given in the Table 4.2 as below.

Table: 4.2 Raw Sewage and wastewater characteristics

S.No.	Parameters	Sewage sample	Rice mill	Dying unit
I	**PHYSICAL EXAMINATION**			
	Appearance	Turbid	Turbid	
	Odour	Sewage smell	None	
	Turbidity NTU	85.7	24.8	
	Total Dissolved Solids mg/L	1814	1188	
	Electrical Conductivity	2300	1600	
II	**CHEMICAL EXAMINATION**			
	pH	7.27	6.91	
	Alkalinity pH (as $CaCO_3$)mg/L	Nil	Nil	
	Alkalinity Total (as $CaCO_3$)mg/L	688	356	
	Total Hardness (as $CaCO_3$)mg/L	400	540	600
	Calcium (as Ca) mg/L	96	132	325
	Magnesium(as Mg) mg/L	38	50	275
	Sodium(as Na) mg/L	270	130	1000
	Potassium(as K) mg/L	45	20	62.5
	Iron(as Fe) mg/L	9.37	5.32	1.53
	Manganese(as Mn) mg/L	Nil	Nil	Nil
	Free Ammonia(as NH_3) mg/L	8.05	2.98	
	Nitrite(as NO_2) mg/L	Nil	Nil	
	Nitrate(as NO_3) mg/L	19	11	13
	Chloride(as Cl) mg/L	338	274	667
	Fluoride(as F) mg/L	167	0.53	
	Sulphate(as SO_4) mg/L	133	122	114
	Phosphate(as PO_4) mg/L	45.33	34.72	Nil
	Tidy's test(as O) mg/L	55	17.6	
	Silica(as SiO_2) mg/L	46.54	30.8	209.04
III	**SPECIAL TESTS**			
	Arsenic(as As) mg/L	Nil	Nil	Nil
	Cadmium(as Cd) mg/L	0.00096	0	0
	Copper(as Cu) mg/L	0.987	0.00781	0.0567
	Chromium(as Cr) mg/L	0.00231	Nil	0.00116
	Zinc(as Zn) mg/L	0.397	70	0.265
	BOD mg/L	180	70	80
	COD mg/L	482	188	248
	TS	1912	1234	32
	TSS	98	46	632

4.4 VISITS TO DIFFERENT TYPES OF STPs IN INDIA

The different types of STPs in India have been visited to collect information, data collection, to assess the real working condition and the performance.

- WSP - Rishikesh, Muzaffar Nagar,
- UASB - Saharanpur, Erode,
- ASP - Haridwar, Chennai,
- MBBR – PCMC Pune, VIT Vellore, Thiruppur and
- SBR - Goa.

4.5 LAND COST AND AVILABILITY FOR STP

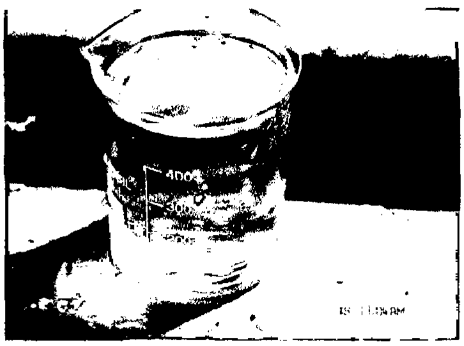
The municipality has 112 acres of land for STP site and sewage farm near Thirukalimedu 3 km away from the town. Even though this land is in possession by the municipality, for the purpose of economics the value of land is included. The land cost in the STP site is obtained from the Register office. The cost of land is Rs. 600/= per cent i.e., Rs.60, 000/= per acre or Rs.1.50 lakhs per ha.

4.6 TECHNOLOGY FOR ANALYSIS

The following technologies were considered for analysis.

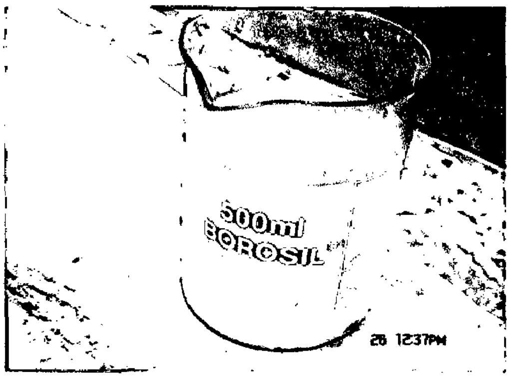
- Waste Stabilization Pond (WSP).
- UASB Technology with post treatment final polishing pond (UASB+FPP).
- Activated Sludge Process(ASP).
- Moving Bed Biofilm Reactor (MBBR).
- Sequencing Batch Reactor (SBR).

The effluents of various STPs are shown in Fig 4.2



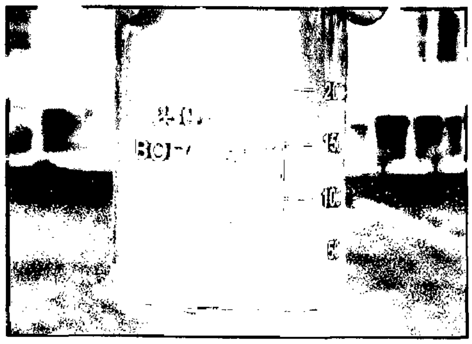
Effluent at Goa SBR

Effluent at Pune FAB



Effluent at Saharanpur UASB

Effluent at ASP, Haridwar



Effluent at Oxidation pond at Rishikesh

Fig 4.2 Effluents of various STPs

The performance characteristics for the technologies considered are given in the following Table 4.3. The technology/process comparisons are furnished in Table 4.4

Table: 4.3 Performance characteristics of the technologies

Item	WSP	UASB+FPP	ASP	MBBR	SBR
BOD Removal, %	75-85	75-85	85-92	85-95	98
Nutrient Removal, %N	40-50	-	30-40	35-40	<5 mg/L
Nutrient Removal, %P	20-60	-	30-45	25	<1mg/L
Coliform Removal, %	60-99.99	99.99	99.99 after chlorination	99.99 after chlorination	99.99 after chlorination
Helminth Removal, %	Yes	Yes	-	-	-
Land requirement,(ha per MLD)*	1.00	0.225	0.11	0.021	0.033
Power requirement, (HP per MLD)**	2.5	3.25	11	10	9
Sludge handling	Manual desilting once in 5 -10 years	Directly dry on sludge drying beds or mechanical devices	First digest then dry on sludge drying beds or mechanical devices	Mechanical devices	Mechanical devices
Equipment requirement (except screening and grit removal which are required for all cases)	Nil	Nil(except gas collection and flaring; gas conversion to electricity is optional)	Aerators, Recycle pumps, Scapers, Thickeners, digestors, driers, gas equipment	Blowers, sludge pumps	Aerators, PLC, Decanters, sludge pumps
Operational characteristics	Simplest	Simpler than ASP	Skilled operation is required	Skilled operation is required	More skilled personnel required
Effect of population	Slight	Relatively little	Considerable	Considerable	Considerable

* In the area calculation for MBBR and SBR centrifuge is assumed instead of sludge drying b

** Power requirement includes power for mechanical screen and grit. (HP=0.746 kW)

Table 4.4 TECHNOLOGY/PROCESS COMPARISON

Description	WSP	UASB+FPP	ASP	MBBR	SBR
Type of Process	Aerobic Suspended growth process.	Anaerobic Suspended growth process.	Aerobic Suspended growth process	Aerobic. Fixed film attached growth process.	Aerobic suspend growth
Principle of operation	Organic matter converted to new cell mass by natural process with the aid of sunlight algal growth photosynthesis	Organic matter is reduced by anaerobic bacteria present in the sludge blanket.	The organic matter is brought in contact with bacteria in suspension.	Organic matter is brought in contact with bacteria attached to plastic media, which is in suspension.	Filling, Aeratic Settling decanti carried single o Tank i batches.
Mode of Oxygen supply	No external supply of oxygen is required.	No oxygen supply is required.	Oxygen is supplied by surface aerators	Oxygen is supplied by blowers through air grid system	Oxygen supplie blowers t diffuse
Sludge recirculation in the reactor	Not required	Not required	Sludge recirculation is necessary to maintain MLSS in aeration tank	Not required.	Option
Process variables.	No monitoring Natural process depends on Temperature wind	Volatile fatty acids, sludge blanket levels, alkalinity, pH must be checked on daily basis.	MLSS, SVI, F/M ratio must be monitored Sludge recycle and wastage should be controlled regularly	No sludge volume index / recycle need be checked. System is self sustaining Excess biomass automatically gets wasted off.	Oxygen requiren monitor sensor. operatio filling aeration decantir done by system.
Cost for installation	Less, easy construction	Medium	Higher than USAB	Slightly higher than ASP	High
Annual Maintenance	Less, easy to maintain, skilled personnel not required	Slightly higher than WSP Requires skilled personnel	High, Requires technical and skilled personnel	Slightly lower than ASP but higher than UASB requires skilled personnel	Very hig technic skilled personn required
Area requirement	Large area is required.	Moderately large area required.	Medium area	Very small area required.	Small a
Power requirement	No power	Almost negligible power.	Large power required.	Power Requirement lesser than ASP as there is no	Large p Require For aera Also, P optimiz

				recirculation of sludge but higher than UASB	is condu by PLC
Total Coliform content in treatedsewage.	10^4-10^5 MPN/100 ml	10^4-10^5 MPN/100 ml	10^4-10^5 MPN/100 ml	10^3-10^4 MPN/100 ml	10^3-10^4 MPN/1(
Effluent quality	Meets the standard	Meets the standard	Very Good Quality	Meets the standard	Best Qu
Sludge production	less	medium	more	medium	medium
Methane recovery	Methane recovery is possible but no reference in India	Yes	Yes	No methane recovery	No metl recover;
Expandability	Higher loads possible by providing aerators	Limited	Limited	Higher loads can be accepted with extra media filling.	Easy
Moving parts	Nil	Nil	High	Less than ASP	High
Sensitivity of process	Less sensitive	Highly sensitive.	Moderately sensitive.	Sensitivity is low, owing to very high bacterial population	Less Se:

MLSS- Mixed Liquor Suspended Solids, SVI- Sludge Volume Index, F/M Ratio – Food to Microorganism Ratio, PLC- Programmable Logic Controller

4.7 LIFE CYCLE COST ANALYSIS

The costs of construction for WSP, UASB and ASP were calculated as per the Schedule of Rates of Tamil Nadu and per MLD cost were arrived and used in this study. The cost also coincides with the cost used for comparison of technology in the DPR for Bhubaneshwar. The cost of construction per MLD for the MBBR has been personally enquired from M/s Thermax, Pune. The construction cost per MLD for SBR has been assessed from C-Tech Director, Mumbai in person. The annual operation and maintenance charges were calculated based on the energy required, personnel, chemicals required and other repair etc. Careful / accurate attention is needed in the calculation of AM cost as it is highly sensitive in technology selection in the life cycle cost analysis. The life cycle cost for each technology has been calculated by the following method.

