Fifth Meeting
Building Works Committee
National Institute of Technology, Uttarakhand

Date : 02nd May, 2018
Time : 12:00 Noon
Venue : IIT Roorkee
Roorkee, Uttarakhand

AGENDA

Item No.	Items	Page No
BWC 05.01	To Confirm the minutes of the Fourth meeting of Building Works Committee	01
BWC 05.02	Ratification of notes approved by the Hon'ble Director.	01
BWC 05.03	Procurement and Installation of Pre-Fabricated Sewage Treatment Plant	01
BWC 05.04	Expansion of lab behind the Electrical Engineering Department	01
BWC 05.05	Any other item with the permission of Chair	01

Registrar

BWC 05.01: **To Confirm the minutes of the Fourth meeting of Building Works Committee.**

The minutes of the Fourth meeting of the Building Works Committee are placed as **Annexure BWC 05.01.**

The BWC is requested to confirm the minutes.

BWC 05.02: **Ratification of notes approved by the Hon'ble Director.**

Approval was taken from the Hon'ble Director for emergent and inevitable construction related activities at Temporary Campus.

The notesheet duly approved by the Hon'ble Director is placed at **Annexure BWC 05.02.**

The BWC is requested to ratify.

BWC 05.03: **Procurement and Installation of Pre-Fabricated Sewage Treatment Plant.**

As per FC resolution vide agenda item no 13.04, detailed report on procurement and installation of Pre-Fabricated Sewage Treatment Plant is placed before the Building Works Committee as **Annexure BWC 05.03**.

The approximate cost is 43.00 Lakh. The proposed expenditure is inevitable keeping in view the severe unhygienic conditions prevailing in the Temporary Campus.

Building Works Committee is requested to approve the above proposal.

BWC 05.04 **Expansion of lab behind the Electrical Engineering Department**

NIT Uttarakhand is running at its Temporary Campus at two different clusters, first is ITI Campus and other is Polytechnic Campus.

Labs of Engineering Departments are at ITI campus. At present the number of students is in peak and the labs are also need to be developed, therefore Expansion of labs may be done by creating prefabricated structure behind the Electrical Engineering Department as **Annexure BWC 05.04**

Building Works Committee is requested to approve the above proposal.

BWC 05.05: **Any other item with the permission of Chairman, BWC.**

Registrar

Annx. BWC 05.01

राष्ट्रीय प्रौद्योगिकी संस्थान, उत्तराखण्ड
NATIONAL INSTITUTE OF TECHNOLOGY, UTTARAKHAND

MINUTES OF 4TH MEETING OF BUILDING & WORKS COMMITTEE, HELD ON 17TH JULY 2016.

The following members were present:

1. Prof. H. T. Thorat - Chairman
2. Col. Sukhpal Singh - Member Secretary
3. Sri Ajay Sharma - Member
4. Dr. Kranti Jain - Member
5. Dr. Anil Dewan - Special Invitee

Ministry representatives & Experts from IIT Roorkee could not attend the meeting due to prior commitment and incessant rains in the region.

At the outset, the Chairman welcomed all the members.

The Committee discussed the following agenda:

BWC 04.01 Confirmation of the minutes of previous BWC Meeting.
Resolution: The minutes of previous BWC Meeting are confirmed.

BWC 04.02 Action Taken Report upon previous BWC Meeting.

Resolution: Action Taken Report upon previous BWC Meeting is noted.

BWC 04.03 Approval of Detailed Project Report Of NIT Uttarakhand.

Resolution: After approval from DPR committee, detailed Project Report of NIT Uttarakhand was placed before the Building and Works Committee. After detailed deliberation committee approved the Detailed Project Report of NIT Uttarakhand and further the committee authorized to the Director NIT Uttarakhand to make minor modification/correction as recommended and if required, keeping the present DPR in principal the same.

BWC 04.04 (A) Approval for two additional chapters in Detailed Project Report.
Resolution: Both the additional chapters placed before the BWC was approved by the committee.

The meeting ended with Vote of thanks to the Chair.

(Prof. H. T. Thorat) 17/7

(Dr. Anil Dewan)

17/07/16
(Sri Ajay Sharma)

17/07/16
(Dr. Kranti Jain)

17/07/16
(Col. Sukhpal Singh)

OK Annx BWC 05.02

राष्ट्रीय प्रौद्योगिकी संस्थान उत्तराखंड

NATIONAL INSTITUTE OF TECHNOLOGY, UTTARAKHAND

NOTE

1125

Dated: 10th July, 2017

Subject: Assigning of Work order to C.P.W.D. Srinagar Garhwal for construction of Temporary shed, Aluminum Partition Paver block & Soak Pits at temporary campus of NIT Uttarakhand

Some construction works as attached in Annexure-A was required at temporary campus of NIT Uttarakhand. To execute these construction works, Institute have sent a letter to CPWD Ltd (Letter No. NITUK/Estates/CPWD/2017/224, Dated: 01/05/2017), NBCC Ltd., UPRNN Ltd, and State PWD Srinagar Garhwal, but only CPWD expressed the interest yet.

CPWD has sent a preliminary cum detailed estimate vide Letter No. (D.B.29(24)/G.K.M/944, Dated 01/06/2017) for the said works amounting Net Cost **Rs. 22,35,458/-** and Total Cost as **Rs. 32,02,700/-** including Cost Index, Contingencies, and other taxes.

In accordance with G.F.R 2017 Rule 133, Permission may be granted to assign the work to C.P.W.D Srinagar Garhwal amounting **Rs. 32,02,700/-** and **Rs. 10,56,900/-** (Approximate 33%) may be released as advance in favor of Executive Engineer, Garhwal Central division, C.P.W.D Srinagar Garhwal. Total actual cost will be checked after completion of the work and may be refined as per CPWD norms.

Lalit
10/07/2017
(Lalit Mohan Bisht)
Junior Engineer (Civil)

for
Sharma
11/07/17
Associate Dean (Estate)
(Dr. H. Sharma)

Registrar
As per provisions of GFR-2017 Rule 133(2) permission may be granted to assign the original/minor work of value Rs 32,02,700/- to CPWD. Advance will be paid as per norms.
13/07

AR(Admin) :- Supdt (CP/C) for mark
11/7

Permission may be granted to assign work order to CPWD as per GFR2017 Rule 133(2).
Ravinder Singh
13/07/17
(RAVINDER SINGH)

DIRECTOR
13/7/17

A.R. (Admin):— As per provision in GFR (133)(2) permission may be granted to assign the work to CPWD. Advance will be issued as per norms.

राष्ट्रीय प्रौद्योगिकी संस्थान, उत्तराखण्ड
National Institute of Technology,
Uttarakhand

(32)

Ref. No:. NITUK/ESTATES/2017/CPWD/938

Dated: 27 JUL 2017

To,

The Executive Engineer,
Garhwal Central Division,
CPWD, Srinagar (Garhwal)

Sub: Regarding Administrative Approval and Expenditure Sanction for construction of Temporary Shed, Soak Pits, Paver Blocks and Aluminum Partition at temporary Campus of NIT Uttarakhand.

Ref No:Your Preliminary cum Detailed estimate: डी.बी. 29(24)/ग.के.मं./944dated:01/06/2017

Sir,

NIT, Uttarakhand hereby issues the Administrative Approval and Expenditure Sanction (A/A&E/S) for an amount of ₹32,02,700/- for construction of Temporary Shed, Soak Pits, Paver Blocks and Aluminum Partition at temporary Campus of NIT, Uttarakhand with following terms & conditions.

1. **Date of Issue of A/A& E/S**: 27 JUL 2017
2. **Completion time:** 04 months after issuing of A/A & E/S.
3. **Scope of work:** As per Annexure-A.
4. **Expenditure sanction**: ₹ 32,02,700/-.(Thirty two lakhs two thousand seven hundred only).
5. **Rates and Taxes:** Based on DSR 2016, Cost index @27.45%, Contingencies @5%, Vat@ 6% / GST (as per actual in final bill), Labour Cess @1%.
6. **Payment Terms:** Against this work, first installment of ₹ 10,56,900/-(Rupees Ten lakhs fifty six thousand and nine hundred only) is enclosed vide cheque no. 193807 dated 27/07/2017 Balance amount will be released in installments. The amount will be released only after submission of Demand Note and Progress Report. Final Installment will be released only after completion of work and transfer of inventory.
7. **Documents and reports:**
   a. 'Quality Certificates' at different stages.
   b. Monthly report indicating physical & financial progress of work.
   c. Expenditure Report with completion report.
   d. Laboratory Test Report of construction material, if any.
   e. Detail drawing, Details of Measurement and BOQ.
8. **Other Terms and Conditions**:
   a. The work should be completed within completion period, failing which penalty/ deductions may be imposed on final bill.
   b. Specification of work should be according to CPWD specification.
   c. Remaining terms and conditions will be according to CPWD manuals.

REGISTRAR

Copy to:
1. Asso Dean (P&D)
2. Assistant Registrar (Admin)
3. Asso Dean (Estate)

राष्ट्रीय प्रौद्योगिकी संस्थान,
उत्तराखण्ड
National Institute of Technology,
Uttarakhand

Annexure-A

Summary of works

1. **Construction of 2 No. Soak Pits for Student Hostels in Polytechnic Campus:** Construction of deep Soak Pits in Hostel 2 & Hostel 7 is required.

2. **Construction of paved blocks flooring and color coated tin shed supported at steel structure near dispensary area:** In the said area of approximately 142 Sqmt. paved block flooring and tin shed structure is required, drawing is attached as Annexure-I

3. **Paved block flooring and color coated tin shed at back side of hostel-02:** In the said area of approximately 33 Sqmt. paved block flooring and tin shed structure is required, drawing is attached as annexure-II

4. **Construction of Paved blocks flooring in path of academic block:** In the path of approximately 55 Sqmt. Paved block flooring is required. Rough drawing is attached as Annexure- III.

5. **Covering of all D.G Sets installed in campus by color coated tin sheet supported by Steel Structure:** 3 D.G sets need to be covered in Polytechnic Campus and 1 shed is required at ITI Campus. Approximate area for this work is 40 Sqmt.

6. **Construction of color coated tin shed supported at steel columns at Canteen, ITI Campus:** Approximate area for this work is 150 Sqmt. Rough drawing is attached as Annexure- IV.

7. **Aluminum partition at corridor of library:** Approximate area for the same is 8 Sq.mt. drawing is attached as Annexure-V

Temporary Campus-Government Polytechnic Sringar (Garhwal), Distt. Pauri Garhwal, Uttarakhand Pin-246174
Phone: 01346-257400 (O), Fax: 01346-251095 E-Mail: nituttarkhand@gmail.com, Website: www.nituk.com

608

Annx BWC05.03 (31)

Proposal

As the campus of NITUK falls on hilly area where no sewer lines are laid yet, toilet waste is being disposed beneath the ground in Septic Tanks and Soak-Pits.

The campus of NIT Uttarakhand at present is temporary in nature having lesser space availability for constructing more and more Soak Pits and Tanks. Also, the area falls in the vicinity of the river Alaknanda basin, therefore the water table is not significantly deep from earth crust. Capacity of Soak pits become lesser with passage of time and the waste outflow from the underground tanks instead of soaking it. Sometime the sewage collector vehicle of Municipality Corporation does not reach at our peak requirement, resulting in unhygienic condition at campus.

Generally, the sewage waste was disposed by Sewage collector vehicle by Municipality Corporation on the STP of Jal Sansthan, but at present Jal Sansthan is not providing consents to dispose the waste on the same.

A letter dated 07/04/2017 was received from Jal Sansthan Srinagar Garhwal subjected to disposal of sewage on 3.5 M.L.D sewer treatment plant, It was told not to dispose the dead sewage waste on plant and suggested only fresh sewage (Not more than one or two days old) may be disposed. Another letter dated 25/04/2017 was received by the same organization and it was mentioned on the letter that due to dead sewage disposal, the reports of samples are reaching beyond the standard limits, N.G.T have also shown rage about the same.

Institute has sent a letter dated 17/07/2017 to Jal Sansthan requesting them to allow the disposal of sewage waste. A letter in this regard also sent to Chairman, Nagar Palika Parishad and S.D.M Srinagar on dated 01/08/2017.

After this several verbal request have also been made for the same, but the positive reply is still awaited. At present the sewage waste is being disposed at Soak pits of buildings at ITI Campus, the capacity of which may be over at any time.

The approximate expenditure to be incurred is 43 Lakh.

(Paras Sah)
Tech. Asst.
(Civil)

A.D. (Estate): The detailed project report for your perusal is submitted

1/4/18

Registrar :- Permission may be granted to present the report in the next FC meeting.