Life cycle cost for 20 years = Capital Cost including land cost + Present Worth of AM cost for 20 years.(assuming interest rate of 10%)

Present worth of AM cost for 20 years = AM cost*[{1-1/(1+i)^n}/i]

Where i = interest rate (10% assumed)

n = Total life or period (20 years assumed)

The life cycle cost for each technology for various capacities of STP with land cost as Rs. 1.50 lakhs per ha has been calculated and plotted in graph. The graph showing the life cycle cost for each technology is furnished in Fig 4.3 for various capacities of STP with land cost as Rs. 1.50 lakhs per ha.

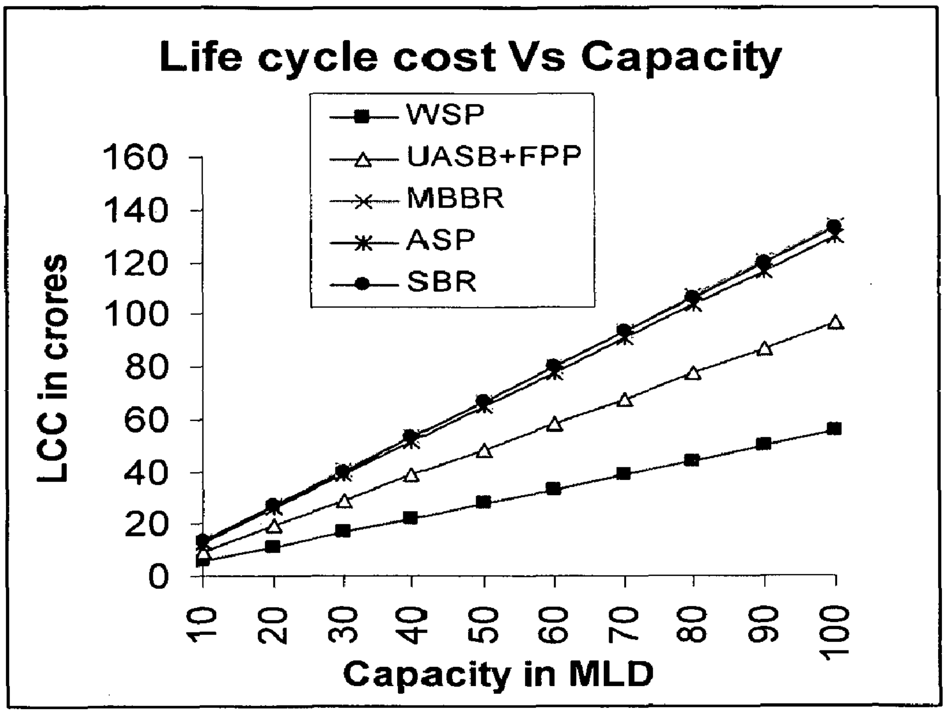


Fig 4.3 Life cycle cost for different capacities with land cost Rs. 1.5 lakhs/ha

The Life cycle cost analysis with land cost of Rs. 1.50 lakh per ha for 15.05 MLD for Kancheepuram is given below in Table 4.5

Table: 4.5 Life Cycle Cost Analysis for 15 .05 MLD for Kancheepuram

S.No	Description	Unit	WSP	UASB+ FPP	MBBR	ASP	SBR
1	Present Flow in 2007	MLD	12.11	12.11	12.11	12.11	12.1
2	Design Flow in 2017	MLD	15.05	15.05	15.05	15.05	15.0
3	Unit area of STP required	ha	0.917	0.225	0.021	0.102	0.03
4	Area required for ultimate flow	ha	13.80	3.39	0.32	1.54	0.48
5	Rate of land	Rs. in Lakhs / ha	1.50	1.50	1.50	1.50	1.5
6	Unit cost of construction of STP	Rs. in Lakhs / MLD	17.00	40.00	50.00	45.00	55.0
7	Unit cost of annual O&M of STP	Rs. in Lakhs / MLD	4.33	6.63	9.81	9.90	9.17
8	Cost of land	Rs. in Lakhs	20.70	5.08	0.48	2.30	0.72
9	Cost of construction of STP(excluding cost of land)	Rs. in Lakhs	255.85	602.00	752.50	677.25	827.7
10	Cost of construction of STP(including cost of land)	Rs. in Lakhs	276.55	607.08	752.98	679.55	828.4
11	Total cost of annual O&M of STP	Rs. in Lakhs	65.17	99.78	147.64	149.00	138.0
12	Capitalized cost of O&M for 20 years @ 10% int.	Rs. in Lakhs	554.80	849.50	1256.95	1268.48	1174.
13	Life cycle cost of STP for 20 years	Rs. in Lakhs	**831.35**	**1456.58**	**2009.93**	**1948.03**	**2003.**

From the above table, it is obvious that the WSP is the cost effective option for Kancheepuram as the land cost is Rs. 1.5 lakhs per ha. The land cost has been increased for different values and from the analysis, it is also found that if the land cost is more than Rs. 62 lakhs per ha, then UASB becomes the cost effective for which the Life Cycle Cost Analysis is shown below in the Table 4.6

Table: 4.6 Life Cycle Cost Analysis with land cost of Rs 62 lakh per ha.

S.No	Description	Unit	WSP	UASB+FPP	MBBR	ASP	SBR
1	Present Flow in 2007	MLD	12.11	12.11	12.11	12.11	12.11
2	Design Flow in 2017	MLD	15.05	15.05	15.05	15.05	15.05
3	Unit area of STP required	ha	0.917	0.225	0.021	0.102	0.032
4	Area required for ultimate flow	ha	13.80	3.39	0.32	1.54	0.48
5	Rate of land	Rs. in Lakhs / ha	62.00	62.00	62.00	62.00	62.00
6	Unit cost of construction of STP	Rs. in Lakhs/ MLD	17.00	40.00	50.00	45.00	55.00
7	Unit cost of annual O&M of STP	Rs. in Lakhs/ MLD	4.33	6.63	9.81	9.90	9.17
8	Cost of land	Rs. in Lakhs	855.65	209.95	19.78	95.18	29.86
9	Cost of construction of STP(excluding cost of land)	Rs. in Lakhs	255.85	602.00	752.50	677.25	827.75
10	Cost of construction of STP(including cost of land)	Rs. in Lakhs	1111.50	811.95	772.28	772.43	857.61
11	Total cost of annual O&M of STP	Rs. in Lakhs	65.17	99.78	147.64	149.00	138.01
12	Capitalized cost of O&M for 20 years @ 10% int.	Rs. in Lakhs	554.80	849.50	1256.95	1268.48	1174.94
13	Life cycle cost of STP for 20 years	Rs. in Lakhs	**1666.30**	**1661.44**	**2029.23**	**2040.90**	**2032.55**

In the life cycle cost analysis, the annual maintenance cost is highly sensitive; a small difference in AM cost among the technologies will lead to wrong selection. Therefore, it is suggested that the technology developers/bidders may be requested to offer the annual maintenance for the lifetime and a decision may be arrived as per the least life cycle cost. Beyond Rs. 190 lakhs per ha MBBR, SBR and ASP are economical. The life cycle cost analysis for land value of Rs. 190 lakhs per ha is furnished below in Table 4.7.

Table:4.7 Life Cycle Cost Analysis with land cost of Rs 190 lakhs per ha

S.No	Description	Unit	WSP	UASB+FPP	MBBR	ASP	SBR
1	Present Flow in 2007	MLD	12.11	12.11	12.11	12.11	12.11
2	Design Flow in 2017	MLD	15.05	15.05	15.05	15.05	15.05
3	Unit area of STP required	ha	0.917	0.225	0.021	0.102	0.032
4	Area required for ultimate flow	ha	13.80	3.39	0.32	1.54	0.48
5	Rate of land	Rs. in Lakhs / ha	190.00	190.00	190.00	190.00	190.00
6	Unit cost of construction of STP	Rs. in Lakhs MLD	17.00	40.00	50.00	45.00	55.00
7	Unit cost of annual O&M of STP	Rs. in Lakhs/ MLD	4.33	6.63	9.81	9.90	9.17
8	Cost of land	Rs. in Lakhs	2622.16	643.39	60.62	291.67	91.50
9	Cost of construction of STP(excluding cost of land)	Rs. in Lakhs	255.85	602.00	752.50	677.25	827.75
10	Cost of construction of STP(including cost of land)	Rs. in Lakhs	2878.01	1245.39	813.12	968.92	919.25
11	Total cost of annual O&M of STP	Rs. in Lakhs	65.17	99.78	147.64	149.00	138.01
12	Capitalized cost of O&M for 20 years @ 10% int.	Rs. in Lakhs	554.80	849.50	1256.95	1268.48	1174.94
13	Life cycle cost of STP for 20 years	Rs. in Lakhs	**3432.81**	**2094.88**	**2070.07**	**2237.40**	**2094.20**

The graph showing the variation of life cycle cost Vs land cost for the technologies is furnished in Fig 4.4.and its corresponding values in Table 4.8.