07/02

DIRECTOR

08/12/2010

07/02

Detailed Project Report on Sewage Treatment Plant

INDEX

P/ (Paras Nath)

(Paras Sah)

SEWAGE TREATMENT PLANT

1. **Introduction:** As the campus of NITUK falls on hilly area where no sewer lines are laid yet, toilet waste is being disposed at beneath the ground at Septic Tanks and Soak-Pits.

The campus of NIT Uttarakhand at present is temporary in nature having lesser space availability for constructing more and more Soak Pits and Tanks.

Also, the area falls in the vicinity of the river Alaknanda basin, therefore the water table is not significantly deep from earth crust. Capacity of Soak pits become lesser with passage of time and the waste outflow from the underground tanks instead of soaking it.

Sometime the sewage collector vehicle of Municipality Corporation does not reach at our peak requirement, resulting in unhygienic condition at campus. Also, in the event of strike or shortage of manpower in future at Municipality Corporation, it would be difficult to control such intolerable unhygienic conditions because of our entire dependency on Municipality Corporation.

Generally, the sewage waste was disposed by Sewage collector vehicle by Municipality Corporation on the STP of Jal Sansthan, but at present Jal Sansthan is not providing consents to dispose the waste on the same.

A letter dated 07/04/2017 was received from Jal Sansthan Srinagar Garhwal subjected to disposal of sewage on 3.5 M.L.D sewer treatment plant, It was told not to dispose the dead sewage waste on plant and suggested only fresh sewage (Not more than one or two days old) may be disposed.

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Institute has sent a letter dated 17/07/2017 to Jal Sansthan requesting them to allow the disposal of sewage waste. A letter in this regard also sent to Chairman, Nagar Palika Parishad and S.D.M Srinagar on dated 01/08/2017.

A letter was received from office of Executive Engineer, Jal Sansthan Pauri on dated 15/09/2017, which stated that disposal of fresh sewage waste, shall be allowed only after testing of sample, it was also instructed to arrange for sewage treatment at from Institute's level.

Institute sent a letter to Jal Sansthan requesting them to allow disposal of sewage waste after sample testing on dated 03/10/2017, after this several verbal request have also been made for the same, but the positive reply is still awaited.

At present the sewage waste is being disposed at Soak pits of buildings at ITI Campus, the capacity of which may be over at any time.

(Paras Sah)

In the light of the facts, a **Sewage Treatment Plant** is required for the campus of NIT Uttarakhand with a **Tractor towed Sewer Suction Machine mounted on Trailer Chassis.**

1.1 OBJECTIVE

The object of sewage treatment is to stabilize the organic matter present in sewage so as to produce an effluent liquid and a sludge, both of which can be disposed of into the environment without causing health hazard or nuisance.

The endeavor should be to adopt modern and cost-effective technologies and equipment to achieve value for money and maximum user satisfaction.

2. BASIC DESIGN CONSIDERATIONS

2.1 Essential Parameters

Before proceeding with design of the treatment plant & disposal mechanism, it is essential to know the following-

a) Quantity of sewage and its origin- e.g Domestic.

b) Physicochemical characteristics of the raw sewage.

c) Desirable final effluent standards which shall be dependent upon the conditions under which the effluent is to be discharged e.g., on land, into a water body etc.

2.2 Degree of Treatment

The degree of treatment shall be decided by regulatory bodies like local municipality or Pollution Control Board (PCB) which may have laid down standards for effluent and may have specified the conditions under which the effluent could be discharged into a natural stream, sea or disposed of on land. Besides, the method of treatment adopted should not only meet the above requirements of regulatory bodies but also result in the maximum use of end products.

2.3 Design Period

The treatment plant is normally designed for a 30 year period. It is suggested that the construction of the STP be organised in phases with an initial design period of 5 to 10 years. STPs are to be designed for average flow of wastewater per day. Generally these are designed for present loads with possibility of augmentation for future increase. Care should be taken to see that the plant is not considerably under loaded in the initial stages.

2.4 Population Served

(Paras Nath)

Estimates for present and future population or areas Involved In the project needs to be on realistic basis.

3. POLLUTANTS IN WASTEWATER

The three chief categories of pollutants in wastewater are the dissolved and suspended solids and the water-borne organisms. These are tabulated hereunder-

Table 1:Pollutants in Wastewater

DISSOLVED SOLIDS		SUSPENDED SOLIDS		MICRO-ORGANISMS
Inorganic Compounds	Biodegradable, Water Soluble Organic Compounds (BOD) Such as Starches, Fats, Carbohydrates, Proteins, Alcohols, Fatty and Amino Acids, Aldehydes and esters	Biodegradable, Water Insoluble Organic Compounds (COD) Such as Tannin, Lignin, Cellulose, Phenols, Detergents, Petroleum Products, Pesticides, Insecticides, Industrial Chemicals and Hydrocarbons	Biodegradable, Water Insoluble Organic Compounds Resistant to Bacterial Decomposition	Includes various Species of Bacteria including Pathogenic Bacteria, Viruses, Protozoa, Fungi etc.

4. WASTE WATER FLOW AND SEWAGE CHARACTERISTICS

The quantity of sewage and its characteristics are important considerations. Detailed analysis of waste being obtained in each specific case is essential for characterisation of wastewater in order to develop an effective and economical wastewater management program. This constitutes the primary data required for process design which helps in choice of treatment methods, deciding the extent of treatment, assessing the beneficial uses of wastewater in a planned and controlled manner. Collection of waste water from other similar location may be taken during initial stages of planning for this data. The various parameters to be determined are -

a) Sources of Toxic waste water (If any):-
   - (i) Hospital Waste
   - (ii) Butchery's Waste
   - (iii) Industrial Waste

b) Sewage Characteristics for each type- Physical and chemical properties of raw sewage viz. BOD_5 (mg/l) at 20° and suspended solids (mg/l), etc. as given below are to be forwarded preferably at peak flow & lean flow time, with a repeat test at an interval of 2 days.
   - (i) Temperature.
   - (ii) pH.
   - (iii) Color & Odour
   - (iv) Solids-TSS,VSS,NVSS

P.T. (Paras Nath)

(v) Nitrate
(vi) Phosphorus
(vii) Chlorides
(viii) BOD_5
(ix) COD
(x) Toxic Metals & Compounds
(xi) Greases & Oils, etc

4.1 Characterization of Wastewater

a) **Temperature:** This is useful in indicating Oxygen transfer capacity of aeration equipment and rate of biological activity. Extremely low temp affects adversely, thus proper design and selection of technology for low temp areas are required.

b) **Hydrogen Ion Concentration (pH):** This indicates development of septic conditions.

c) **Colour and Odour:** With passage of time waste become stale, dark and emits foul smell.

d) **Solids:** Sewage contains only 0.1 percent solids, the rest being water. Still the nuisance caused by the solids cannot be overlooked, as they are highly putrescible and therefore need propel disposal. The sewage solids may be classified into suspended and dissolved fractions which may be further subdivided into volatile and non- volatile solids. Information of the volatile or organic fraction of solid, which is putrescible, becomes necessary as this contributes to the load on biological treatment units.

e) **Nitrogen:** The principal nitrogenous compounds in domestic sewage are proteins, amines, amino-acids and urea. Generally domestic sewage contains sufficient nitrogen to take care of the needs of the biological treatment.

f)

g) **Phosphorus:** substantially to the phosphorus content. Phosphorus, just as nitrogen, is an essential nutrient for biological process.

h) **Chlorides:** Concentration of chlorides in sewage above the normal chloride content in the water supply is used as an index of the strength of the sewage. The daily contribution of chlorides averages to about 8 gm per person.

i) **Biochemical Oxygen Demand:** The Biochemical Oxygen Demand (BOD) of sewage or of polluted water is the amount of oxygen required for the biological decomposition of biodegradable organic matter under aerobic conditions.

j) **Chemical Oxygen Demand:** The Chemical Oxygen Demand (COD) test gives a measure of the oxygen required for chemical Oxidation. This test

(Paras Bah)

does not differentiate between biologically Oxidiable and nonoxidiable material. However, the ratio of the COD to BOO does not change significantly for a particular waste and hence this test could be used conveniently for interpreting performance

k) **Toxic Metals and Compounds:** Some heavy metals and compounds such as chromium, copper and cyanide, which are toxic, may find their way into sewage through hospital/ industrial discharges, also from institutional laboratories. Determination of these compounds assumes importance if such waste is to be treated by biological process or disposed off into a stream or on land.

l) Grease and oils in excessive amounts not only add considerably to the cost of treatment, but also pose a disposal problem.

5. DEGREE OF TREATMENT

5.1 Choice of Treatment

Analysis, in totality, for collection, disposal, treatment and safe reuse of wastewater is done before selecting a technology. Due care be taken for climate conditions while selecting technologies particularly with regard to biological units. For very small and isolated population, the time tested septic tank with two soak wells may still be a safe option, provided water table is not too high (<8.0m). Modifications to septic tank or soak well can be planned if rocky strata are encountered. However this may not be a preferred option.

5.2 Effect of Hospital, Butchery or Workshop Wastes

Wastes from these locations can form an important component of sewage flows both in volume and composition. It is therefore necessary that detailed data about the nature of the waste from these sources is estimated. Quantity and character of wastes based on laboratory analysis and their variations which may affect the sewerage system or the sewage treatment process, are to be assessed for individual and for the composite samples. Where water reclamation is to be practiced, due consideration is to be given to the effect in these waste components on the final effluent. In certain instances, it is more economical to tackle these wastes at the source itself.

5.3 Other Considerations

Degree of Treatment required shall also depend on

a) Method of Effluent Disposal.

b) Possibilities of Reuse, if any during monsoon, winters and summers with confirmation of same from users.

5.4 Treatment Parameters

In case of sewage, the degree of treatment is considered in terms of removal of BOD/COD, nutrients (nitrogen and phosphorous), coliforms, heavy metals etc. Land disposal generally has to meet less stringent discharge standards than disposal to

(Paras Sah)

surface waters. Land disposal also has the advantage of obtaining nutrient utilization for the soil and is, thus, preferred wherever feasible. It is not enough to aim only at BOD removal and other factors be left to unspecified, incidental removal. The selection of a treatment process depends on the extent of removal efficiency required for all important parameters and the need to obviate nuisance conditions.

Table 2: Wasterwater Characteristics for Disposal

a)	Ph	:	6.5-9
b)	TSS	:	<20 mg/l
c)	BOD	:	<10 mg/l
d)	COD	:	<50 mg/l
e)	Fecal Coliform	:	<100 MPN/100 mL

5.5 Recycle and Reuse

As a matter of policy wastewater should be recycled for non-potable users after proper treatment unless there are reasons for not doing so. Normally tertiary treatment has three stages i.e. filtration by dual media sand filter, super chlorination and finally adsorption by activated carbon column. Following specifications are to be adhered for treated effluent for non-potable reuse. In case wastewater is to be reused for cooling towers, softening will be required to avoid scaling of pipes.

6. EFFLUENT DISPOSAL AND UTILISATION

The sewage after treatment may be disposed either into a water body such as lake, stream, river, or onto land. It may also be utilized for several purposes such as agriculture, washing of vehicles, cooling systems, golf courses or boiler feed. If the sewage effluent is to be discharged into inland surface waters, tolerance limits prescribed by statutory agencies, IS: 4764 or as mentioned above, should be followed.

7 REACTOR DESIGN PRINCIPLES

7.1 Unit Operations and Processes

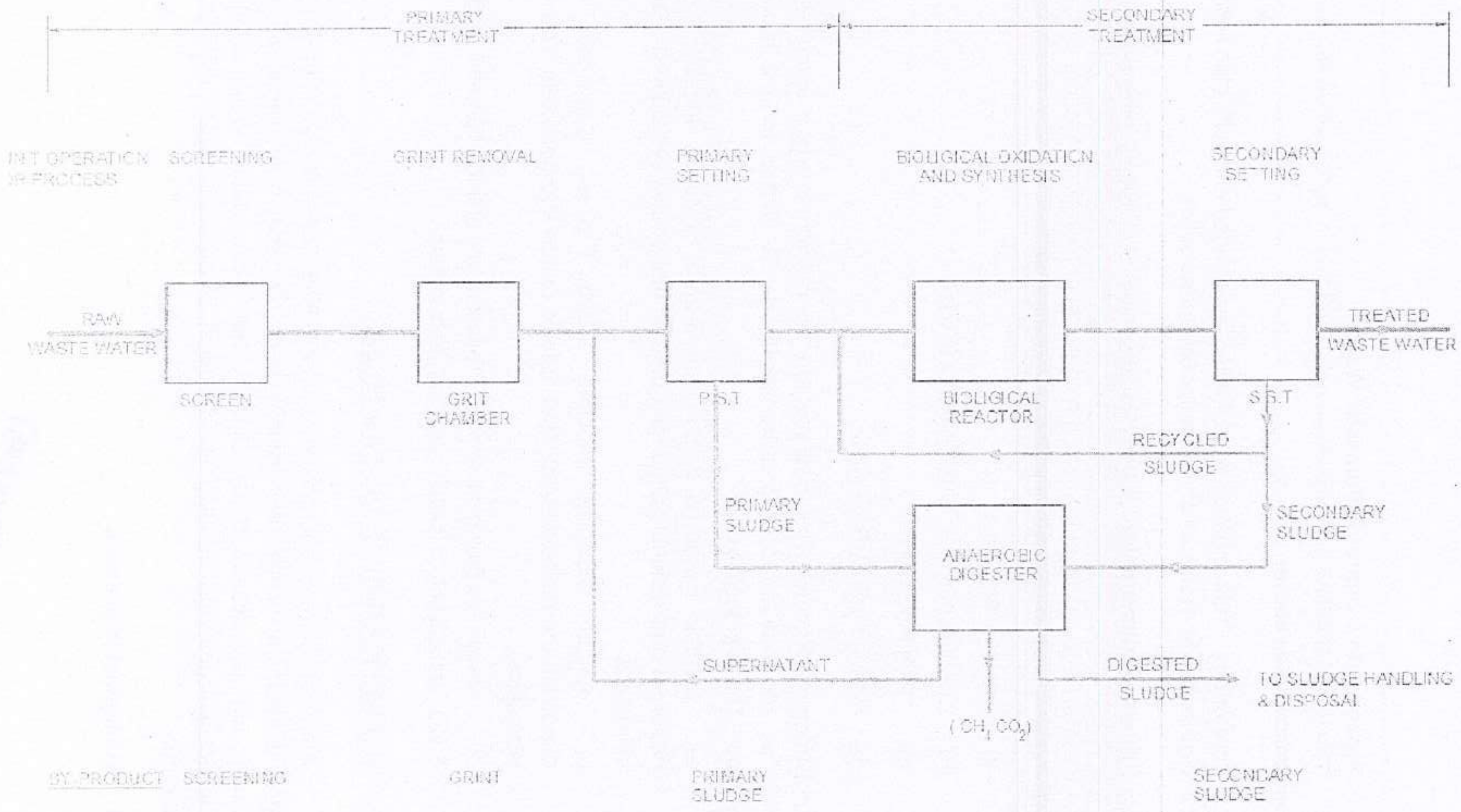
Removal of contaminants is brought about by a sequential combination of various physical, chemical and biological unit processes. The physical unit operations Include -

a) Pretreatment – removes material that can cause operational problems through screening, such as settleable solids, floating plastics etc.

b) Primary treatment – removes ~60% of solids and ~35% of BOD.

c) Secondary treatment – removes ~85% of BOD and solids.

d) Tertiary treatment– varies:~ 95+ % of BOD and solids and also Nitrogen add phosphorus.



P.T.O. (Paras Dash)

7.2 **Process Flow Chart for Domestic Waste**

The unit operations and processes employed in domestic wastewater treatment are as shown in Fig (as above)

7.2.1 **Screening:** This removes large floating, suspended and settleable solids.

7.2.2 **Grit Removal:** Removal of inorganic suspended solids.

7.2.3 **Primary Sedimentation:** Removal of organic and inorganic settleable solids

7.2.4 **Reactor:** Any container in which the chemical or biological reactions occur can be termed as a reactor. Reactors are basically classified as:

a) Batch Reactors

b) Continuous flow Tank Reactors (CSTR)

c) Plug Flow (PF)

d) Arbitrary Flow Reactors.

7.2.5 **Biological Reactor:** Biological reactors are reactors in which organic matter, which serves as substrate or food to micro organisms, is utilized for the growth of micro organisms. These processes are-

a) Aerobic Biological Suspended Growth Process: Conversion of colloidal, dissolved and residual suspended organic matter into settleable biofloc and stable inorganics.

b) Aerobic Biological Attached Growth Process: Conversion of colloidal, dissolved and residual suspended organic matter into settleable biofloc and stable inorganics.

c) Anaerobic Biological Growth Process: Conversion of organic matter into CH_4 & CO_2 and organic relatively stable organic residue.

8. CLASSIFICATION OF THE PROCESSES

A number of treatment processes are available depending upon method of disposal, degree of treatment, waste water influent quality (domestic or industrial), availability of the land etc and requirement of recycling treated waste water. Waste Water Treatment Methodology commonly adopted for treatment of domestic waste may be any of the following:

8.1 Biological Processes

(Paras Nath)

In these processes a mixture of wastewater and microorganisms (biomass) is agitated and aerated. Certain microbes, mainly bacteria of specific kind, have the capability to oxidize the dissolved organic matter in the waste water. Microbial growth is accelerated and controlled in the process. Thus, reduction or removal of organic matter in waste is brought about by microorganisms by oxidation. After oxidation, the sludge is separated from wastewater. These, microbial induced processes are further classified as Aerobic and Anaerobic.

a) Aerobic Processes- In presence of oxygen
b) Anaerobic Processes- In absence of oxygen

8.1.1 **Aerobic Processes-** The following conventional methodologies are examples of Aerobic Processes-

a) Activated sludge process (ASP)
b) Trickling filters
c) Facultative aerated lagoons
d) Extended aeration process
e) Wet Lands
f) Oxidation ponds
g) Oxidation ditches

In modern nomenclature the aerobic processes are divided into Aerobic Suspended and Attached Growth Processes and the Soil Biotechnology.

8.1.1.1 <u>Aerobic Suspended Growth Processes (SGP)</u> The conventional activated sludge process (ASP) is the best known suspended growth aerobic system and is the process most commonly used in large, centralized WWTPs though it can also be used in small plants. Some of the process varients of ASP are-

a) Sequencing Batch Reactor (SBR)
b) Extended Aeration
c) Membrane Bioreactors (MBR)

8.1.1.2 <u>Aerobic Attached Growth Processes (AGP)</u> Under the AGP, two proven and fairly known treatment processes are available as following:

a) Moving Bed Biological Reactor (MBBR) The Moving Bed Biological Reactor may be known by different names as under, however the process remaining same with free floating media of different shapes, sizes and materials (generally plastic).

(i) Fluidised Bed Reactor (FBR)
(ii) Moving Bed Bio Reactor (MBBR)
(iii) Sequential Batch Reactor (SBR)

b) Fixed Bed Biological Reactor (FBBR) Similarly, the Fixed Bed Biological Reactor may also be known by different names as under, but the technology remains same as that

(Paras Dah)

of MBBR except that the media is fixed horizontally/ radially or sloping (normally at 60°) in packed beds of different depths and of different sizes and materials (generally plastics).

(i) Submerged Aerobic Fixed Film (SAFF)
(ii) Fixed Bed Reactor (FBR)
(iii) Fixed Media Reactor (FMR)
(iv) Fixed Media Biological Reactor(FMBR)
(v) Fixed Bed Biological Reactor(FBBR)
(vi) Bio Tower
(vii) Rotating Biological Contractors (RBC) (Also called Biodisks).

8.1.1.3 Soil Biotechnology or Constructed Wetlands.

8.1.2 **Anaerobic Units** These can be generally grouped into the following:-

a) Anaerobic ponds/ stabilization ponds

b) Upflow Anaerobic Sludge Blanket (UASB) reactor followed by lagoons etc (Suitable for large capacity plants say 20 mld or above).

8.2 **Chemical unit processes**

a) Chemical neutralization: to control or adjust pH.

b) Chemical coagulation: to remove colloidal particles by chemical destabilization and flocculation.

c) Chemical precipitation: to enhance the removal of suspended solids, Phosphorous, heavy metals, and BOD in the specific system conditions.

d) Chemical oxidation: to remove grease, ammonia, BOD, COD, and odour control.

e) Chemical disinfection: to kill pathogens in influent and treatment effluents.

8.3 **Design of Process Flow Sheets**

8.3.1 The process design involves selection of an appropriate combination of various unit operations and unit processes to achieve a desired degree of contaminant removal. The selection of unit operations and processes primarily depends on the characteristics of raw wastewater and the required levels of contaminants permitted in the processed effluents.

8.3.2 The main contaminants in domestic wastewater to be removed are biodegradable organics. The contaminants are usually measured in terms of BOD_5, suspended solids and pathogens. It is generally the objective of domestic wastewater treatment plant to produce treated effluents having BOD_5, of 30 mg/l or less and suspended solids of 50 mg/1 or less for disposal into inland water bodies.

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8.3.3 The conventional process flow sheet of wastewater treatment plant comprises the unit operations of screening, grit removal and primary sedimentation followed by unit process of aerobic biological treatment. The sludges removed by primary and secondary sedimentation are digested anaerobically followed by drying on sludge drying beds.

8.3.4 For new central sewage schemes, the sewage load should be worked out and STP based on any of technologies referred above or a combination of two or more technologies can be adopted. These modern systems are based on technologies which requires lower hydraulic retention time; obviate recycling of sludge and provisioning of sludge digester for a viable population load.

8.3.5 For the quantity of treated waste water that can not be reused, or where re-use of treated water is NOT required, treatment should only be planned up to the secondary level. Disinfection, wherever required, can be considered depending upon location of discharge of treated water.

8.3.6 Higher detention time should be catered for in the design of STP where ambient temperature is lower than 20°C or alternate design criteria may be adopted.

8.3.7 With the better understanding of microbiology and biochemistry of anaerobic treatment, It is now feasible to treat domestic wastewater also directly through anaerobic treatment such as Upflow Anaerobic Sludge Blanket (UASB) Reactor, Fluidised-Bed Submerged Media Anaerobic Reactor (FB·SMAR) and Anaerobic Filter (AF) or Static-Bed SMAR(SB·SMAR) and Anaerobic Rotating Biological Contactor (ARBC). It is generally reported that BOD removal efficiencies may range from 60-80%. Consequently post treatment will generally be required to achieve .the prescribed effluent standards.

8.4 Selection of Treatment System

Selection of treatment system is not an easy decision to make. It is a tough job that requires substantial field experience as well as sound technical knowledge of the various unit operations. It shall depend on availability and topography of land at the treatment site, availability of mechanical equipment and skilled personnel and various factors as stated below.

a) Less to No Need for Skilled Supervision

b) Auto Vigilance of MLSS, DO and F/M Ratios

c) Low Power Requirement

d) Low Footprint (Plan) Area

e) High Oxygen Transfer Efficiencies

f) Least Need For Sludge Recycling

g) Less to No Need for Drives or Moving Parts Within Units

h) Less Sludge Production

P.f (Paras Sah)

i) Stainless Steel Construction to Ensure Longevity and Corrosion Safety

j) No Odour Problem

k) Least No. Of Operational Units And Hence Least Staff And O & M Headaches

l) No Need for Tertiary Units

m) Least Operation Cost

n) Flexibility And Adaptability to High Loads

o) Nitrification (N) And Denitrification (DN) for ensuring Stable, Disposable Sludge with No Odor and Storable Longitivity.

p) Nutrient and Phosphorus Removal to Safe Guard against Algal Growth Downstream After Disposal in Receiving Water Bodies etc.

8.5 Comparison and Assessment of Various Treatment Processes

A comparison of various treatment processes has been given as **Annexure-I.**

8.6 Oxygen Requirements

Oxygen is required in the aeration process for the oxidation of a part of the influent organic matter and also for the endogenous respiration of the micro- organisms in the system. The total oxygen requirements per Kg BOD removed for different aeration processes are important to work out for each STP depending upon raw sewage report of waste water. The amount of oxygen required for a particular process will increase within the range as the F/M value decreases.

8.6.1 Aeration Facilities: The aeration facilities at the plant are designed to provide the calculated oxygen demand of the waste water against a specific level of dissolved oxygen (DO) in the waste water. The aeration devices apart from supplying the required oxygen demand shall also provide adequate mixing or agitation in order that the entire mixed liquor suspended solids (MLSS) present in the aeration tank will be available for the biological activity. The recommended dissolved oxygen concentration in the aeration tank is in the range 1 to 2 mg/l for extended aeration type activated sludge plants and above 2 mg/l when nitrification is required in the activated sludge plant. Aerators are rated based on the amount of oxygen they can transfer to tap water under standard conditions of 20°C, 760 mm Hg barometric pressure and zero DO.

8.6.2 Diffused Aeration: Diffused air aeration involves the introduction of compressed air into the sewage through submerged diffusers or nozzles. Compressed air is released at or near the bottom of the aeration tank through porous tubes or plates made of aluminum oxide or silicon oxide grains cemented together in a ceramic matrix. The aerators may be of the fine bubble or coarse bubble type. Air supplied to diffusers should contain less than 0.02 mg of dust per ml. Diffusers are located 0.3m to 0.6m above tank floor to aid in tank cleaning and reduce shutdown.