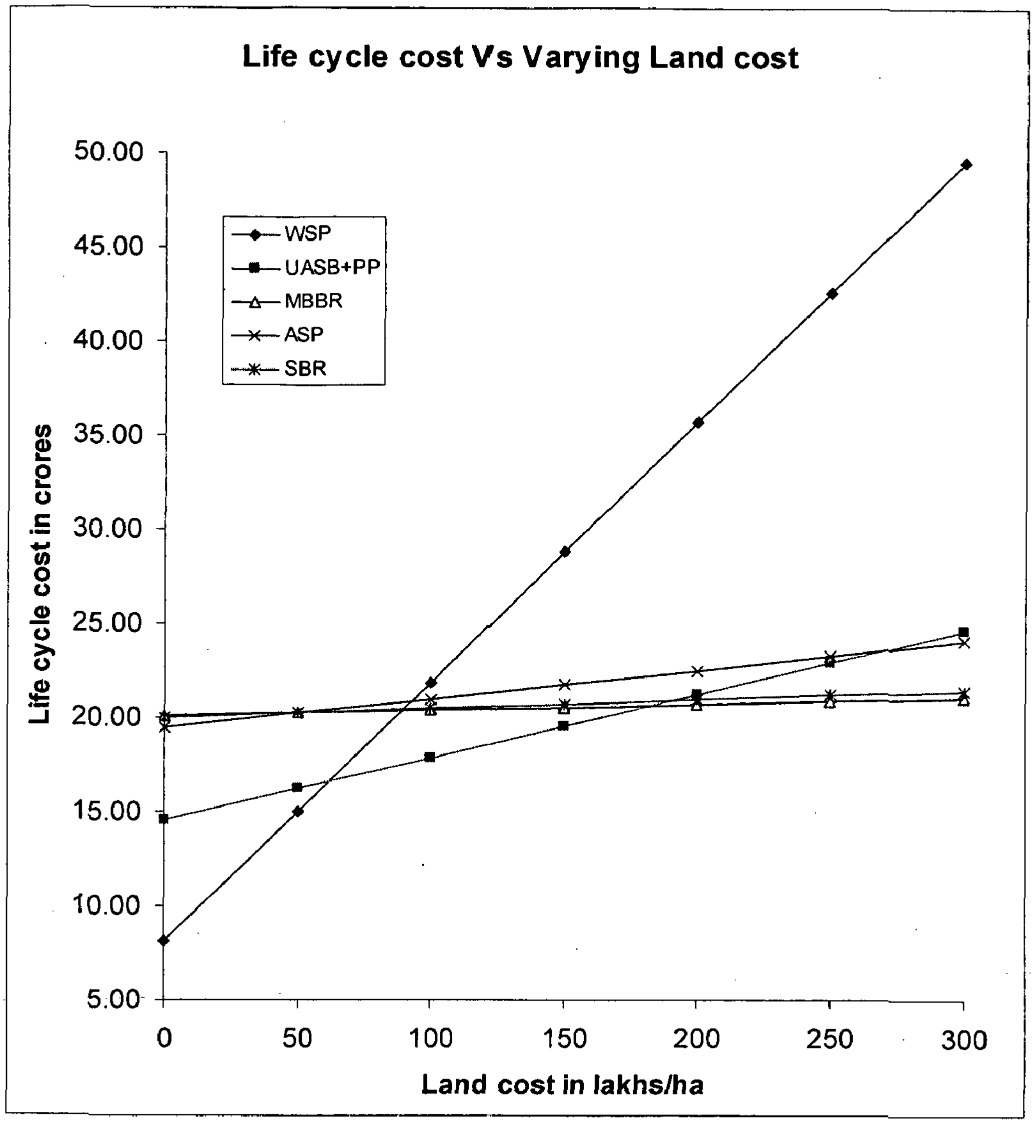


Fig 4.4 Life cycle cost (15 MLD) Vs Land cost

Table: 4.8 Life cycle cost for different land cost for 15 MLD

Land cost Rs in Lakhs	WSP	UASB+PP	MBBR	ASP	SBR
	Rs in crores				
0	8.11	14.514	20.094	19.457	20.027
50	15.01	16.208	20.254	20.225	20.268
100	21.91	17.901	20.414	20.992	20.509
150	28.81	19.594	20.573	21.76	20.749
200	35.71	21.287	20.733	22.527	20.99
250	42.61	22.980	20.892	23.295	21.231
300	49.51	24.673	21.05165	24.062	21.47174

4.8 BENEFIT COST RATIO

The Benefit cost ratio has been worked out to find which technology below is a better option. The benefit cost ratio worked out assuming 10% discount rate for these technologies and is given below in the Table 4.9. The technology with higher BCR is the best cost effective technology. The detailed calculations are furnished in the Annexure-2.

Table: 4.9 Benefit Cost Ratio

BCR/Technology	**WSP**	**UASB+PP**	**MBBR**	**ASP**	**SBR**
BCR	1.07	0.61	0.43	0..43	0..46

Based on the above analyses technology wise, cost wise, economic analysis wise, treatment efficiency wise, WSP is the best technology for the town under consideration. Therefore, the WSP is the appropriate technology and hence the design of the same is carried out based on the Design Manual for WSP issued by the NRCD, Ministry of Environment and Forest, GOI.

4.9 DESIGN OF WSP

4.9.1 Design parameters

There are four important design parameters for WSP, including temperature, net evaporation, flow and BOD. The climate also is important in as much as the processes responsible for BOD_5 and fecal bacterial removal are temperature-dependent. Further, algal photosynthesis depends on solar radiation, itself a function of latitude and cloud cover.

4.9.2 Design of anaerobic ponds

The design of anaerobic ponds is based on volumetric loading (λv, $g/m^3/d$), which is given by:

$$\lambda v = L_i Q / V_a$$

Where L_i is influent BOD (mg/l), Q is flow rate (m^3/day), and V_a is anaerobic pond volume (m^3). Once the organic loading is selected, the volume of the pond is then determined with the using the above equation. The hydraulic retention time is given by the following equation:

$$HRT = V_a / Q$$

A retention time less than one day should not be used for anaerobic ponds; if it occurs, however, a retention time of one day should be used, and the volume of the pond should be recalculated. Table 4.10 illustrates the permissible loadings to the anaerobic ponds.

Table: 4.10. Design value of permissible volumetric BOD loadings on, and percentage BOD removal in, anaerobic ponds at various temperatures

Temperature (^{o}C)	Volumetric loading ($g/m^3.day$)	BOD removal (%)
< 10	100	40
10 - 20	20T – 100	2T+20
20-25	10T+100	2T+20
>25	350	70

4.9.3 Design of facultative ponds

The facultative ponds are designed based on the surface BOD loading, (λ_s, kg/ha.day), which is give by:

$$\lambda_s = 10 * L_i * Q / A_f$$

Where L_i is the concentration of influent sewage (mg/l), and A_f is the facultative pond area (m^2).

As per CPHEEO Manual on Sewerage and sewage treatment there are 2 methods for selecting the permissible design values for surface BOD loading λ_s, one based on latitude and another bε on temperature.

Surface BOD loading S_L based on latitude

The variation of design value for λ_s, with latitude in India is given in the Table 6.3. The mathen relation is expressed as below

λ_s =375-6.25L where L is latitude

Table: 4.11 Variation of design BOD loading on facultative ponds in India with latitude

Latitude in ^{0}C	Design BOD loading λ_s in kg / ha.d)
36	150
32	175
28	200
24	225
20	250
16	275
12	300
8	325

Surface BOD loading S_L based on temperature

The design value for surface BOD loading λ_s based on temperature is given by the eqn

$\lambda_s = 20T - 120$

Once a suitable value for surface BOD loading has been selected , the pond area can be calculated by the following eqn and its HRT is

HRT $= \theta_f = A_f * D / Q_m$ where

D = Depth of facultative pond

Q_m = Mean flow

Qm =(Qi+Qe) / 2 where

Qi = influent flow

Qe = effluent flow

HRT $= \theta_f = A_f * D / [(1/2)/(Q_i + Q_e)]$

Qe =Qi -0.001*A_f* e where

e = net evaporation rate in mm / day

HRT $= \theta_f = 2 * A_f * D / (2Q_i - 0.001 * A_f * e)$

4.9.4 Design of maturation Ponds

The design of maturation pond is is to remove feacal coliform. The faecal coliform removal can be modelled by first order kinetics and is given by the eqn for a single pond

$N_e = N_i / (1 + K_T \theta)$ where

N_i = no of FC per 100 ml of influent,

N_e = no of FC per 100 ml of effluent,

K_T= First order rate constant for FC removal in d^{-1},

θ = Retention time in days,

For a series of anaerobic, facultative and maturation ponds the above eqn becomes

$$\theta_m = \{[N_i / N_e (1 + K_T \theta_a)(1 + K_T \theta_f)]^{1/n} - 1\} / K_T$$

where

N_i = no of FC per 100 ml of influent,

N_e = no of FC per 100 ml of effluent,

K_T= First order rate constant for FC removal in d^{-1},

θ = Retention time in days,

4.9.5 RESULTS

The WSP has been designed for unrestricted irrigation for the average flow of 15.05 MLD based on the above procedure and is enclosed in Annexure-3. The results of the design and area are given below in table 4.11

Table: 4.11 Area of ponds as per design for Kancheepuram for 15.05 MLD

Description	Mid depth Area				Depth	HRT
Area of anaerobic pond	5017	m^2 or	1.24	acres	3 m	1 day
Area of facultative pond	39868	m^2 or	9.85	acres	1.5 m	4 days
Area of 1st maturation pond	44755	m^2 or	11.06	acres	1 m	3 days
Area of 2nd maturation pond	44088	m^2 or	10.89	acres	1 m	3 days
Total	133727	m^2 or	33.04	acres		11 days

4.9.6 COST OF WSP

The cost of the WSP based on Tamil Nadu Schedule of rates have been woked out and the cost is Rs. 256 Lakhs for installation. The annual maintenance cost arrived based on NRCD norms and works out to Rs. 38.23 Lakhs. The detailed design and cost estimates were furnished in annexure-3.

4.10 DISCUSSION

In a country like India, the selection of the technology for sewage treatment is based on the following.

- It should consume no or less power for the treatment.
- Mechanization should be avoided as much as possible.
- If mechanization is to be used, it must be locally made, must be easily repairable by local skilled personnel. No machinery should be imported. If imported, availability of spares should be ensured.
- Technology must be capable of treating the sewage without addition of any chemicals.
- It should be locally manageable and easy to maintain.
- Adverse effects must be minimum.
- The resources found in the effluent must be reused effectively.
- Collaborative arrangement / mechanism should be made to reuse the resources.

4.10.1 WSP

In the study area under consideration, to achieve the above, employing the Waste Stabilization Pond for the sewage treatment is the best option as it is a low cost, no or low energy systems, simple to construct, and easy to maintain. The only disadvantage of adopting this system is the large area requirement, but this can be treated as an investment on land.

In WSP, Macrophytic ponds (water hyacinth ponds) and microphytic ponds can replace the anaerobic pond, which gives high removal efficiency than anaerobic pond. This requires research in India.

4.10.2 Resource Recovery

4.10.2.1Biogas

The resources in the sewage can be used by putting fermentation pits with submerged gas collectors in the anaerobic pond to recover methane. The methane gas should be used for cooking, fuelling the vehicles, heating purposes in the nearby industries etc. The biogas recovered should not be used for electricity production, as it requires mechanization, duel fuel engine etc... which again needs fossil fuel (30%) for generation of power.

4.10.2.2 Nutrients

The nutrients in the effluent can be utilized for growing grass, jetropah plants, from which bio diesel can be produced. The effluent can be used for green belt development, which will provide aesthetic appearance. The water can also be used for non-potable uses in water stressed areas.

4.10.3 UASB with final polishing pond

For towns in other areas, where land availability is a concern the next option is UASB with Final polishing pond. This technology consumes less power and methane recovery is possible. The effluent from this pond can be reused for urban agriculture. The annual maintenance is also less.

4.10.4 MBBR and SBR

In Metropolitan areas like Chennai, Mumbai, Delhi, Calcutta where land cost is very high and huge area not available for WSP. In such cases, Sequencing Batch Reactor is a good option, which produces good quality effluent. This technology occupies a small footprint and produces effluent BOD less than 5 with high nitrification. The effluent can be reused for non-potable purposes like gardening, car washing, toilet flushing, Highway green belt development etc. The MBBR also requires less land but the effluent meets the standards but effluent quality is not good as SBR

CHAPTER - 5

CONCLUSIONS

From the economic analysis, it is found that WSP is the most cost effective technology of sewage treatment of the town or city where land price is less than Rs. 62 Lakhs per ha. Between Rs. 62 Lakhs to 190 Lakhs per ha, the Upflow Anaerobic Sludge Blanket (UASB) with final polishing pond is more economical. Above Rs. 190 Lakhs per ha Sequencing Batch Reactor (SBR), Moving Bed Biofilm Reactor (MBBR), & Activated Sludge Process are better options. For the Kanchipuram town, WSP is better and economical Sewage treatment technology as the land cost is very cheap around (Rs. 1.5 lakhs/Ha). WSP meets generally meets the effluent standards if maintained properly. The problem occurs only in winters season and cloudy weather. The disadvantage odor, insect breeding and high SS/Algae (greenish color) effluent, etc., the effluent can only be reuse for irrigation purpose. There is no other direct reuse of WSP effluent.

However, the effluent of advanced treatment technologies such as SBR, ASP, MBBR is of much better quality and it can be directly used for industrial cooling, golf course landscaping, gardening, toilet flushing by adopting dual plumbing. Moreover, there will not be any problems of odor, insect breeding etc., Therefore, if stakeholders are ready to pay for better environment, advanced technologies such as ASP, SBR, MBBR could be a better option. It was found out that if sewer connection charges can be increased to Rs. 200/cap.year, the Benefit Cost Ratio of ASP, SBR and MBBR can be more than one (1).

Therefore, it is suggested that techno-economic analysis is essential for the selection of appropriate sewage treatment technologies; Escalating land prices and land acquisition for STP become a troublesome task nowadays. Sometimes, there are objections for the construction of WSP from the nearby dwellers, with a fear of foul smell, and mosquito nuisance. Considering these factors, we cannot directly goes towards conventional or advanced techniques for the selection; instead, cost-effective solution must be explored.

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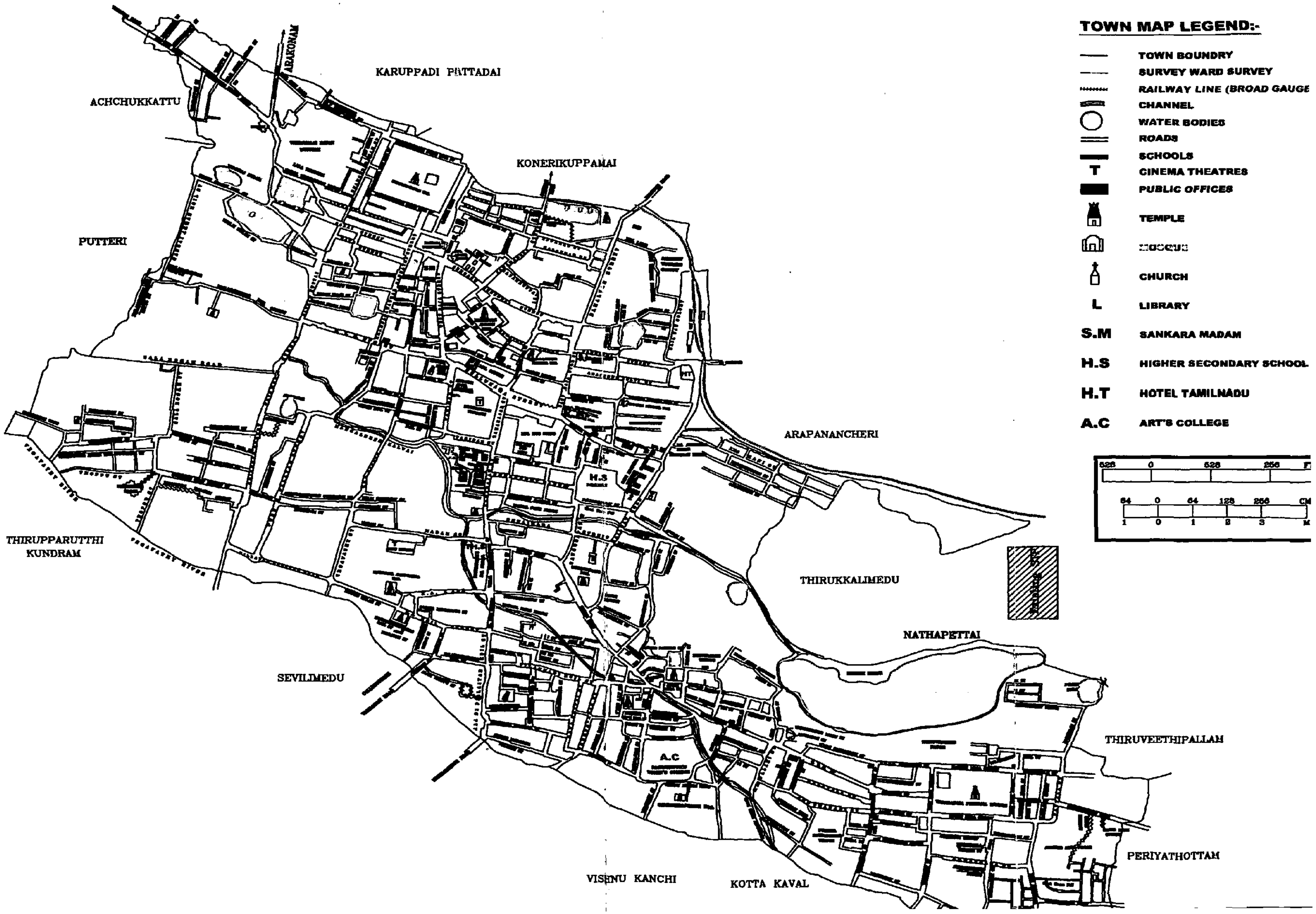
Annexure-1
Town Map of Kancheepuram

KANCHEEPURAM MUNICIPALITY

TOWN MAP

AREA OF THE TOWN :- 11.72 SQ KM
POPULATION : 152984 (2001 Census)



Annexure-2

Benefit cost ratio calculations

S.No	Description	WSP	UASB	ASP	MBBR	SBF
		Rs in Lakhs				
	Flow in MLD	15.05	15.05	15.05	15.05	15
1	Capital cost Per MLD cost	17	40	45	50	
2	AM charges Per MLD cost	4.33	6.62	8.61	8.52	
3	Land Area per MLD in ha	0.917	0.225	0.102	0.0212	(
	Construction cost excluding land cost	255.85	602	677.25	752.5	82
	Land cost Rs in lakhs per ha	1.50	1.50	1.50	1.50	
	Capital cost including land cost	**257.23**	**602.34**	**677.40**	**752.53**	**82**
	AM charges	65.15	99.70	129.52	128.26	11
	Capitalised cost of AM or PV of AM for 20 years	555	849	1,103	1,092	1
	Life cycle cost for 20 years	**811.88**	**1451.14**	**1780.06**	**1844.49**	**183**

Note: i.Capital cost of construction for WSP, UASB and ASP are taken from DPR fo Bhubaneshwar . For the MBBR and SBR, the per MLD rates were assessed by me in person with the Thermax and C-Tech persons.

ii. The rate for land has been obtained by me from the register office Kancheepuram

iii. The AM cost has been arrived at as per the requirements of machineries for each technology

Benefits

S.No	**Description**	**Amount in Rs**	**Rs in Lakhs**
1	By sale of sludge cake as manure	300000	3.00
2	By sale of grass grown in grass farms	200000	2.00
3	By Tax per capita =24000*360	8640000	86.40
4	By Tax from public/ office 100*2000	200000	2.00
5	By Tax from commercial 1500*2000	3000000	30.00
	Total Benefits	12340000	123.40
	Deduct for maintaining MPS,Collection system and EB charges @ 25 % of total benefits	-3085000	-30.85
	Net Benefit	**9255000**	**92.55**

For WSP

Expenditure	Discount rate 10%	Discounted Expenditure	Benefits	Discounted Benefits	Period
405.94	0.90909	369.04			1
38.23	0.82645	31.59	92.55	76.49	2
38.23	0.75131	28.72	92.55	69.53	3
38.23	0.68301	26.11	92.55	63.21	4
38.23	0.62092	23.74	92.55	57.47	5
38.23	0.56447	21.58	92.55	52.24	6
38.23	0.51316	19.62	92.55	47.49	7
38.23	0.46651	17.83	92.55	43.18	8
38.23	0.4241	16.21	92.55	39.25	9
38.23	0.38554	14.74	92.55	35.68	10
38.23	0.35049	13.40	92.55	32.44	11
38.23	0.31863	12.18	92.55	29.49	12
38.23	0.28966	11.07	92.55	26.81	13
38.23	0.26333	10.07	92.55	24.37	14
38.23	0.23939	9.15	92.55	22.16	15
38.23	0.21763	8.32	92.55	20.14	16
38.23	0.19784	7.56	92.55	18.31	17
38.23	0.17986	6.88	92.55	16.65	18
38.23	0.16351	6.25	92.55	15.13	19
38.23	0.14864	5.68	92.55	13.76	20
		659.73		703.79	
BCR	**1.07**	**NPV**	**44.06**	**IRR**	**11.70%**

For UASB

Expenditure	Discount rate 10%	Discounted Expenditure	Benefits	Discounted Benefits	Period
725.57	0.90909	659.61			1
65.02	0.82645	53.73	92.55	76.49	2
65.02	0.75131	48.85	92.55	69.53	3
65.02	0.68301	44.41	92.55	63.21	4
65.02	0.62092	40.37	92.55	57.47	5
65.02	0.56447	36.70	92.55	52.24	6
65.02	0.51316	33.36	92.55	47.49	7
65.02	0.46651	30.33	92.55	43.18	8
65.02	0.4241	27.57	92.55	39.25	9
65.02	0.38554	25.07	92.55	35.68	10
65.02	0.35049	22.79	92.55	32.44	11
65.02	0.31863	20.72	92.55	29.49	12
65.02	0.28966	18.83	92.55	26.81	13
65.02	0.26333	17.12	92.55	24.37	14
65.02	0.23939	15.56	92.55	22.16	15
65.02	0.21763	14.15	92.55	20.14	16
65.02	0.19784	12.86	92.55	18.31	17
65.02	0.17986	11.69	92.55	16.65	18
65.02	0.16351	10.63	92.55	15.13	19
65.02	0.14864	9.66	92.55	13.76	20
		1154.02		703.79	
	BCR	**0.61**			

For ASP

Expenditure	Discount rate 10%	Discounted Expenditure	Benefits	Discounted Benefits	Period
890.03	0.90909	809.12			1
110.62	0.82645	91.42	92.55	76.49	2
110.62	0.75131	83.11	92.55	69.53	3
110.62	0.68301	75.55	92.55	63.21	4
110.62	0.62092	68.68	92.55	57.47	5
110.62	0.56447	62.44	92.55	52.24	6
110.62	0.51316	56.76	92.55	47.49	7
110.62	0.46651	51.60	92.55	43.18	8
110.62	0.4241	46.91	92.55	39.25	9
110.62	0.38554	42.65	92.55	35.68	10
110.62	0.35049	38.77	92.55	32.44	11
110.62	0.31863	35.25	92.55	29.49	12
110.62	0.28966	32.04	92.55	26.81	13
110.62	0.26333	29.13	92.55	24.37	14
110.62	0.23939	26.48	92.55	22.16	15
110.62	0.21763	24.07	92.55	20.14	16
110.62	0.19784	21.89	92.55	18.31	17
110.62	0.17986	19.90	92.55	16.65	18
110.62	0.16351	18.09	92.55	15.13	19
110.62	0.14864	16.44	92.55	13.76	20
		1650.31		703.79	
	BCR	**0.43**			