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8.6.3 Surface Aerators: Surface aerators were not widely installed in the past but with recent improvements in their design, they are being increasingly used for large plants in preference to diffused air aeration systems. Some of their advantages are higher oxygen transfer capacity, absence of air piping and air filter and simplicity of operation and maintenance.

8.6.4 Mixing Requirements: The aeration equipment is also required to provide adequate mixing in the aeration tank to keep the solids in suspension.

8.7 Measuring Devices

Measuring Devices should be installed for indicating flow rates of raw sewage or primary effluent, return sludge and air to each aeration tank.

8.8 Secondary Settling

Secondary settling assumes considerable importance in the Activated Sludge process as the efficient separation of the biological sludge is necessary not only for ensuring final effluent quality but also for return of adequate sludge to maintain the MLSS level in the aeration tank. The most important aspect in the operation of an activated sludge plant is the maintenance of proper F/M which is achieved by increasing or decreasing the MLSS levels in the aeration tank to suit the influent BODs loads.

8.9 Nitrification

Activated sludge plants are ordinarily designed for the removal of only carbonaceous BOD. However, there may be incidental nitrification in the process. Nitrification will consume part of the oxygen supplied to the system and reduce the DO level in the aeration tank. Nitrification will also lead to subsequent denitrification.

8.10 Maintenance

Due consideration must be given in the design of aeration tanks to the need for emptying them for maintenance and repair of the aeration equipment. Intermediate walls should be designed for empty conditions on either side. The method of dewatering should be considered in the design and provided for during construction.

Effluent parameter should be well within pollution norms laid down by Central Pollution Control Board/ State Pollution Control Board, whichever is more stringent. In this connection please refer our policy letters. This may also be referred on web site www.cpcb.nic.in.

9. TERTIARY TREATMENT OF SEWAGE FOR REUSE

9.1 General

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Tertiary treatment is supplementary to primary and secondary treatment for the purpose of removing the residual organic and inorganic substances and in some cases for even the refractory and dissolved substances to the degree necessary. Tertiary Treatment of sewage is increasingly being adopted in India.

Re-use of treated wastewater should invariably be planned while selecting the overall scheme. Reuse may be restricted to only non potable applications i.e. irrigation, arboriculture, recreation lake, eco lake, gardening, golf-courses fire fighting, air conditioning, water in cooling systems, flushing, car wash or ground water recharge for augmenting ground water resources.

The tertiary treatment may be considered only to the extent of quantity of water to be reused and hence designed accordingly to achieve cost economy. All technologies except Soil Bio-technology (SBT) require tertiary treatment before wastewater is reused. It consists of filtration, adsorption and chlorination.

Tertiary treatment is quite use-specific and may involve only one item like simple chlorination of treated sewage or several items depends on end use. It is, therefore, very important that clear cut specifications of the reusable water are first obtained.

A tertiary treatment plant, therefore, generally, looks like a sewage treatment plant followed by a typical industrial water treatment plant.

10. EFFLUENT DISPOSAL AND UTILISATION

10.1 General

The effluent from sewage treatment plants may be discharged in receiving waters such as lakes, streams, rivers, estuaries, oceans or on land. The nature and degree of treatment given to the sewage depends upon the requirements imposed by the regulatory authorities. It is necessary to adhere to the standards laid down by the Pollution Control Boards with regard to the quality of the sewage to be discharged into a body of water, inland or marine or on land for farming purposes or underground for purposes of recharge aquifers.

10.2 Disposal into Water Bodies

Treated effluent conforming to prescribed standards may be disposed into a stream course or into sea or a stagnant body of water. The quality, quantity and use of the receiving water body into which the effluent is discharged, decides the degree of treatment required for the sewage. Since the treated waste water may still have a high coliform density, disinfection or any other treatment methods may be considered for reducing the coliform density before disposal of water into the water body. Disposal of wastewater in a river causes organic, chemical and microbial pollution. Organic pollution not only depletes

P.T. (Paras pati)

the oxygen content in the river resulting in killing of fish and marine life but also leads to heavy algal growth downstream.

10.3 Reclamation of Treated Effluent

Complete reclamation of sewage effluent is not generally adopted. Reclamation is restricted to meet the needs depending upon the availability and cost of fresh water, transportation and treatment costs and the water quality standards and its end uses like irrigation, arboriculture, recreation lake, eco lake, gardening, Golf-courses fire fighting, air conditioning water in cooling systems, flushing and car wash, ground water recharge for augmenting ground water resources. Some of these uses may need tertiary treatment as discussed

10.4 Artificial Recharge of Aquifers

Artificial recharge of ground water aquifers is one of the valuable source and methods for combining effluent disposal with water reuse. Replenishment of ground water sources has been done on a practical scale.

10.5 Disposal on Land (Sewage Farming)

The nutrients in sewage like nitrogen, phosphorus and potassium along with the micronutrients as well as organic matter present in it could be advantageously employed in sewage farming to add to the fertility and improve the soil quality. Even application of treated effluent to land has to be done with certain precautions as it is not completely free from this risk.

11 EMERGING TECHNOLOGIES FOR SEWAGE TREATMENT

11.1 General

Activated Sludge Process and Extended Aeration Systems give insignificant return on capital investment. To overcome these limitations of currently practiced sewage treatment technologies, researches have been carried out to develop alternative technologies. Some of these emerging technologies include.

a) Duckweed Pond Technology

b) Vermiculture Technology

c) Technology utilising raw sewage for forestry

d) Artificial wet Lands / Root Zone Technology

These technologies are based on natural systems of waste management and treatment. They possess the following distinct advantages-

a) Minimum use of mechanical equipment

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b) More Eco - Friendly

c) Capable of generating revenue

11.2 Duckweed Pond Technology

The wastewater treatment employing duckweed pond system is relatively simple to construct, operate arid maintain. Duckweed (lemnaceae) is an aquatic plant which can grow prolifically when temperature ranges between 15 to 30° C, doubling its weight with in 2 - 4 days. It requires basically nitrogen, phosphorus and potassium tor growth. It can be used as cheap and high quality (high protein) animal feed, valuable protein component of chicken feed and feed for fish.

11.3 Vermiculture Technology

This technology utilises earthworms for the treatment of domestic wastewater. The earthworms have been called as natural bioreactors. The earthworms produce both microorganisms and enzymes that breakdown complex bio-molecules into simple compounds which are utilised by the micro organisms. It is claimed that aerobic conditions are maintained by virtue of its hemoglobin with high saturation constant and therefore no external aeration may be required. The earthworms produce vermicastings with immobilised microflora and nutrients. Vermicastings have the potential of being used as biofertilisers.

11.4 Root Zone Technology or Wet land process

This method is useful for smaller stations where availability of land is not a problem and water table is more than 20m below ground level. In this method, the domestic wastewater, after the septic tank, is diverted into a lined pond filled with media of coarse aggregates. The liquid flows through the pores of media in sub surface condition and there is a growth of plants on top of media, their roots spreading upto the bottom of pond. The bacterial growth takes place around the roots. Aerobic bacteria grow near the roots due to presence of oxygen in roots and anaerobic bacteria grow away from roots. Thus the organic matter in the effluent is trapped and stabilized in the pores by aerobic as well as anaerobic bacteria.

This method does not require any maintenance for many years. The only precaution to be taken is that flow should remain sub surface to avoid breeding of mosquitoes. Many varieties of plants including flowering ones are available for this treatment and one has to check from local horticulture department for specific local species.

The root zone technology also referred to as artificial constructed wetland system, is basically a man made wetland where wastewater is kept at or above the soil surface for enough time during the year to maintain saturated conditions and appropriate vegetation. The three essential components of the system include the soil, the

P.T. (Paras Sah)

appropriate vegetation such as reeds. Cat tails, bulrushes and sedges and the microbial organisms.

The principal merits of the system include:-

a) No requirement of energy and mechanical equipment for aeration.

b) Self regeneration of reed bed and virtually maintenance free.

c) System can provide natural habitat for fauna.

12. EFFECT OF EXTERNAL TEMPERATURE ON TREATMENT

Biological activity reduces sharply with drop in temperature. As such necessary modification to the plant design is necessitated in areas experiencing extended periods of cold weather. On the other hand, the dissolved oxygen (DO) content reduces with increase in temp. This causes rapid putrification of organic matter and hence necessitates design modification to speed up the treatment. It may be remembered that the standard plant design caters for ambient temperature of about 20-25°C at which the microbes thrive.

13. OPERATION & MAINTENANCE FOR STP

Treatment system should be simple as far as possible in operation. The treatment plant should be operational round the clock to achieve the laid down parameters. STP should have low capital cost, lower power consumption and low life cycle cost for a period of 30 years.

The Contract Agreement will include construction, commissioning, operations and maintenance and defect liability period (DLP). The CEs should invariably enter in to contract with the executing firms as per criteria laid down in the policy at Appx. However, while preparing the specification for O&M, proper clause/schedule for the periodical checking of the plant, oiling, greasing, and routine maintenance and consumables for the same may be included in the scope of the work. Electricity for operation of the STP may be provisioned to be given by the department. While estimating the project, it may be borne in mind that the cost for revenue expenditure is debitable to maintenance and operation.

A report regarding Recommendations and Guidelines of Sewage Treatment Plant from the experts of IITs and other prestigious organization is attached as Annexure-II.

14. General Specification and approximate cost:

1. Fully Automated.
2. Prefabricated type.
3. Capacity =60 Kld

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4. Water quality of output should be as per standards of CPCB (File No. A-19014/43/06-MON, Dated 21/04/15) or as per new amendments from time to time.
5. Any technology may be adopted to achieve latest output parameters of CPCB/ Uttarakhand Environmental protection & Pollution Control board.
6. System may consist of Bar Screen, Oil & Grease unit, new Equalization tank/ Collection tank, Aeration units, filtering system, pumping units, and other essential units
7. U.V / chlorine dozer is required
8. Complete Installation of plant shall be done by vender including platform, foundations and equipment shed/ panel room.
9. Demonstration of Plant Operation will be required after complete installation.
10. Site Visit shall be welcomed.

Estimated expenditure to be incurred is Rs. 43,00,000/-
The requirement may be fulfilled through open tender process.

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APPENDIX 'A'

15. LIST OF INDIAN STANDARDS ON SEWERAGE AND SEWAGE TREATMENT

IS 2470 (PT 1)&(PT 2) : 1985	Code of practice for installation of septic tanks: Design criteria and construction (second revision) Secondary treatment and disposal of septic tank effluent (second revision)
IS :4733-1972	Methods of Sampling Test Sewage Effluent
IS : 6908-1975	Sewage and Drainage
IS :7022 (PT II)-1979	Glossary of Terms Relating to Water Sewage and Industrial Effluents PT II
IS:1538-(PT-XXIV)-1982	Press Pipes for Water, Gas and Sewage
IS 5600: 2002	Pumps-sewage and Drainage-Specification
IS 5611 : 1987	Code of practice for waste stabilization ponds (facultative type) (first revision)
IS : 5600-1970	Specification for Sewage and Drainage Building Elements
IS : 4764-1973	Tolerance Limits for Sewage Effluents Discharged In to In land Surface Water
IS 6279 :1971	Equipment for grit removal devices
IS 6280 : 1971	Sewage screens
IS 7232 : 1974	Method for Imhoff cone test
IS 7784: Part 1 & 2: Sec 1 to 5	Code of practice for design of cross drainage work : Part 1 General features
IS 8413 (PT 1) : 1977	Requirements for biological treatment equipment Part 1 Trickling filters
IS 8413 (PT 2) : 1982	Requirements for biological treatment equipment Part 2 Activated Sludge process
IS 9110 : 1979	Hand operated augers for cleaning water closet, pipe and sewer
IS 9213 : 1979	BOD Bottle
IS 10037 : PT1 to 3 : 1981	Requirements for sludge dewatering equipment. Part 1 sludge drying beds-sand, gravel and underdrains
IS 10261 : 1982	Requirement for settling tank (clarifier equipment) for waste water
IS 10552 : 1983	Buckets to be used in power driven buckets type sewer cleaning machine

IS 10595 : 1983	Requirement for power driven bucket-type sewer

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	cleaning machine
IS 11117 : 1984	Requirement for power driven rodding machine for sewers
IS 11387 : 1985	Requirement for high pressure jetting machine for sewer cleaning
IS 11972 : 1987	Code of practice for safety precautions to be taken when entering a sewerage system
IS 12115: Part 1 to 4 : 1987	Specification for Couplings for Disposal of Sewage water for Inland Vessels- Part 1 : Flange Coupling)

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Annexure-I

Table 4- COMPARISION OF VARIOUS TREATMENT PROCESS

Parameter	Moving Bed Bio- reactor (MBBR- FAB)	Sequencing Batch Reactor (SBR)	Upflow Anaerobic Sludge Blanket Reactor (UASB)	Activated Sludge Process (ASP) - Extended aeration	Rotating Biological Contactors (RBCs)
Type of Process	BOD reduction takes place aerobically. Fixed film process.	BOD reduction takes place aerobically. Suspended growth process. Improvised Activated Sludge Process	This is strictly anaerobic process. BOD reduction takes place by converting organic matter to methane / carbon di-oxide and other gases, through bacterial systhesis.	BOD reduction takes place aerobically. Suspended growth process.	This is an attached growth process, much similar to trickling filters. The biomass is attached to rotating media.
	Organic matter is brought in contact with bacteria attached to plastic media, which is in suspension. Excess sludge is sloughed off automatically, and separated in the clarifier. No sludge recycle is required.	The organic matter is brought in contact with bacteria in suspension. Oxygen supplementation is normally done by surface aerators or diffused air aeration. The biomass is separated in same tank. The operation of the process is in two main phases & two intermediate phases. The sewage is fed to the 1st compartment & mixed with activated sludge. After partial absorption of organic matter the sewage is taken into 2nd compartment & continuously aerated for further absorption of organic matter. Finally the sewage is taken into 3rd compartment for sedimentation. The operation is cyclic in nature. Excess sludge has to be wasted form the last compartment. In the next cycle the operation is same except the direction is reversed.	Pre-treated sewage is passed through a blanket (bed) of sludge in an upwards direction. Upon contact with the organic matter, the bacteria anaerobically convert the organics to methane and other gases. The gas bubbles get released from the sludge bed and rise upwards. Gas - Solid and Liquid separation is achieved in a separator placed at the top of the reactor. Additional settling devices may be provided outside the reactor.	The organic matter is brought in contact with bacteria in suspension. Oxygen supplementation is normally done by surface aerators or diffused air aeration. The biomass is separated in subsequent clarifier. Settled biomass is recycled to aeration tank to maintain Mixed Liquor suspended Solids of the desired level (usually between 2,500 to 4,000 mg/l).	The media is in a form of circular / octagonal discs, mounted on a central shaft. The discs are submerged in a 'VAT' (upto about 45%). The discs slowly rotate, thereby submerging in the sewage for half the time and then in the air for remaining time. The "air time" induces oxygen, allowing bacterial biomass to synthesize the organic matter, when the discs are submerged. Sloughing takes similar to that in trickling filter system.
Process	No sludge volume	Need to maintain certain level of	Upflow velocity plays a	Need to maintain	The disc speed must be

variables.	index / recycle need be checked. System is self sriaustaining. Excess biomass automatically gets wasted off. MLSS levels upto 12,000 mg/l are easily achieved.	MLSS, sludge volume index like activated sludge process. MLSS levels upto 5000 mg/l are possible. Higher levels hinder settling and results in poor performance.	very crucial role in performance. Also variation in inlet BOD / COD affects performance. Sludge bed height and sludge concentration are very important variables.	certain level of MLSS, sludge volume index like SBR system. MLSS levels upto 5000 mg/l are possible. Higher levels hinder settling and results in poor performance.	precisely controlled, else process efficiency drops drastically.
Sensitivity of process	Sensitivity is low, owing to very high bacterial population. No sensitivity to temperature.	Moderately sensitive.	UASB is also very sensitive to low temperatures, and performance drastically reduces with lower temperatures. Flow fluctuations can disturn the sludge blanket, thereby affecting performance.	Moderately sensitive to flow fluctuations, organic loading rates etc.	Highly sensitive to load variations, hydraulic loading and power failures.
Area requirements	Very small area required as compared to SBR, ASP, UASB, RBC	Area required is higher than MBBR but less then ASP.	Area required is larger than ASP and other processes.	Very large area required for aeration tank as well as for secondary clarifiers.	Very large area is required since the loading rates on the disc are limited by the surface area available.
Power requirement	Power requirement is lower than MBR.	Power required is more than MBBR or equal to activated sludge process.	Power requirement is lower than most of the processes. However UASB alone cannot produce desired outlet quality. Additional ASP / ponds must be provided, thereby increasing the power requirement.	Large power is required for aeration, return sludge pumping etc.	Low power than ASP, higher than UASB.

Moving parts	No moving part in biological process.	Moving parts in biological process. Decanter mechanism is mechanically activated and hence needs continuous maintenance. Without decanter, SBR does not function at all. Very high level of instrumentation is required.	No moving parts within UASB. However downstream ASP has typical maintenance requirements.	Depending on the aeration system, there can be moving parts such as surface aerators, brush rotors etc, which need maintenance.	Main moving part is the central shaft and drive, which come under continuous stress
Operation & Maintenance	No scum formation in the process & less moving parts in the system. Hence very low maintenance. Therefore the manpower cost is low. All the components of the system are indigenous & are readily available. Media for FAB never needs replacement of cleaning. Media life of more than 25 years can be guaranteed.	The entire plant operation is cyclic in nature & controlled by **PLC only**. The process requires very high level of instrumentation & sequencing operation. The entire instrumentation & control equipment are usually imported. The entire plant performance depends on functioning of all the instruments & sequence of operation. Needs spares of all the imported instruments in stock for repairing / replacing so that the plant is in operation within a short period. Availability of spares needs to be checked. The decanter mechanism is motorized and hence high degree of maintenance is required. Spares must be imported, Indian spares are not suitable.	Gas hoods need to be cleaned every 06 months or so, to remove scum that accumulates at the top surface. This is a major operation, needing to take the UASB out of service. Maintenance of other related equipments in the downstream ASP is also required.	Relatively simpler maintenance of mechanical equipment such as aerators, blowers, pumps etc. Because of shock loadings, filamentous growth takes place and makes the sludge particles to float in secondary clarifier. Once formed, it is difficult to remove such growth, making operation more operator dependent.	Prone to lot of maintenance of shaft / drive parts. In few cases, media discs have been seen to be buckled under biomass weight, needing complete replacement.
Power shut downs	Prolonged power shutdowns does not affect performance since after power cut-off, media floats at the top, keeping the micro-organisms, alive	At power shut down, all the sludge settles down and becomes septic within short span of time. Hence quick restart is not possible.	The downstream ASP process is severely affected during power shut-downs. UASB itself has little effect.	At power shut down, all the sludge settles down and becomes septic within short span of time. Hence quick restart is not possible.	Power failure causes serious process problems since top half of the disc remains in air, and becomes dry. The submerged portion remains in sewage and becomes septic, hence quick restart is not possible.
Sludge	Sludge is fully	Sludge is active hence anaerobic	Sludge is active and must	Sludge is mostly	Sludge is mostly

properties	digested hence can be dewatered directly without any further treatment	(or aerobic) digester is a must, for complete destruction of biomass. This increases plant cost and operator attention.	be further digested aerobically. Because of presence of SRB, sludge can smell very bad (rotten egg smell).	digested and does not need further treatment, similar to MBBR system. Dewatering is relatively easier.	digested and does not need further treatment, similar to MBBR system. Dewatering is relatively easier.
Amount of excess sludge	Sludge age is very high, and hence sludge production is about 0.1 – 0.15 kg / kg of BOD destroyed, hence very small amount of excess sludge is generated.	Sludge age is low hence sludge production is about 0.3 – 0.6 kg / kg BOD destroyed. Which means that the amount of excess sludge generated is about 200 to 400% higher than MBBR. This calls for large sludge handling system.	Excess sludge production of UASB itself is low, lower than most of the processes. However downstream ASP sludge production is high.	Excess sludge production is low, since Mean Cell Residence Time is high.	Excess sludge production is low, since Mean Cell Residence Time is high.
Expandability	High. Higher loads can be accepted with extra media filling. Modular construction is possible.	Very low. Higher loads can not be accepted. However, Modular construction is possible.	Very low. Overloading is not possible. Parallel units must be added to expand capacity.	Low. Usually extended aeration systems are not suitable for expansion. Separate parallel tanks and clarifiers must be built, which can be very expensive.	Low. Multiple modules need to be installed. Expansion within existing system is not possible.
Usage of treated effluent	No further treatment required for gardening & horticulture.	Treated effluent "as-such" can be used for low end purposes such as construction, floor washing etc. For gardening or higher end uses, chlorination and filtration are a must.	Treated effluent "as-such" can not be used for even low end purposes such as construction, floor washing etc. Secondary treatment in form of ASP., followed by tertiary treatment must be provided even for low end uses.	Treated effluent "assuch" can not be used for even low end purposes such as construction, floor washing etc. Tertiary treatment must be provided even for low end uses.	Treated effluent "assuch" can not be used for even low end purposes such as construction, floor washing etc. Tertiary treatment must be provided even for low end uses.
Treated sewage disinfection : Chlorine demand	About 2 - 3 ppm chlorine required to reduce "E-Coli" to less than 1000 MPN / 100 ml.	About 10 - 15 ppm chlorine required to reduce "E-Coli" to less than 1000 MPN / 100 ml.	About 10 - 15 ppm chlorine required to reduce "E-Coli" to less than 1000 MPN / 100 ml, provided there is an ASP process succeeding UASB system.	About 15 - 20 ppm chlorine required to reduce "E-Coli" to less than 1000 MPN / 100 ml.	About 15 - 20 ppm chlorine required to reduce "E-Coli" to less than 1000 MPN / 100 ml.
"SIZE-WISE" suitability of the process	Suitable for any size, no limitation.	Suitable for any size, no limitation. Larger sizes demand much higher space.	Suitable for any size, no limitation. Larger sizes demand much higher	Suitable for any size, no limitation. Larger sizes demand much	Suitable only for small sizes. Larger sizes demand much higher

			space.	higher space.	space, and also much higher maintenance.

Comparison of SAFF, FAB & SBR

Sr No	Parameter for Comparison	Submerged Aerobic Fixed Film (SAFF)	Fluidised Aerobic Bed (FAB)	Sequencing Batch Reactor (SBR)
1	Space (Sqm/ Avg. DWF MLD) (say)	600 - 800	500 - 700	500 - 600
2	Capital Cost (Rs./ MLD)	65	50	70
3	Material of Construction	open units	open units	stainless steel container
4	Cost of O & M/Annum (Rs.Lakh/ MLD)	10-11	7.5 - 8.5	7.65 - 8.65
	Chemical	1.5	2.5	0.45
	Manpower	1.5	1.5	0.7
	Power	7-8	3.5 - 4.5	6.5 - 7.5
5	Quality of Sludge	short life and needs to be disposed off early	short life and needs to be disposed off early	sludge can be stored for several months in underground storage tank
6	Power (units / day)	11000	12000	8000
7	**Additions**			

	Secondary Settling	Tube Settler	Clari Settler	nil
	PAC (chemical)	nil	yes	nil
8	Fitness of Effluent for Irrigation	1 to 2 dilution water for tolerant and semi tolerant crops	1 to 2 dilution water only for semi tolerant type of crops	totally fit without dilution.
9	Acceptibility by Industries for Reuse	nil	nil	yes

(15)

ANNEXURE - II

Report Code: 003_GBP_IIT_EQP_S&R_02_Ver 1_Dec 2010

Sewage Treatment in Class I Towns:
Recommendations and Guidelines

Preface

In exercise of the powers conferred by sub-sections (1) and (3) of Section 3 of the Environment (Protection) Act, 1986 (29 of 1986), the Central Government has constituted National Ganga River Basin Authority (NGRBA) as a planning, financing, monitoring and coordinating authority for strengthening the collective efforts of the Central and State Government for effective abatement of pollution and conservation of the river Ganga. One of the important functions of the NGRBA is to prepare and implement a Ganga River Basin: Environment Management Plan (GRB EMP).

A Consortium of 7 Indian Institute of Technology (IIT) has been given the responsibility of preparing Ganga River Basin: Environment Management Plan (GRB EMP) by the Ministry of Environment and Forests (MoEF), GOI, New Delhi. Memorandum of Agreement (MoA) has been signed between 7 IITs (Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) and MoEF for this purpose on July 6, 2010.

This report is one of the many reports prepared by IITs to describe the strategy, information, methodology, analysis and suggestions and recommendations in developing Ganga River Basin: Environment Management Plan (GRB EMP). The overall Frame Work for documentation of GRB EMP and Indexing of Reports is presented on the inside cover page.

There are two aspects to the development of GRB EMP. Dedicated people spent hours discussing concerns, issues and potential solutions to problems. This dedication leads to the preparation of reports that hope to articulate the outcome of the dialog in a way that is useful. Many people contributed to the preparation of this report directly or indirectly. This report is therefore truly a collective effort that reflects the cooperation of many, particularly those who are members of the IIT Team. Lists of persons who are members of the concerned thematic groups and those who have taken lead in preparing this report are given on the reverse side.