For MBBR

Expenditure	Discount rate 10%	Discounted Expenditure	Benefits	Discounted Benefits	Period
922.24	0.90909	838.40			1
105.50	0.82645	87.19	92.55	76.49	2
105.50	0.75131	79.26	92.55	69.53	3
105.50	0.68301	72.06	92.55	63.21	4
105.50	0.62092	65.51	92.55	57.47	5
105.50	0.56447	59.55	92.55	52.24	6
105.50	0.51316	54.14	92.55	47.49	7
105.50	0.46651	49.22	92.55	43.18	8
105.50	0.4241	44.74	92.55	39.25	9
105.50	0.38554	40.68	92.55	35.68	10
105.50	0.35049	36.98	92.55	32.44	11
105.50	0.31863	33.62	92.55	29.49	12
105.50	0.28966	30.56	92.55	26.81	13
105.50	0.26333	27.78	92.55	24.37	14
105.50	0.23939	25.26	92.55	22.16	15
105.50	0.21763	22.96	92.55	20.14	16
105.50	0.19784	20.87	92.55	18.31	17
105.50	0.17986	18.98	92.55	16.65	18
105.50	0.16351	17.25	92.55	15.13	19
105.50	0.14864	15.68	92.55	13.76	20
		1640.68		703.79	
	BCR	**0.43**			

For SBR

Expenditure	Discount rate 10%	Discounted Expenditure	Benefits	Discounted Benefits	Period
918.85	0.90909	835.32			1
93.01	0.82645	76.87	92.55	76.49	2
93.01	0.75131	69.88	92.55	69.53	3
93.01	0.68301	63.53	92.55	63.21	4
93.01	0.62092	57.75	92.55	57.47	5
93.01	0.56447	52.50	92.55	52.24	6
93.01	0.51316	47.73	92.55	47.49	7
93.01	0.46651	43.39	92.55	43.18	8
93.01	0.4241	39.44	92.55	39.25	9
93.01	0.38554	35.86	92.55	35.68	10
93.01	0.35049	32.60	92.55	32.44	11
93.01	0.31863	29.64	92.55	29.49	12
93.01	0.28966	26.94	92.55	26.81	13
93.01	0.26333	24.49	92.55	24.37	14
93.01	0.23939	22.27	92.55	22.16	15
93.01	0.21763	20.24	92.55	20.14	16
93.01	0.19784	18.40	92.55	18.31	17
93.01	0.17986	16.73	92.55	16.65	18
93.01	0.16351	15.21	92.55	15.13	19
93.01	0.14864	13.83	92.55	13.76	20
		1542.60		703.79	
	BCR	**0.46**			

Annexure-3

DESIGN OF WASTE STABILIZATION POND FOR KANCHEEPURAM, TAMILNADU

INPUT DETAILS

FLOW (Q)			15.05 MLD or	15050 m^3/day
Latitude L	12^0 50'	or say	13	
DESIGN TEMPERATURE (T)			25 ^{0}C	
NET EVAPORATION			5 mm/day	
BOD OF INFLUENT (Li)			200 mg/L	

DESIGN OF ANAEROBIC POND

The design is based on the **"Design Manual for Waste Stabilization Ponds in India"** issued by NRCD , the Ministry of environment & Forest, GOI.

Design of anaerobic pond is based on Volumetric BOD loading

Table 4.1 Design values of permissible volumetric BOD loadings on and percentage BOD removal in anaerobic ponds at various temperatures T

Temp (T) in ^{0}C	Volumetric loading in g/m3.d	BOD Removal in %
<10	100	40
10 - 20	20T-100	2T+20
20 - 25	10T+100	2T+20
>25	350	70

T= Temperatures in ^{0}C

Volumetric BOD loading = Li *Q / Va where

Li = influent BOD, in mg/L(=g/m^3)

Q = Flow in m^3/day

Va = volume of anaerobic pond

Design volumetric loading is calculated from Table4.1 for the design temperature

Volumetric BOD loading =10T+100= 10*25+10= 350 g/m^3d

Volumetric BOD loading = 350 g/m^3d

HRT = Va / Q

HRT = Li / Vol. loading
= 0.57 day or say 1 day
1 day

Va = HRT * Q
= 15050 m^3

Depth of anaerobic pond will be normally from 3-5 m.

	for 3m depth	4m depth	5m depth
Area of pond =	5016.67 m^2 or	3762.5 m^2 or	3010 m^2 or
	1.240 acres	0.930 acres	0.744 acres

1 acre= 4046.9 m^2

So provide anaerobic pond area with a depth of 3m **5016.67 m^2 or** **1.240 acres**

DESIGN OF FACULTATIVE POND

Facultative Ponds are designed based an surface BOD loading (S_L) in kg / ha.d)

S_L=10*Li *Q / A_f where

A_f - area of facultative pond in . m^2

As per CPHEEO Manual on Sewerage and sewage treatment there are 2 methods for selecting the permissible design values for surface BOD loading S_L one based on latitude and another based on temperature. The variation of design value for S_L with latitude in India is given in the Table 4.3. The mathematical relation is expressed as below

SL=375-6.25L where L is latitude

Table 4.3: Variation of design BOD loading on facultative pondsin India with latitude

Latitude in ^{0}C	design BOD loading S_L in kg / ha.d)
36	150
32	175
28	200
24	225
20	250
16	275
12	300
8	325

Surface BOD loading S_L based on latitude

S_L=375-6.25L where L is latitude which is 12^0 50' or 13

S_L = 375-6.25*13

S_L = 293.75 kg / ha.d

A_f = 10* Li *Q / S_L

Li for facultative pond is 70% of BOD ie. =200-0.7*200= 60

A_f = 30740.4 m^2 or 30741 m^2 based on latitude

Surface BOD loading S_L based on temperature

The design value for surface BOD loading S_L based on temperature is given by the eqn

S_L= 20T - 120

Once a suitable value for surface BOD loading S_L has been selected , the pond area can be calculated by the following eqnand its HRT is

HRT $$\theta_f = A_f * D / Q_m$$

where

D = Depth of facultative pond nornally = 1.5 m

Q_m = Mean flow

Q_m = (Qi+Qe) / 2 where

Qi = influent flow

Qe = effluent flow

HRT $$\theta_f = A_f * D / [(1/2)/(Q_i + Q_e)]$$

Qe =Qi -0.001*A_f* e where

e = net evaporation rate in mm / day.

HRT = $$\theta_f = 2 * A_f * D / (2Q_i - 0.001 * A_f * e)$$

2 * 30741 *1.5 / (2 * 15050 - 0.001* 30741 *5)

HRT = 3.08 days or 4 days

Area of pond = $$A_f = 2Q_i\theta_f /(2D + 0.001e\theta_f)$$

= 2*15050*4/(2*1.5+0.001*5*4)

39867.5 m^2

So Provide 4 days retention period for thefacultative ponds and 1.5 m depth

Area provided = 39868 m^2

DESIGN OF MATURATION PONDS

i) For restricted irrigation

The retention time for anaerobic and facultative ponds are 1 and 3 days respectively from Table 4.7 the percentage of helminth egg removals in the pond are

Anaerobic pond	74.67
Facultative pond	93.38

Assuming the wastewater contains 750 helminth eggs/litre, the anaerobic pond effluent contains (0.2533*750) i.e 190 eggs per litre, and the facultative pond effluent contains (0.066*190) i.e. 13 eggs per litre. A maturation pond is therefore required to reduce the number of eggs to 1 per litre for restricted irrigation (Table 10.1)

The required percentage egg removal in the maturation pond is

100[(13-1)/13]

i.e. 92% . So from Table 4.7 , choose θ_m = 3.6 days.

The maturation pond area is given by the following eqn.

$$A_m = 2Q_i\theta_m /(2D + 0.001\, e\theta_m)$$

where

Qi is the effluent flow from the facultative pond, and is therefore given by

D = depth of maturation pond = 1 m

Qi = Q - 0.0001*A_f*e = 15050 - 0.001*39868* 5

'= 15030 m^3/day

Therefore taking the depth of pond as 1m

Am = 2*15030*3.6 / ((2*1)+(0.001*5*3.6))

'= 53626 m^2

The final effluent flow for restricted irrigation is given by

Qe = Qi-(0.001*Am*e) = 15030-(0.001*39868*5)

= 14762 m^3/day

Thus 1.3 % of the flow is lost due to evaporation

For restricted irrigation the area requirements of pond is

Area of anaerobic pond	=		**5017**	**m^2 or**	**1.24**	**acres**
Area of facultative pond	=		**39868**	**m^2 or**	**9.85**	**acres**
Area of maturation pond	=		**53626**	**m^2 or**	**13.25**	**acres**
		Total area	**98510**	**m^2 or**	**24.34**	**acres**

ii) For unrestricted irrigation

The faecal coliform removal can be modelled by first order kinetics and is given by the eqn for a single pond

$$\boxed{Ne = Ni/(1+K_T\theta)}$$ where

Ni = no of FC per 100 ml of influent

Ne = no of FC per 100 ml of effluent

K_T = First order rate constant for FC removal in d^{-1}

$\boxed{\theta}$ Retention time in days.

For a series of anaerobic, facultative and maturation ponds the above eqn becomes

$$\theta_m = \{[N_i / N_e(1+K_T\theta_a)(1+K_T\theta_f)]^{1/n} - 1\} / K_T$$

where

Ni = no of FC per 100 ml of influent

Ne = no of FC per 100 ml of effluent

Ne = 1000 for unrestricted irrigation

K_T = First order rate constant for FC removal in d^{-1}

θ_m Retention time in days for maturation pond

a, f, m = for aerobic, facultative and maturation ponds

n = no of maturation ponds .

K_T = $2.60(1.19)^{T-20} = 2.6(1.19)^{25-20}$ = 6.20 days

Ni = 5×10^7 per 100 ml

θ_a 1 day

θ_f 4 days

Substituting all the above values

θ_m = $\{[(5 \times 10^7) / 1000(1+6.20*1)(1+6.20*3)]^{1/n} - 1\} / 6.20$

43.19 days for n=1

θ_m 2.48 days for n=2

2.5 days or D = 1 m

3 days

Porovide 2 ponds with 3 days retention period and depth as 1m for each pond

Check for BOD loading on first maturation pond using the following equation, assuming 80% cumulative removal in the anaerobic and facultative ponds and a depth of 1 m

$$\lambda_{s(m1)} = 10 * (0.2Li) D / \theta_{m1}$$

133 kg/ha.day

This is satisfactory as it is less than 75% of the permissible design loading on facultative ponds at 25^0 C (350 kg / ha day)

The area of first maturation pond is given by the following eqn

$$A_{m1.} = 2Q_i\theta_m / (2D + 0.001e\theta_m)$$

where

Q_i	effluent flow from facultative pond	
e	net evaporation rate in mm / day.	
D	depth of maturation pond in m =	1 m
θ_m	Retention time in days for maturation pond	

A_{m1} = 2*15030*3 / ((2*1)+(0.001*5*3))

'= 44755 m^2

The effluent flow from first maturation pond is

$$Q_e = Q_i - 0.001A_{m1} * e$$

= 15030-(0.001*29919.7*5)

= 14806 m^3/day

The area of second maturation pond is

A_{m2} =2*14981*3/((2*1)+(0.001*5*3))

'= 44088 m^2

Qe= 14891-(0.001*28383*3)

'= 14674 m^3/day

Thus only 1.6% of flow lost by evaporation.

For unrestricted irrigation the area requirements of pond is

Description		**area**		**area**		**depth**
Area of anaerobic pond 1 day HRT	**=**	**5017**	**m^2 or**	**1.24**	**acres**	**3 m**
Area of facultative pond 4Day HRT	**=**	**39868**	**m^2 or**	**9.85**	**acres**	**1.5 m**
Area of 1st maturation pond 3Day HRT	**=**	**44755**	**m^2 or**	**11.06**	**acres**	**1 m**
Area of 2nd maturation pond 3 Day HRT	**=**	**44088**	**m^2 or**	**10.89**	**acres**	**1 m**
Total area		**133727**	**m^2 or**	**33.04**	**acres**	

RESULT (For unrestricted irrigation)

Description	**Mid depth Area**				**Depth**
Area of anaerobic pond 1 day HRT	**5017**	**m^2 or**	**1.24**	**acres**	**3 m**
Area of facultative pond 1 day HRT	**39868**	**m^2 or**	**9.85**	**acres**	**1.5 m**
Area of 1st maturation pond 1 day HRT	**44755**	**m^2 or**	**11.06**	**acres**	**1 m**
Area of 2nd maturation pond 1 day HRT	**44088**	**m^2 or**	**10.89**	**acres**	**1 m**
Total	**133727**	**m^2 or**	**33.04**	**acres**	

DESIGN OF UASB

I DESIGN OF PRELIMINARY UNITS

1. DESIGN OF INLET CHAMBER

Average flow	15.05 MLD or	0.174 m^3/sec
Peak flow (2.25 X avg flow)	33.86 MLD or	0.392 m^3/sec

Assuming a retention time of 10 seconds

Volume of inlet chamber = 0.392 X 10 = 3.92 m^3

Assuming a depth of 1.0 m and a free board of 0.5 m

Area of inlet chamber = 3.92/1.0= 3.92 m^2

Providing a width of 2m, length = 1.96 m

Provide Size of inlet chamber 2 X 2 X 1.5 m

2. DESIGN OF SCREEN CHAMBER

Peak flow 33.86 MLD or 0.392 m^3/sec

Let the velocity through the screen be 0.90m/sec

Area of screen = Q/V= 0.44 m^2

Assume a depth of flow in screen be 0.9m

Width of screen = 0.48 m

Providing a clear spacing of 25mm no of spacing = 19 nos

Using 20mm dia bars width of screen = 863.82 mm or 900mm

Provide a screen of width 1m with one no as standbye

3. DESIGN OF GRIT CHAMBER

Peak flow 33.86 MLD or 0.392 m^3/sec

Adopting a settling velocity/ suface overflow rate= 0.75 m/min

Area of grit chamber =0.392 X 60 / 0.75 = 31.35 m^2

Assuming a width of 1m length of channel = 31.35 m

Provide 2 nos of grit chamber of size 1m X 16m

Assuming a depth of 1m

The horizontal velocity = 0.392 / 2*1 = 0.20 m/sec

Horizontal seetling velocity = 0 .2 / 2*1 = 0.10 m/sec < 0.3 m/sec

Hence O.K.

Check for HRT

HRT = V / Q = 2 X 1 X 16 X 1 / 0.392 = 81.63 sec

It is in between 60 to 120 sec

Hence O.K.

Provide 2 nos of grit chambers of size 1m x 16m x 1.5m each (including 0.5m free board)

4. DESIGN OF DIVISION BOX

The flow is divided into two streams and is conveyed to distribution box.

Avg flow =	15.05 MLD or	0.174 m^3/sec
Peak flow (2.25 X avg flow)	33.86 MLD or	0.392 m^3/sec
Assume a HRT =	10 sec	
Total volume of division box =	3.92 m^3	
Total width of grit chamber =	2 m	
Assume a depth of division box =	1 m	
Surface area = 3.92 / 1 =	3.92 m^2	

Size of division box = 2 x 2 x 1.5 m (including 0.5m free board)

Flow is divided into two streams of 7.53 MLD (avg)

Max flow =	16.93 MLD or	0.196 m^3/sec
Assume velocity in pipe	1 m/sec	
Area of cross section of pipe	0.196 m^2	
Dia of pipe	0.499 m or say	**500 mm**

5. DISTRIBUTION BOX

The flow from the division box is received in the central compartment of the distribution box. The flow is distributed over 8 compartments through flow weirs. The flow to the feeding boxes placed on the top of the UASB reactors is carried through 200mm OD HDPE pipes.

Avg flow =	15.05 MLD or	0.174 m^3/sec
Peak flow =	33.86 MLD or	0.392 m^3/sec
Distribution box per UASB =	1.00	
No of Distribution box =	2	
Avg flow per UASB = 15.05/2	7.525 MLD or	0.087 m^3/sec
Peak flow =	16.93 MLD or	0.196 m^3/sec

Assume HRT =	10 sec
Assume depth of distribution box	1 m
Volume of distribution box=	1.960 m^3
Area of distribution box =	1.960 m^2
Surface area =	1.960 m^2

Size of distribution box = 1.5 x1.5 x 1.5 m (including 0.5m free board) 2 nos

No of feed pipe =	8
Flow per pipe = 0.196/8	0.024 m^3/sec
Assume velocity in pipe =	1 m/sec
Area of pipe =	0.024 m^2
Dia of feed pipe = SQRT(1.96/.785)	0.177 m or
	200 mm

6. DESIGN OF UASB REACTORS

Avg flow =	15.05 MLD or	0.174 m^3/sec
Peak flow =	33.86 MLD or	0.392 m^3/sec
Inlet BOD =	200.00 mg/ L	
Inlet TSS =	270.00 mg/ L	
Inlet COD =	482.00 mg/ L	
Inlet BOD in UASB reactor = 200-10% of 200 =200-20=180 mg/ L	180 mg/ L	Assuming 10% reduction in BOD during Physical
Inlet TSS in UASB reactor = 270-30% of 270 =270-81=189 mg/ L	189 mg/ L	Assuming 30% reduction in TSS during Physical

Provide 2 nos of reactors of capacity 7.525MLD or 7525m^3/day

Capacity of one reactor =7.525 MLD or	7525 m^3/day or 313.54	m^3/hr
Peak flow =2.25*313.54		705.47 m^3/hr
Assume max upflow velocity =	1.2 m/hr	
Adopt upflow velocity =	0.54 m^3/m^2/hr	
Surface area one reactor = 313.54/.54	580.63 m^2	

Provide 2 nos of reactor of size 40 x 16 m each

Area provided =40 x 16 m **40**	**16**	**640 m^2**	
Check for peak upflow velocity = 705.47/580.63	1.215	m/hr	
	< 1.5	m/hr	
No of bays required (assuming idth as 4m) =	4 no		
Assume height of reactor =	5 m		
Volume of reactor = area x height = 640 x 5 =	3200 m^3		
Volmetric loading = Q x COD /VOL	1.13 kg COD /m^3/d		
Design criteria = 0.8 - 1.2 kg COD /m^3/d	< 1.2 kg COD /m^3/d		
	Hence OK		
HRT =V/Q= 3120/313.54=	10.21 hr		
Design criteria = 8 - 12 hrs	< 12 hr		
	Hence OK		

Sludge Production

Expected BOD Removal Efficiency=	70%	140 mg/L
Ash Content in TSS =	30%	81 mg/L
VSS Content = 70% of TSS	70% of TSS	189 mg/L
New VSS Produced in BOD removal =	10% of BOD rem.	
= 0.1 x 0.7 x200 =	14 mg/L	
Sludge Produced (A) = 15.050 x 0.014kg/m^3	210.7 Kg/d	
Non-Degradable VSS = 60% VSS	113.4 mg/L	
Sludge Produced (B) = 15050 x 0.1134 kg/m3	1706.67 Kg/d	
Ash Received in flow = 30% TSS =0.3*270	81 mg/L	
Sludge Produced (C) =15050 x 0.081 kg/m3	1219.05 Kg/d	
Total Sludge Production A+B+C=	**3136.42 Kg/d**	
Sludge bed concentration = 65 kg TSS /m^3	65 kg TSS /m3	
Volume of sludge to be removed = 3136.42/65	48.25 m^3/day or	
	50.00 m^3/day	

Design of Sludge drying bed

Sludge application depth =	0.2	m
Area of Sludge drying beds = 50/0.2	250	m^2
Adopt drying time =	6	Days
Total Sludge Drying Bed Area = 250 x 6=	1500	m^2
Provide size of bed of 16 m x 8 m	16	8
No. of beds required =1500/(15 x10)	11.71875	nos

Provide 12 nos of sludge drying beds of size 16 m x 8 m

Biogas production

Biogas yield = 0.08 m3 / kg COD removed

COD = 482 mg/ L

COD removed = 70%

COD load = 15050 x 0.482 kg /d	7254.1	kg /d
COD removed = 70% x 7254.1 =	5077.87	kg /d
Biogas production = 0.08 x 5077.87	406.2296	m^3/day
Methane content = 60 - 70 %		
Methane gas produced = 60 % methane gas	243.74	m^3/day

Energy/Electricity Production

Energy Equivalent of methane = 33810 kJ/m3 of methane

COD removed = 5077.87 kg/d

Methane generated = 0.35 x 5077.87 = 1777.25 m^3/day

Energy produced = 3920 m3/d x 33810 kJ/m3 = 13.25 x 107 KJ/d

Theoretical Electricity produced = 1533 KW

Efficiency of generator = 10 % - 20 % (generally 10 %)

Actual Electricity Produced: 1533 x 0.1= 153.3 KWh

DESIGN OF MBBR

I DESIGN OF PRELIMINARY UNITS

1. DESIGN OF INLET CHAMBER

Average flow	15.05 MLD or	0.174 m^3/sec
Peak flow (2.25 X avg flow)	33.86 MLD or	0.392 m^3/sec

Assuming a retention time of 10 seconds

Volume of inlet chamber = 0.392 X 10 = 3.92 m^3

Assuming a depth of 1.0 m and a free board of 0.5 m

Area of inlet chamber = 3.92/1.0= 3.92 m^2

Providing a width of 2m, length = 1.96 m

Provide Size of inlet chamber 2 X 2 X 1.5 m

2. DESIGN OF SCREEN CHAMBER

Peak flow 33.86 MLD or 0.392 m^3/sec

Let the velocity through the screen be 0.90m/sec

Area of screen = Q/V= 0.44 m^2

Assume a depth of flow in screen be 0.9m

Width of screen = 0.48 m

Providing a clear spacing of 25mm no of spacing = 19 nos

Using 20mm dia bars width of screen = 863.82 mm or 900mm

Provide a screen of width 1m with one no as standbye

3. DESIGN OF GRIT CHAMBER

Peak flow 33.86 MLD or 0.392 m^3/sec

Adopting a settling velocity/ suface overflow rate= 0.75 m/min

Area of grit chamber =0.392 X 60 / 0.75 = 31.35 m^2

Assuming a width of 1m length of channel = 31.35 m

Provide 2 nos of grit chamber of size 1m X 16m

Assuming a depth of 1m

The horizontal velocity = 0.392 / 2*1 = 0.20 m/sec

Horizontal seetling velocity = 0 .2 / 2*1 = 0.10 m/sec < 0.3 m/sec

Hence O.K.