Dr Vinod Tare
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Development of GRB EMP
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Contents

13

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3. Treatment Chain

All sewage treatment plants should follow a process chain depending upon the technology chosen and the treatment capacity. In general, treatment is to be done in three stages as per the flow sheet presented in Figure 1.

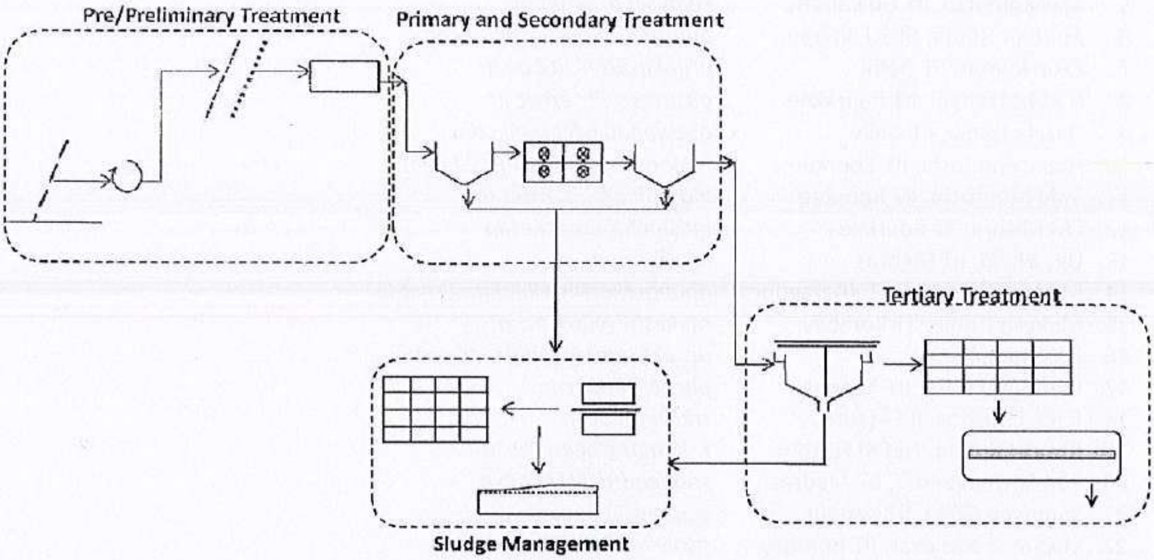

Figure 1: Process Chain for Sewage Treatment

Specifications and treatment objectives at each stage of treatment are as follows.

Stage I Preliminary Treatment:

a) Three Stage Screening: - 25 mm bar racks (before pumping)
- 12 mm bar racks
- 5 mm mesh (< 2 mm mesh for Membrane Bio Reactor, MBR)

b) Aerated Grit Chamber if following unit operation is aerobic and Normal Grit Chamber if following unit operation is anaerobic.

Expected effluent quality after preliminary treatment:

- No floating materials including polythene bags, small pouches, etc.
- Proper collection and disposal of screening and grit.

Stage II Primary and/or Secondary Treatment: Many options are available for second stage treatment. These options can be grouped into following three categories.

a) Pond Based Systems or
b) Activated Sludge Process (ASP) and its Modifications or equivalent systems including but not limited to SBR, UASB followed by ASP, ASP operated on Extended Aeration mode (EA-ASP), ASP with Biological Nutrient Removal (ASP+BNR), and MBBR or
c) Membrane Bio Reactor (MBR)

1. General

Sewage is a major point source of pollution. The target of "Nirmal Dhara" i.e. unpolluted flow can be achieved if discharge of pollutants in the river channel is completely stopped. Also, sewage can be viewed as a source of water that can be used for various beneficial uses including ground water recharge through surface storage of treated water and/or rain/flood water in an unlined reservoir. This may also help achieving "Aviral Dhara".

In order to reduce substantial expenditure on long distance conveyance of sewage as well as treated water for recycling, decentralized treatment of sewage is advisable. As a good practice, many small sewage treatment plants (STP) should be built rather than a few of very large capacity. All new developments must build in water recycling and zero liquid discharge systems. Fresh water intake should be restricted only to direct human-contact beneficial uses of water. For all other uses properly treated sewage/wastewater should be used wherever sufficient quantity of sewage is available as source water for such purposes. All new community sanitation systems must adopt recycling of treated water for flushing and completely isolate fecal matter until it is converted into safe and usable organic manure. The concept of decentralized treatment systems and water/wastewater management will be covered in detail in subsequent reports.

2. Selection of Appropriate Sewage Treatment Technology

Item 4.5.2 in Guidelines for the Preparation of Urban River Management Plan (URMP) for all Class I Towns in Ganga River Basin (Report No. 002_GBP_IIT_EQP_S&R_01) concerns with sewage treatment plant. One of the most challenging aspects of a sustainable sewage treatment system (either centralized or decentralized) design is the analysis and selection of the treatment processes and technologies capable of meeting the requirements. The process is to be selected based on required quality of treated water. While treatment costs are important, other factors should also be given due consideration. For instance, effluent quality, process complexity, process reliability, environmental issues and land requirements should be evaluated and weighted against cost considerations. Important considerations for selection of sewage treatment processes are given in Table 1.

Table 1: Sewage Treatment Process Selection Considerations

Consideration	Goal
Quality of Treated Sewage	Production of treated water of stipulated quality without interruption
Power requirement	Reduce energy consumption
Land required	Minimize land requirement
Capital Cost of Plant	Optimum utilization of capital
Operation & Maintenance costs	Lower recurring expenditure
Maintenance requirement	Simple and reliable
Operator attention	Easy to understand procedures
Reliability	Consistent delivery of treated sewage
Resource Recovery	Production of quality water and manure
Load Fluctuations	Withstand variations in organic and hydraulic loads

country should not be construed as showing technological limitations, nor to affirm that plants outside that range do not exist. The ranges simply indicate most frequently found sizes. A comparison of treatment costs and evaluation of various technologies for sewage treatment in India is presented in Table 2.

In general it is accepted worldwide that the technologies which are deemed to be appropriate have to be qualified through application of a rigorous framework underscoring the performance expectations as well as the choice should be concurrent with the socio-economic acceptability.

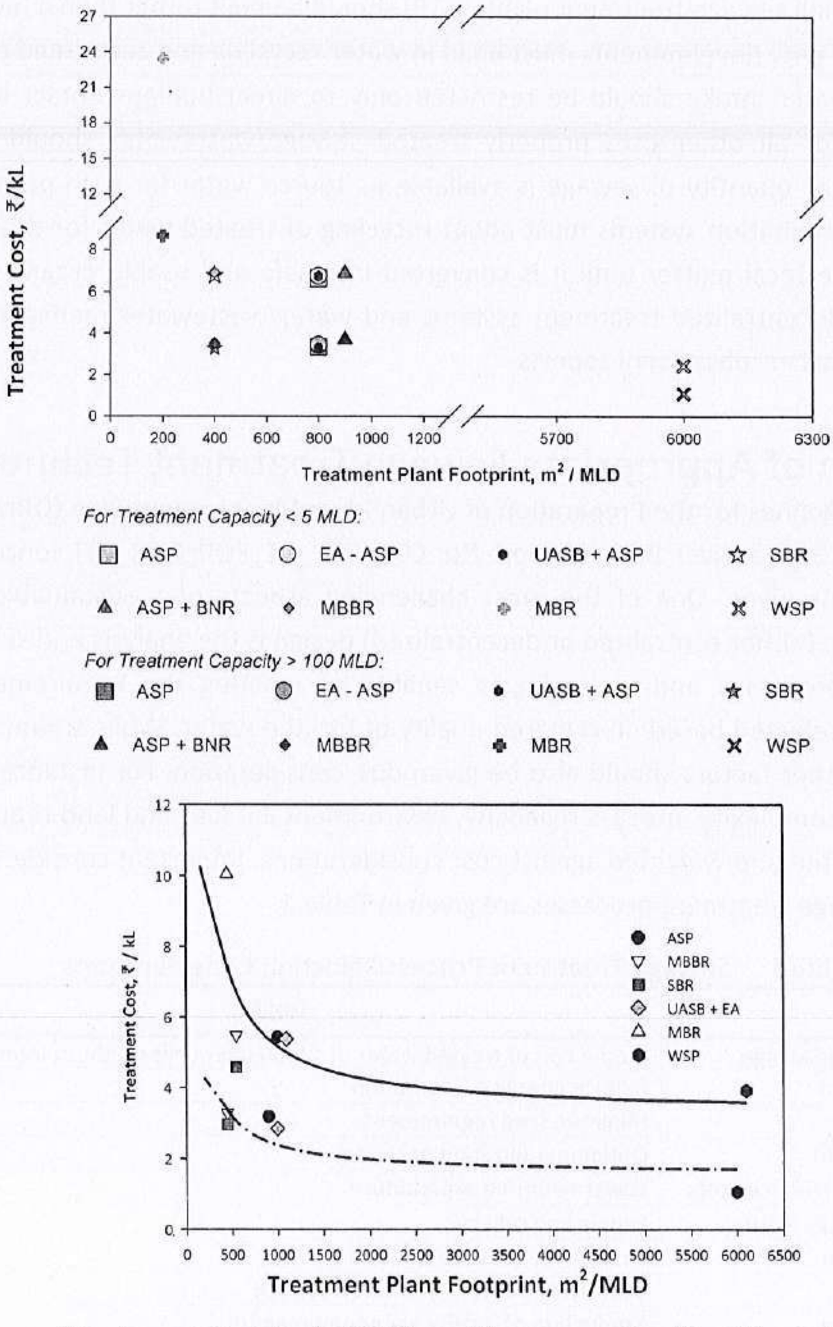

Figure 2: Treatment Cost (as in 2010) and Corresponding Plant Footprint for various Secondary Treatment Options

Expected effluent quality after primary and secondary treatment:

- BOD < 30 mg/L
- SS < 20 mg/L
- Nitrified effluent

A brief description of various technological options available for secondary treatment are presented in Appendix I. EA-ASP, ASP+BNR are considered to be variations of ASP and produce more or less same quality effluent (particularly when tertiary treatment is adopted after secondary treatment) and have approximately same treatment plant footprint. The treatment cost is also of the same order and hence are not considered to be distinctly different than ASP.

Stage III Tertiary Treatment: Coagulation-flocculation-settling followed by filtration and disinfection is generally recommended. Other processes could be selected on the basis of land availability, cost considerations, O&M cost, reuse option, compatibility issues in case of up-gradation of existing plants, etc. However, disinfection operation should invariable be included. Expected effluent quality after tertiary treatment:

- BOD < 10 mg/L
- SS < 5 mg/L
- Phosphate < 0.5 mg/L
- MPN of fecal coliforms < 10/ 100 mL

Where sewage flows are low and/or land can be spared without compromising on other developmental objectives or agriculture, waste stabilization ponds followed by constructed wetland can be adopted without coagulation-flocculation-settling.

4. Cost of Treatment and Land Requirement

Comprehensive analysis of capital cost, operation and maintenance costs, reinvestment cost, energy cost and land requirement based on data obtained from various STPs in the Ganga river basin and elsewhere in India has been done. This analysis has been summarized in Figure 2 as linkage between the treatment cost (₹/KL as in 2010) and the required footprint of the treatment plant (m^2/MLD) for various suggested technological options. For a particular desired effluent quality, the technological option with higher treatment cost will generally require lower treatment plant footprint, and vice versa.

5. Decision Matrix

The selection of a process requires analysis of all factors, not just treatment costs. In order to provide additional factors for the final considerations, key parameters need to be evaluated and weighed as shown in the Exhibit 1 to reach a final recommendation. The matrix attributes are ranked as Low, Medium, High and Very High recognizing that differences between processes are relative, and often, the result of commonly accepted observations. The column entitled "Typical Capacity Range" is added to illustrate the range in which the treatment plants based on specific processes have been built so far in the

S. No.	Assessment Parameter/Technology	ASP[*,a]	MBBR[*,c]	SBR[*,a]	UASB+ASP[*,b]	MBR[*,a]	WSP[**,b]
5.0	Operation & Maintenance Costs						
5.1	**Energy Costs (Per MLD)**						
5.1.1	**Avg. Technology Power Requirement**, *kWh/d/MLD* *Secondary Treatment + Secondary Sludge Handling*	180.00	220.00	150.00	120.00	300.00	2.00
5.1.2	**Avg. Technology Power Requirement**, *kWh/d/MLD* *Tertiary Treatment + Tertiary Sludge Handling*	1.00	1.00	1.00	1.00	1.00	1.00
5.1.3	**Avg. Non-Technology Power Req.**, *kWh/d/MLD* *Secondary Treatment*	4.50	2.50	2.50	4.50	2.50	2.50
5.1.4	**Avg. Non-Technology Power Req.**, *kWh/d /MLD* *Tertiary Treatment*	0.20	0.20	0.20	0.20		0.20
5.1.5	**Total Daily Power Requirement (avg.)**, *kWh/d /MLD*	185.70	223.70	153.70	125.70	302.50	5.70
5.1.6	**Daily Power Cost (@₹ 6.0 per KWh)**, *₹ /MLD/h* *(Including Standby power cost)*	46.43	55.93	38.43	31.43	75.93	1.43
5.1.7	**Yearly Power Cost**, *₹ lacs pa/MLD*	**4.07**	**4.90**	**3.37**	**2.75**	**6.65**	**0.49**
5.2	**Repairs cost (Per MLD)**						
5.2.1	**Civil Works per Annum**, *as % of Civil Works Cost*	3.00	3.00	3.00	3.00		3.00
5.2.2	**E&M Works**, *as % of E&M Works Cost*	1.00	1.00	1.00	1.00		1.00
5.2.3	**Civil Works Maintenance**, *₹ Lacs pa /MLD*	1.94	1.30	1.04	2.11		1.70
5.2.4	**E & M Works Maintenance**, ₹. *Lacs pa*/MLD	0.43	0.65	0.81	0.38		0.06
5.2.5	**Annual repairs costs**, *₹ Lacs pa/MLD*	**2.38**	**1.94**	**1.84**	**2.48**		**1.76**
5.3	**Chemical Cost (Per MLD)**						
5.3.1	**Recurring Chemical/Polymer Costs**, *₹ Lacs pa/MLD* *Secondary Treatment*	0.40	0.40	0.40	0.40		0.00
5.3.2	**Recurring Chemical**, *₹ Lacs pa/MLD* *(Alum, Chlorine, Polymer) Costs, Tertiary Treatment*	4.00	4.00	2.00	5.00		6.00
5.3.3	**Other Chemical Cost**, *₹ Lacs pa/MLD*	0.90	0.90	0.90	0.90		1.20
5.3.4	**Total Chemical Cost**, *₹ Lacs pa/MLD*	**5.30**	**5.30**	**3.30**	**6.30**		**7.20**
5.4	**Manpower Cost (Assuming 50 MLD Plant)**						
5.4.1	**Manager**, ₹. pa (1 No.)	3.60	3.60	3.60	3.60		3.60
5.4.2	**Chemist/Engineer**, *₹ pa (1 No.)*	3.60	3.60	3.60	3.60		3.60
5.4.3	**Operators**, *₹ Pa (@₹ 12000 pm)*	8.64	5.76	4.32	8.64		4.32
5.4.4	**Skilled technicians**, *₹ pa (@₹ 10000 pm)*	7.20	4.80	3.60	7.20		1.20
5.4.5	**Unskilled personnel**, *₹ pa (@₹ 7000 pm)*	5.04	2.88	2.16	5.04		8.64
5.4.6	**Total Salary Costs**, *₹ Lacs pa*	28.08	20.64	17.28	28.08		21.36
5.4.7	**Benefits (50% of total salary)**, *₹ Lacs pa*	14.04	10.32	8.64	14.04		10.68
5.4.8	**Salary + Benefits**, *₹ Lacs pa*	**42.12**	**30.96**	**25.92**	**42.12**		**32.04**
5.4.9	**Total annual O&M costs**, *₹ Lacs pa*	629.26	638.11	451.22	618.96	832.55	504.86

Table 2: Comparison of Treatment Costs of Various Technologies for Sewage Treatment in India

S. No.	Assessment Parameter/Technology	ASP*,a	MBBR*,c	SBR*,a	UASB+EA*,b	MBR*,a	WSP**,b
1.0	Performance after Secondary Treatment						
1.1	Effluent BOD, *mg/L*	<20	<30	<10	<20	<5	<40
1.2	Effluent SS, *mg/L*	<30	<30	<10	<30	<5	<100
1.3	Faecal coliform removal, *log unit*	upto 2<3	upto 2<3	upto 3<4	upto 2<3	upto 5<6	upto 2<3
1.4	T-N Removal Efficiency, *%*	10-20	10-20	70-80	10-20	70-80	10-20
2.0	Performance After Tertiary Treatment						
2.1	Effluent BOD, *mg/L*	<10	<10	<10	<10	<10	<10
2.2	Effluent SS, *mg/L*	<5	<5	<5	<5	<5	<5
2.3	Effluent NH_3N, *mg/L*	<1	<1	<1	<1	<1	<1
2.4	Effluent TP, *mg/L*	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2.5	Effluent Total Coliforms, *MPN/100 mL*	10	10	10	10	10	10
3.0	Capital cost						
3.1	Average Capital Cost (Secondary Treatment), *₹ Lacs/MLD*	68.00	68.00	75.00	68.00	300.00	23.00
3.2	Average Capital Cost (Tertiary Treatment), *₹ Lacs/MLD*	40.00	40.00	40.00	40.00		40.00
3.3	Total Capital Cost (Secondary + Tertiary) *₹ Lacs/MLD*	**108.00**	**108.00**	**115.00**	**108.00**	**300.00**	**63.00**
3.4	Civil Works, *% of total capital costs*	60.00	40.00	30.00	65.00	20.00	90.00
3.5	E & M Works, *% of total capital costs*	40.00	60.00	70.00	35.00	80.00	10.00
4.0	Area Requirements						
4.1	Average Area, m^2 per MLD *Secondary Treatment + Secondary Sludge Handling*	900.00	450.00	450.00	1000.00	450.00	6000.00
4.2	Average Area, m^2 per MLD *Tertiary Treatment + Tertiary Sludge Handling*	100.00	100.00	100.00	100.00	0.00	100.00
4.3	**Total Area, m^2 per MLD** *Secondary + Tertiary Treatment*	**1000.00**	**550.00**	**550.00**	**1100.00**	**450.00**	**6100.00**

Sludge Treatment: * Thickener + Centrifuge; ** Drying

Process Type : [a] Aerobic; [b] Anaerobic-Aerobic; [c] Anoxic/Anaerobic-Aerobic

10

Exhibit 1: Assessment of Technology Options for Sewage Treatment in the Ganga River Basin

Criteria	ASP	UASB+ASP	SBR	MBBR	MBR	WSP
Performance in Terms of Quality of Treated Sewage						
Potential of Meeting the RAPs TSS, BOD, and COD Discharge Standards						
Potential of Total / Faecal Coliform Removal						
Potential of DO in Effluent						
Potential for Low Initial/Immediate Oxygen Demand						
Potential for Nitrogen Removal (Nitrification-Denitrification)						
Potential for Phosphorous Removal						
Performance Reliability						
Impact of Effluent Discharge						
Potential of No Adverse Impact on Land						
Potential of No Adverse Impact on Surface Waters						
Potential of No Adverse Impact on Ground Waters						
Potential for Economically Viable Resource Generation						
Manure / Soil Conditioner						
Fuel						
Economically Viable Electricity Generation/Energy Recovery						
Food						
Impact of STP						
Potential of No Adverse Impacts on Health of STP Staff/Locals						
Potential of No Adverse Impacts on Surrounding Building/Properties						
Potential of Low Energy Requirement						
Potential of Low Land Requirement						
Potential of Low Capital Cost						
Potential of Low Recurring Cost						
Potential of Low Reinvestment Cost						
Potential of Low Level of Skill in Operation						
Potential of Low Level of Skill in Maintenance						
Track Record						
Typical Capacity Range, MLD	All Flows	All Flows	All Flows	Smaller	Smaller	All Flows

Low	Medium	High	Very High

ASP : Activated Sludge Process
MBBR : Moving Bed Biological Reactor
SBR : Sequential Batch Reactor
UASB : Upflow Anaerobic Sludge Blanket
EA : Extended Aeration
MBR : Membrane Bio Reactor
WSP : Waste Stabilization Pond

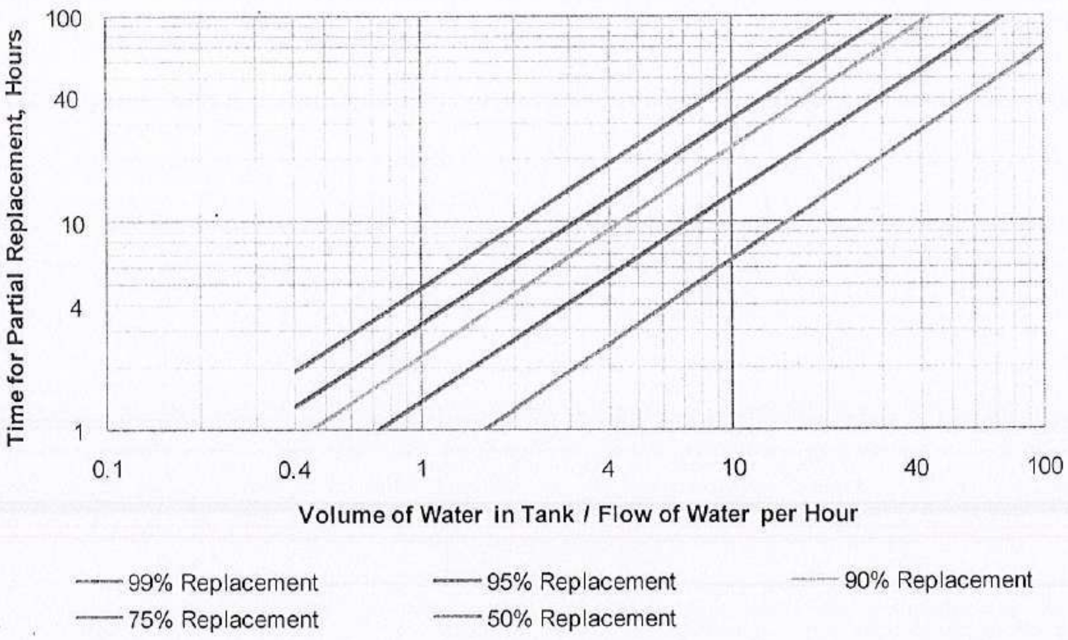

Figure 3: Approximate times required to replace water in test chambers in flow-through tests (For Example: For a chamber containing 4 L, with a flow of 2 L/h, the above graph indicates that 90% of the water would be replaced every 4.8 h. The same time period, such as hours, must be used on both axes, and the same unit of volume, such as liters, must be used for both volume and flow (Adapted from USEPA, 2002)

- Depth of flow-through system or pond: The depth of the flow-through bioassay pond should be within 1.5 to 2.5 m based on an equivalent system of wastewater-fed fish pond (aquaculture) (Costa-Pierce, 1998; Hoan and Edwards, 2005).
- Test organisms: In the bioassay pond, locally found fish, algae and daphnia should be inhabited in the bioassay pond. USEPA (2002) and APHA *et al.* (1995) have recommended following freshwater fish species when fish is the preferred form of aquatic life/test organism:
  1. *Oncorhynchus mykiss* (rainbow trout) and Salvelinus fontinalis (brook trout)
  2. *Pimephales promelas* (fathead minnow)
  3. *Lepomis macrochirus* (Bluegill sunfish)
  4. *Ictalurus punctatus* (Channel catfish)

  Based on above, following equivalent fish species are recommended under Indian conditions.