Check for HRT

HRT = V / Q = 2 X 1 X 16 X 1 / 0.392 = 81.63 sec

It is in between 60 to 120 sec

Hence O.K.

Provide 2 nos of grit chambers of size 1m x 16m x 1.5m each (including 0.5m free board)

DESIGN OF MBBR REACTORS

Design flow	15.05	MLD or	0.174 m^3/sec
Design BOD	200	mg/L	
Total BOD load	3010	kg/day	
No. of MBBR Reactors	2	nos	
HRT	12	hrs	
V olume of each reactor	313.5	m^3	
Depth	5	m	
Area	62.71	m^2	
Diameter	8.9	m	

Provide 2 nos of reactors of dia 9 m and depth of 6m including 1m FB

Oxygen requirement

For BOD removal	0.8 - 1 kg/ kg of BOD	
Sp wt of air	1.21	
Percentage of 0_2 in air	23%	
Oxygen transfer efficiency	15-20%	
Air Blower required	1246.14	m^3/hr
or say	1300	m^3/hr

DESIGN OF SECONDARY CLARISETTLER

Hydraulic Loading	10-15 m3/m2/day	
Plan Area	1368.18	m^2
Surface Area of Tube Mod‹	4.4 m2 / m2 of plan area	
Actual Plan Area	311.0	m^2
Diameter	20	m
Depth	3.75	m

Provide 20 m dia claritube settler 3.75m depth

DESIGN OF CHLORINE CONTACT TANK

HRT	30	min
Volume of CCT	313.5	m^3
depth	2.5	m
Area	125.42	m

Provide 2 nos of circular CCT in annular construction around claritubesettler

Design of Sludge Production

Inlet BOD =	200.00 mg/ L
Inlet TSS =	270.00 mg/ L
	4063.50 kg/day
Total non VSS load due to SS (A)	2438.1 kg/day
Inlet BOD =	200.00 mg/ L
	3010 kg/day
Sludge yield coefficient	0.15 kg/kgBOD removed
Sludge due to BOD removal (B)	451.50 kg/day
Total Sludge after MBBR System (A+B)	2889.60 kg/day
Sludge Consistency	1.0% (Underflow of Clarisettler)
Density of Sludge	1020.00 kg/m^3
Volume of Sludge	283.29 m^3/day (Underflow of Clarisettler)

DESIGN OF SLUDGE SUMP

Inlet Sludge Load	2889.60 kg/day or
	283.29 m^3/day
HRT	4 hrs
Volume of sump	47.22 m^3
depth	2.50 m
Area	18.89 m^2
Diameter	4.90

Provide sump of 5 m dia and depth of 2.5 m

DESIGN OF SLUDGE THICKENER

Inlet Sludge Load	2889.60 kg/day
Solids Loading	60 kg/m^2/day
Area of Thickener	48.16 m^2
Diameter of Thickener	7.8 m
Depth	3.50 m
Sludge Consistency	3.5% (Undrflow of Thickener)
Density of Sludge	1020 kg/m^3
Volume of Sludge	80.94 m^3/day (Undrflow of Thickener)

Provide 8 m dia and 3.5 m depth

Design of Centrifuge

Inlet Sludge Load	2889.60 kg/day
Inlet Sludge Consistency	3.50%
Volume of Sludge	80.94 m^3/day
Operating hrs per day	20 hrs
Centrifuge Capacity	4.05 m^3/hr
Provide centrifuge capacity	5 m^3/hr

Design of Filtrate sump

Flow	280.46 m^3/day
HRT	2 hrs
Volume	23.37 m^3
Depth	2.5 m
Area	9.35
Diameter	3.45

Provide 3.5 m dia and 2.5 m depth

Cost estimate for WSP 15.05 MLD

S.No	Description	Amount
1	Cost for the construction of Anaerobic pond of size 100 x 51 x 3.5 m	1,540,000
2	Cost for the construction of facultative pond of size 285 x 140 x 2 m	6,044,731
3	Cost for the construction of maturation ponds 2 nos of size 310 x 145 x 1.5 m each	12,320,000
4	Inlet screening grit and outlet chamber	1,190,000
5	Provision for Office, Laboratory, internal Roads	2,500,000
6	Provision for Water supply compound wall/ fencing	1,500,000
7	Provision for Tree planting as buffer zone	480,000
	Total	**25,574,731**
	Cost Per MLD	**1,699,318** or say **1,700,000**

COST ESTIMATE FOR ANAEROBIC POND 15 MLD 5100m^2								
Size at mid depth 100 X 51 X 3.5 M(including FB)			100	51	3.5			
S.No	Description	NO	L	B	D	QTY	Rate	Amount
1	EWE = h/3*((A1+A2+(sqrt (A1*A2))) = 1.5/3((364+160+(364*160)^.5)	1	5100	4230	1.5	6987.34		
	For clay filling	1	94	45	0.3	1269		
						8256.34	27.45	226,636
2	Bund formation (2((L+9.5)+(B+9.5)))*((9.5+1.5)/2)*2	1	340	5.5	2	**3740**	10.5	39,270
3	Pre cast slab							
	inside sloping	1	340	7.83		2660.92		
	Top	1	340	1.5		510		
						3170.92	233.51	740,442
4	Turfing outside sloping	1	354	4.47		**1583.14**	8.75	13,852
5	Supplyig & clay filling	1	94	45	0.3	**1269**	275	348,975
6	PCC 1:2:4 for supporting pre	1	278	0.3	0.45	37.53		
	Around pipe	2	9	0.6	0.6	6.48		
						44.01	1874.3	82,488
7	Supply and fixing of pipe	2	20			**40**	1200	48,000
8	Conveyance of earth for bund formation					4516.34	4.2	18,969
9	Miscelaneous						LS	21,368
								1,540,000
						Rate per sq m		**302**

	COST ESTIMATE FOR FACULTATIVE POND for 15 MLD 39900 m^2							
Size at mid depth 285 X 140 X 2 M			285	140	2			
S.No	**Description**	**NO**	**L**	**B**	**D**	**QTY**	**Rate**	**Amount**
1	EWE = h/3*((A1+A2+(sqrt (A1*A2))) = 1.5/3((364+160+(364*160)^.5)	1	39900	38634	0.75	29448.97		
	For clay filling	1	282	137	0.3	11590.2		
						41039.17	27.45	1,126,525
2	Bund formation (2((L+9.5)+(B+9.5)))*((9.5+1.5)/2)*2	1	876	4	1.25	**4380**	10.5	45,990
3	Pre cast slab							
	inside sloping	1	876	4.47		3917.59		
	Top	1	876	1.5		1314		
						5231.59	233.51	1,221,629
4	Turfing outside sloping	1	910	2.80		**2543.53**	8.75	22,256
5	Supplyig & clay filling	1	282	137	0.3	**11590.2**	275	3,187,305
6	PCC 1:2:4 for supporting pre	1	838	0.3	0.45	113.13		
	Around pipe	2	9	0.6	0.6	6.48		
						119.61	1874.3	224,185
7	Supply and fixing of pipe	2	20			**40**	1200	48,000
8	Conveyance of surplus earth					36659.17	4.2	153,969
9	Miscelaneous						LS	14,872
								6,044,731
						Rate per sq m		**151**

	COST ESTIMATE FOR MATURATION POND 15 MLD 44950M²							
	Size at mid depth 310 X 145 X 1.5 M(including FB)		310	145	1.5			
S.No	**Description**	**NO**	**L**	**B**	**D**	**QTY**	**Rate**	**Amount**
1	EWE = h/3*((A1+A2+(sqrt (A1*A2))) = 1.5/3((364+160+(364*160)^.5)	1	44950	44044	0.5	22248.12		
	For clay filling	1	308	143	0.3	13213.2		
						35461.32	27.45	973,413
2	Bund formation (2((L+9.5)+(B+9.5)))*((9.5+1.5)/2)*2	1	932	3.5	1	**3262**	10.5	34,251
3	Pre cast slab							
	inside sloping	1	932	3.35		3126.02		
	Top	1	932	1.5		1398		
						4524.02	233.51	1,056,405
4	Turfing outside sloping	1	970	2.24		**2168.99**	8.75	18,979
5	Supplyig & clay filling	1	308	143	0.3	**13213.2**	275	3,633,630
6	PCC 1:2:4 for supporting pre	1	902	0.3	0.45	121.77		
	Around pipe	2	9	0.6	0.6	6.48		
						128.25	1874.3	240,379
7	Supply and fixing of pipe	2	20			**40**	1200	48,000
8	Conveyance of surplus earth					32199.32	4.2	135,237
9	Miscelaneous						LS	19,707
								6,160,000
						Rate per sq m		**137**
						for 2 nos		**12,320,000**
	Total Pond cost for 15MLD							**19,904,731**
	Others							
	Inlet screening grit and outlet chamber							1,190,000
	Provision for Office, Laboratory, internal Roads						LS	2,500,000
	Provision for Water supply compound wall/ fencing							1,500,000
	Provision for Tree planting as buffer zone							480,000
								25,574,731
						Per MLD		1,699,318

Cost estimate for UASB 15.05 MLD

S.No	Description	Amount	
1	Cost of inlet chamber	100,000	
2	Cost of screen chamber	1,130,000	
3	Cost of Grit Chamber	360,000	
4	Cost of outlet chamber	100,000	
5	Cost of Division Box	110,000	
6	Cost of Distribution Chambers	200,000	
7	Cost of UASB Reactors 2 nos	20,000,000	
8	units	8500000	
9	Effluent channel from reactors to polishing pond	1,000,000	
10	Sludge sump, pump house and Sludge pump	5,000,000	
11	Sludge drying bed	2,500,000	
12	Polishing pond	2,500,000	
13	Filtrate Sump and Filtrate pump	1,000,000	
14	Bio gas holder	1,000,000	
15	Gas engine room	1,000,000	
16	Dual fuel engine	2,500,000	
17	Generator room	800,000	
18	Gas flaring system and gas flow meter	500,000	
19	Sewerage system carying back wash/overflow/drainage	300,000	
20	Water Supply	500,000	
21	Internal roads	1,000,000	
22	Internal Surface drain	500,000	
23	Office Laboratory, Staff Quarters and Compund Wall	2,500,000	
24	Laboratory Intruments, glass ware , Chemicals and furnitures,Equipment and tools	500,000	
25	Effluent Channels	1,500,000	
26	Street Light and Flood lighting arangements	1,000,000	
27	Power Supply	500,000	
28	Miscellaneous Items such as Mechanical gas scrubber, Main LT panel, cable etc.,	3,000,000	
29	River training works, Godown hiring, land scaping, clearing STP site eytc	500,000	
	Total	**60,100,000**	
	Cost Per MLD	**3,993,355**	or say
		4,000,000	

Calculation sheet for AM cost

S.No	Description	no	Avg salary / month	Annual salary	AM OF WSP		AM OF ASP		AM OF UASB		AM OF MBBR		AM OF SBR	
I	**Establishment charges**													
	AE	1	28,190	338,280	1	338,280	1	338,280	1	338,280	1	338,280	1	338,280
	JE	1	21,530	258,360	1	258,360	4	1,033,440	4	1,033,440	4	1,033,440	4	1,033,440
	Fitter I class	1	6,150	73,800		0	1	73,800	1	73,800	1	73,800	1	73,800
	Electrician I class	1	6,150	73,800		0	1	73,800	1	73,800	1	73,800	1	73,800
	Fitter II class	1	5,130	61,560	1	61,560		0		0		0		0
	Electrician II class	1	5,130	61,560	1	61,560	1	61,560	1	61,560	1	61,560	1	61,560
	Gardener	1	4,100	49,200	1	49,200	1	49,200	1	49,200	1	49,200	1	49,200
	Jr. Acct.	1	10,250	123,000	1	123,000	1	123,000	1	123,000	1	123,000	1	123,000
	UDC Sr. Asst	1	9,230	110,760	1	110,760	1	110,760	1	110,760	1	110,760	1	110,760
	LDC Typist/Jr. Asst	1	8,200	98,400	1	98,400	1	98,400	1	98,400	1	98,400	1	98,400
	Peon	1	6,150	73,800		0	1	73,800	1	73,800	1	73,800	1	73,800
	Lab Asst.	1	6,150	73,800	1	73,800	1	73,800	1	73,800	1	73,800	1	73,800
	Lab Attendent	1	5,130	61,560	1	61,560	1	61,560	1	61,560	1	61,560	1	61,560
	Sweeper	1	3,080	36,960	1	36,960	1	36,960	1	36,960	1	36,960	1	36,960
	Operators	1	6,150	73,800		0	13	959,400	13	959,400	13	959,400	10	738,000
	Labours/ Beldars	1	3,080	36,960	13	480,480	31	1,145,760	31	1,145,760	31	1,145,760	20	739,200
						1,753,920		**4,313,520**		**4,313,520**		**4,313,520**		**3,685,560**
II	**Electrical energy charges**													
					338,000	**1,521,000**	1,446,748	**6,510,366**	437,675	**2,034,849**	1322097.6	**5,949,439**	1188951.2	**5,350,280**
III	**Minor repairs, spares, grease, etc**					127,925		1,083,600		918,050		1316875.00		1572725.00
IV	**Consumables, Chemicals, Chlorine**					2,671,963		1,023,988		2,671,963		1199772		1199772
V	Miscellaneous					20,192		20,343		31,631		46480		53980
VI	Others Desilting of ponds in WSP					420,000								
						6,515,000		**12,951,817**		**9,970,013**		**12,826,086**		**11,862,317**
			Per MLD			**432,890**		**860,586**		**662,459**		**852,232**		**788,194**
						4.33	Lakhs	8.61	Lakhs	6.62	Lakhs	8.52	Lakhs	7.88
					AM OF WSP		AM OF ASP		AM OF UASB		AM OF MBBR		AM OF SBR	

Energy requirement for WSP

Flow	15.05	MLD

Assuming sewage is collected in a collection sump and pumped to sceens, grit chamber with ahead of 10m

Inlet HP of pumpset =	46.5	HP
Screen	2	
Grit	2	
	50.5	HP
Energy required=	329693	units
Add for lights	8307	
Total energy	338000	units
Cost @ 4.5/unit	**1521000**	

Desilting of ponds

	Area	depth
AP	5017	3
FP	39868	1.5
MP 2 nos	44755	1

Assuming 30% of depth is accumulated with silt/sludge in AP and 10% in FP

Qty of silt/sludge to be removed

AP	4515.3	
FP	5980.2	
Total sluge	**10495.5**	
Cost for silt/sludge removal =		40
		419820

Energy requirement for ASP

Aerators 2 nos 40 HP	80	
Inlet 50HP	46.5	
Screen	2	
Grit	2	
PST	2	
RC pump	25	
Digestor mixing	30	
SST	2	
Sludge pump	30	
	219.45	HP
Energy required=	1434101	
Add for lights	12647	
Total energy	1446748	
Cost @ 4.5/unit	**6510366**	

Energy requirement for UASB

Inlet 50HP	46.5
Screen	2
Grit	2
Sludge pump	15
	65.45 HP
Energy required=	427717
Add for lights	9958
Total energy	437674.8
Cost @ 4.5/unit	**1969536.6**

Energy requirement for MBBR

Inlet 50HP	46.5
Screen	2
Grit	2
Blowers 2nos 60 HP	120
Sludge pump	10
centrifuge	10
Feed pumps	10.0
	200.5
Energy required=	1309937
Add for lights	12161
Total energy	1322098
Cost @ 4.5/unit	**5949439**

Energy requirement for SBR

Inlet 50HP	46.5
Screen	2
Grit	2
Blowers 2nos 40 HP	80
Sludge pump	10
centrifuge	10
Feed pumps	10.0
Decanter pump 5 HP	5.0
RC pump 15 HP	15.0
	180.5 HP
Energy required=	1179238
Add for lights	9714
Total energy	1188951
Cost @ 4.5/unit	**5350280.4**

Chlorine requirement

Chlorine dose for WSP, UASB	15 mg/L	
Chlorine required	225.75	kg/day
Annual requirement	82398.75	kg
Cost @ Rs 30/kg	**2471963**	

Chlorine dose for ASP, MBBR, and SBR	5 mg/L	
Chlorine required	75.25	kg/day
Annual requirement	27466.25	kg
Cost @ Rs 30/kg	**823988**	
Polymer cost @ Rs 200/ kg	**175784**	

Minor repairs

For WSP

.5% on 95% civil	1.215
.5% on 5% EM works	0.064
	1.28

For UASB

1% on civil works and 2.5% on electromechanical works

65%civil and 35% EM

1% on civil works	3.913
2.5% on EM works	5.268
	9.18

For MBBR

1% on civil works and 2.5% on electromechanical works

50% civil & 50% EM

1% on civil works	3.76
2.5% on EM works	9.41
	13.17

For ASP

1% on civil works and 2.5% on electromechanical works

60% civil & 40%EM

1% on civil works	4.06
2.5% on EM works	6.77
	10.84

For SBR

1% on civil works and 2.5% on electromechanical works

40% civil & 60%EM

1% on civil works	3.311
2.5% on EM works	12.42
	15.73

LAND AREA REQUIREMENTS CALCULATIONS

Flow	15000 m3/day											Toal area	Area with centrifuge
BOD	0.2 kg/m3												
BOD Load	3000 kg/d												
Sludge yield	0.8												
sludge produced	2400 kg/day												
WSP													
detention time	12.5 days	including embankments 11+1.5											
Volume	187500 m3												
depth	1.5 m												
Area	125000 m2									125000 m2	12500	137500 WSP	
SBR											300 Centrifuge Room		
detention time	16 hrs	Excess sludge yield	0.8	HRT	1 days			Drying Beds			450 Pumping station		
Volume	10000 m3	sludge produced	2400 kg/day	Volume	300 m3	sludge produced	2400 kg/day	Drying period	10 days		300 Pretreatment Units		
depth	5 m3	Sludge conc	8 kg/m3	depth	4 m3	Sludge conc	35 kg/m3	Depth of Sludge	0.3 m		300 Chlorination tank		
Area	2000 m2	Sludge vol	300 m3/d	Area	75 m2	Sludge vol	68.57 m3/d	Area	2285.7 m2	5410.7 m2	1623.2	7033.93 SBR	4748 With Centrifuge
ASP													
PST Detention Time	4 h												
AT HRT	8 h												
SST HRT	4 h												
Total HRT	16 h												
Volume	10000 m3												
Depth	4 m	Diffused Aeration 5 m depth											
Area	2500 m2												
Extra for return Sludge	50 %												
pumping etc walls, excess spance													
Total Area	3750 m2												
Anaerobic disgester HRT	30 days												
Excess sludge yield	1												
sludge produced	3000 kg/day												
Sludge conc	10 kg/m3												
Sludge vol	300 m3/d												
Digester Vol	9000 m3	Excess sludge yield	0.3 only secy sludge	HRT	1 days			Drying Beds				300 Gas Holders	
depth	3 m	sludge produced	900 kg/day	Volume	180 m3	sludge produced	3000 kg/day	Drying period	10 days			300 Pretreatment Units	
Area	3000 m2	Sludge conc	5 kg/m3	depth	4 m3	Sludge conc	30 kg/m3	Depth of Sludge	0.4 m			300 chlorination tank	
Total Area of ASP	6750 m2	Sludge vol	180 m3/d	Area	45 m2	Sludge vol	100 m3/d	Area	2500 m2	10195 m2	5097.5	15292.5 ASP	12793 With Centrifuge

UASB + PP										
detention time	8 hrs									
Volume	5000 m3									
depth	5 m3									
Area	1000 m2								300 Gas Holders	
Polishing Pond HRT	2.5 day	Including embankments		Drying Beds					300 Pretreatment Units	
Volume	37500 m3	Excess sludge yield	0.8	Drying perioc	7 days				300 chlorination tank	
depth	1.5 m	sludge produced	2400 kg/day	Depth of Sluc	0.4 m		28000 m2	5720	33720 UASB+P	26025
Area	25000 m2	Sludge conc	30 kg/m3	Area	1400 m2					
Total Area	26000 m2	Sludge vol	80 m3/d							

									Drying Beds			300 Centrifuge Room		
MBBR		Excess sludge yield	0.8	HRT	1 days							300 Pretreatment Units		
detention time	8 hrs	sludge produced	2400 kg/day	Volume	240 m3	sludge produced	2400 kg/day		Drying period	7 days		300 chlorination tank		
Volume	5000 m3	Sludge conc	10 kg/m3	depth	4 m3	Sludge conc	30 kg/m3		Depth of Sludge	0.4 m	3060 m2	918	4578 MBBR	3178 With Centrifuge
depth	5 m3	Sludge vol	240 m3/d	Area	60 m2	Sludge vol	.80 m3/d		Area	1400 m2				
Area	1000 m2													

Area / Technology	**WSP**	**UASB +FPP**	**ASP**	**MBBR**	**SBR**
Area in m^2 for 15 MLD	137500	33720	15292.5	3178	4748.2
Area in m^2 for 1 MLD	9166.67	2248	1019.5	211.87	316.55
Area in ha for 1 MLD	0.91667	0.2248	0.10195	0.0212	0.0317
Area in ha per MLD	**0.917**	**0.225**	**0.102**	**0.021**	**0.032**

Note : For MBBR and SBR centrifuge assumed in stead of Sludge drying beds.