  1. *Puntias stigma*
  2. *Puntias sophore*
  3. *Anabas*
  4. *Chela bacalia*
  5. *Puntias ticto* and
  6. *Colisa faciatus*

S. No.	Assessment Parameter/Technology	ASP*,a	MBBR*,c	SBR*,a	UASB+EA*,b	MBR*,a	WSP**,b
6.0	**NPV (2010) of Capital + O&M Cost for 15 years, ₹. *Lacs***	**14838.92**	**14971.67**	**12518.32**	**14684.42**	**27488.27**	**10722.96**
	Present (2010) Treatment Cost, paisa/L	**0.54**	**0.55**	0.46	0.54	1.00	0.39
7.0	Average Capital Cost, ₹. Lacs/MLD *upto Secondary Treatment*	**68.00**	**68.00**	**75.00**	**68.00**		**23.00**
7.1	**Yearly Power Cost,** ₹. *lacs pa/MLD* *upto Secondary Treatment*	4.04	4.87	3.34	2.73		0.10
7.2	**Annual Repairs Cost,** ₹. *Lacs pa/MLD* *upto Secondary Treatment*	1.50	1.22	1.16	1.56		1.11
7.3	**Annual Chemical Cost,** ₹ *Lacs pa/MLD* *upto Secondary Treatment*	0.85	0.85	0.85	0.85		0.60
7.4	**Manpower Cost,** ₹. *Lacs pa* *for 50 mld plant upto secondary treatment*	33.70	24.77	20.74	33.70		25.63
7.5	**Total Annual O&M Costs,** ₹. *Lacs pa* *upto Secondary Treatment*	**353.02**	**372.11**	**288.15**	**290.72**		**116.09**
7.6	**NPV (2010) of Capital + O&M Cost for 15 years,** ₹. *Lacs* *upto Secondary Treatment*	**8695.35**	**8981.58**	**8072.24**	**7760.85**		**2891.39**
7.7	Present (2010) Treatment Cost, *paisa / L* *upto Secondary Treatment*	**0.32**	**0.33**	**0.29**	**0.28**		**0.11**

Sludge Treatment: *** Thickener + Centrifuge; ** Drying**

Process Type : **[a] Aerobic; [b] Anaerobic-Aerobic; [c] Anoxic/Anaerobic-Aerobic**

1. No Sludge Drying Beds. However can be provided to cater 25 % of sludge dewatering under emergency conditions
2. No FPU after UASB, only Extended Aeration (EA Process)
3. UASB not Recommended for influent SO_4> 25 mg/L
4. No Biological Phosphorus Removal, Coagulants are necessary
5. No Energy Recovery system recommended only if BOD <250 mg/L
6. Less than 5h HRT MBBR is not acceptable
7. Less than 14 h HRT SBR is not acceptable for plants with peak factor 2.5
8. Repair + Chemical + Manpower Cost of MBR is ₹. 500 Lac per 50 MLD
9. O&M of MBR includes all chemical (Cleaning, Polymer etc.,) cost
10. Capital cost of MBR includes membrane replacement cost for 15 years
11. All WSP,s should have mechanical pretreatment works (All types of screens & Grit chambers)
12. SBR data is based on data collected from working Indian SBR with bio selector, OUR control, RAS, Nitrogen removal
13. Manpower cost is assumed to be 20 percent less for treatment only upto secondary stage

ASP **: Activated Sludge Process**
MBBR **: Moving Bed Biological Reactor**
SBR **: Sequential Batch Reactor**
UASB **: Upflow Anaerobic Sludge Blanket**
EA **: Extended Aeration**
MBR **: Membrane Bio Reactor**
WSP **: Waste Stabilization Pond**

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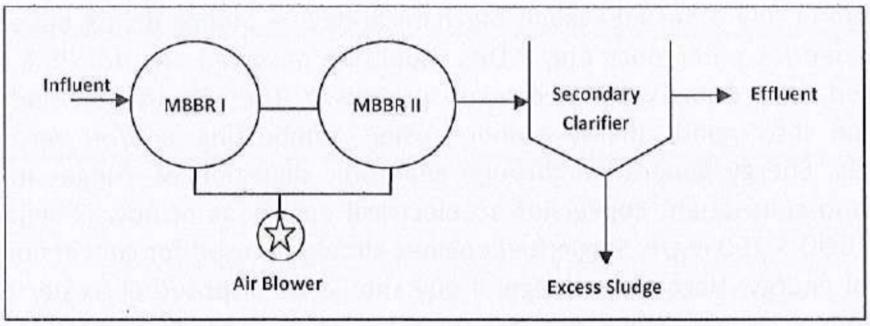
Exhibit 2: MBBR - Moving Bed Biofilm Reactor



Schematic Diagram of a Moving Bed Bio-Reactor

Moving Bed Biofilm Reactor is an aerobic attached biological growth process. It does not require primary clarifier and sludge recirculation. Raw sewage, after screening and de-gritting, is fed to the biological reactor. In the reactor, floating plastic media is provided which remains in suspension. Biological mass is generated on the surface of the media. Attached biological mass consumes organic matter for their metabolism. Excess biological mass leaves the surface of media and it is settled in clarifier. Usually a detention time of 5 to 12 h is provided in the reactors.

MBBR were initially used for small sewage flow rates and because of less space requirement. In large plant, media quantity is very high and it requires long shut down period for plant maintenance. In fact, it may not be successful for large capacity plants. Moreover the plastic media is patented and not available in the open market, leading to single supplier conditions which limit or deny price competition. In addition, due to very less detention time and other engineering factors, functional Moving Bed Biofilm Reactor in India do not produce acceptable quality effluent.

Merits

- Moving Bed Biofilm Reactor needs less space since there is no primary clarifier and detention period in reactor is generally 4-5 h.
- Ability to withstand shock load with equalization tank option
- High operator oversight is not required

Demerits

- High operating cost due to large power requirements
- Not much experience available with larger capacity plants (>1.5 MLD)
- Skilled operators needed
- No energy production
- Effluent quality not up to the mark in India
- Much less nutrient removal
- Designed criteria not well established

6. Sludge Management

The sludge dewatering should be done using thickener followed by filter press or centrifuge or any other equivalent mechanical device. Sludge drying beds (SDB) should be provided for emergency only. SDBs should be designed only for 25% of the sludge generated from primary and secondary processes. The compressed sludge should be converted into good quality manure using composting and/or vermi-composting processes. Energy generation through anaerobic digestion of sludges in the form of biogas and subsequent conversion to electrical energy as of now is viable only when sewage BOD > 250 mg/L. Single fuel engines should be used for conversion of biogas to electrical energy. Hazardous sludge, if any should be disposed of as per the prevailing regulations.

7. Flow Measurement

Flow measuring devices should be installed after the Stage I Treatment as well as at the outlet of the sewage treatment plant. These flow devices should be of properly calibrated V notch with arrangements for automatic measurement of head. Additional electronic or other type of flow meters may also be installed. Arrangements should be made for real time display of measured (both current and monthly cumulative) flows at prominent places.

8. Bioassay Test

The bioassay test is gaining importance in wastewater treatment plant design and operation as the whole effluent toxicity (WET) test. This test uses a standard species of aquatic life forms (like fish, algae) as a surrogate to measure the effect of the effluent on the receiving stream. The flow-through method employing continuous sampling is recommended for on-site tests.

- Flow rate (retention time): For a flow-through system, the USEPA Manual for Acute Toxicity Test of Effluents (USEPA, 2002) specifies that the flow rate through the proportional dilutor must provide for a minimum of five 90% replacements of water volume in each test chamber every 24 h (i.e. a retention time of 4.8 h) (see Figure 3). This replacement rate should provide sufficient flow to maintain an adequate concentration of dissolved oxygen (DO). This implies a maximum HRT of 5.3 h (i.e. 0.9V/Q = 4.8) for a flow-through system. Therefore, a flow-through pond with a maximum HRT of 5 h for 100% exposure is recommended for bioassay test of tertiary-treated effluent.
- Total flow requirement: 10% of the flow (subjected to maximum 1 MLD) is required to pass through the bioassay pond.

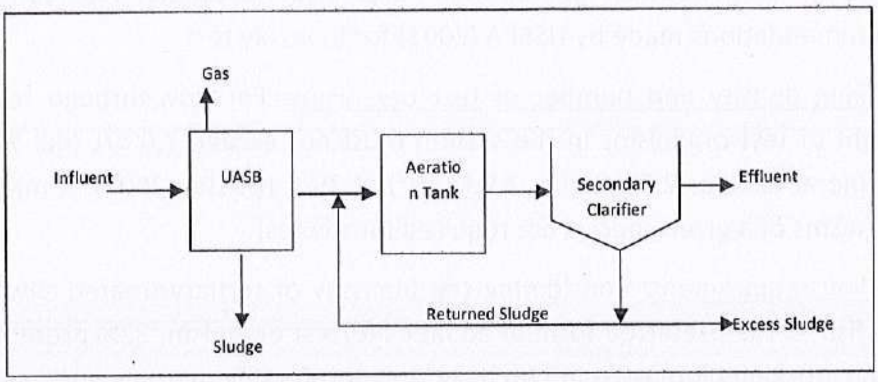
Other freshwater fish species like *Gambusia affinis* (mosquito fish) can also be considered. *Daphnia pulex* and *D. magna* (daphnids), *Selenastrum sp.*, *Scenedesmus aculeala*, *Scenedesmus guadacanda* are also recommended similar to the recommendations made by USEPA (2002) for bioassay test.

- Stocking density and number of test organisms: For flow-through tests, the live weight of test organisms in the system must not exceed 7.0 g/L (i.e. 7.0 kg/m^3) of volume at l5°C, or 2.5 g/L (i.e. 2.5 kg/m^3) at 25°C (USEPA, 2002). A minimum of 20 organisms of a given species are required for the test.
- Feeding requirement: Considering the bioassay of tertiary-treated sewage effluent and fish as the preferred form of aquatic life/test organism, 32% protein feed at 1% of the stocking biomass/d in two daily slots (preferably morning and evening) with a floating system need to be fed (Costa-Pierce, 1998). The feeding regime for fish mentioned in USEPA (2002) can also be adopted.
- Aeration and oxygen requirements: Sufficient DO (4.0 mg/L for warm water species and 6.0 mg/L for cold water species) should be maintained in the pond for proper environment for test organisms. The DO depletion is not a problem in case of a flow-through system because aeration occurs as the water pass through the system. If DO decreases to a level that would be a source of additional stress, the turnover rate of the water volume must be increased (i.e. the HRT of the system must be decreased) sufficiently to maintain acceptable DO levels (USEPA, 2002). Alternatively fountain or cascade aeration arrangements may be provided.
- Requirement of Dechlorination: Dechlorinated effluent only should be passed through the bioassay pond. If the effluent from the STP is chlorinated, the total residual chlorine in the effluent should be non-detectable after dechlorination.
- Bioassay test acceptability criterion: No mortality (100% survival) of test organisms under any condition.

Salient Features of Recommended STPs

- Continuous measurement of flow at the inlet and outlet
- Excellent preliminary treatment
- Treatment up to tertiary level
- Online bioassay test
- Designed and built as modular units
- Pumping and STPs to be taken together for contracting/bidding

Exhibit 4: UASB+ASP - Upflow Anaerobic Sludge Blanket Followed by Activated Sludge Process



Schematic Diagram of an Upflow Anaerobic Sludge Blanket Process followed by ASP

It is an anaerobic process in which influent wastewater is distributed at the bottom of the UASB reactor and travels in an up-flow mode through the sludge blanket. Critical components of UASB design are the influent distribution system, the gas-liquid-solid separator (GLSS) and effluent withdrawal design. Compared to other anaerobic processes, UASB allows the use of high hydraulic loading.

Merits

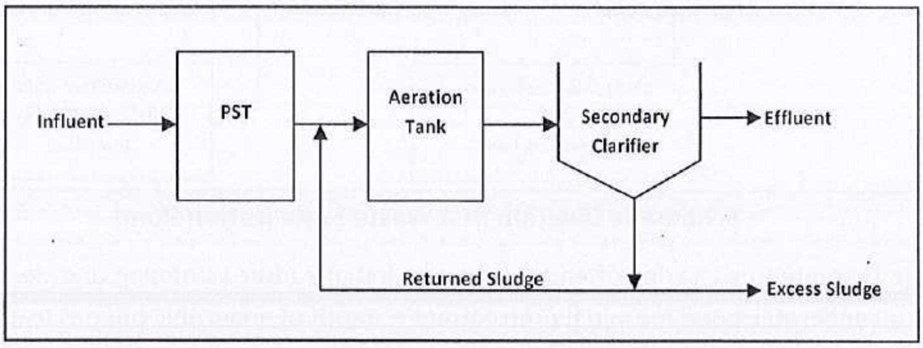
- Relatively simple operation and maintenance
- No external energy requirement and hence less vulnerable to power cuts
- No primary treatment required
- Energy production possible but generally not achieved
- Low sludge production
- No special care or seeding required after interrupted operations
- Can absorb hydraulic and organic shock loading

Demerits

- Post treatment required to meet the effluent standard
- Anoxic effluent exerts high oxygen demand
- Large Land requirement
- More man-power require for O&M
- Effluent quality is not up to the mark and poor fecal and total coliform removal
- Foul smell and corrosion problems around STP area
- High chlorine dosing required for disinfection.
- Less nutrient removal

Appendix I: Exhibits on Options for Secondary Treatment

Exhibit 1: ASP - Conventional Activated Sludge Process



Schematic Diagram of a Conventional Activated Sludge Process

Activated Sludge Process (ASP) is a suspended growth aerobic process. It is provided with primary clarifier to reduce the organic load in biological reactor (aeration basin). About 40% of organic load is intercepted in primary clarifier in the form of sludge, decreasing the loading in the aeration tank. Detention period in aeration tank is maintained between 4-6 h. After aeration tank, the mixed liquor is sent to secondary clarification where sludge and liquid are separated. A major portion of the sludge is re-circulated and excess sludge is sent to a digester.

Sludge generated in primary clarifier and excess sludge from secondary clarifier are not matured, digestion of such sludge is essential before disposal. In anaerobic sludge digestion, such sludge produces biogas which can be used for power generation by gas engines. Generated power can be used for operation of plant.

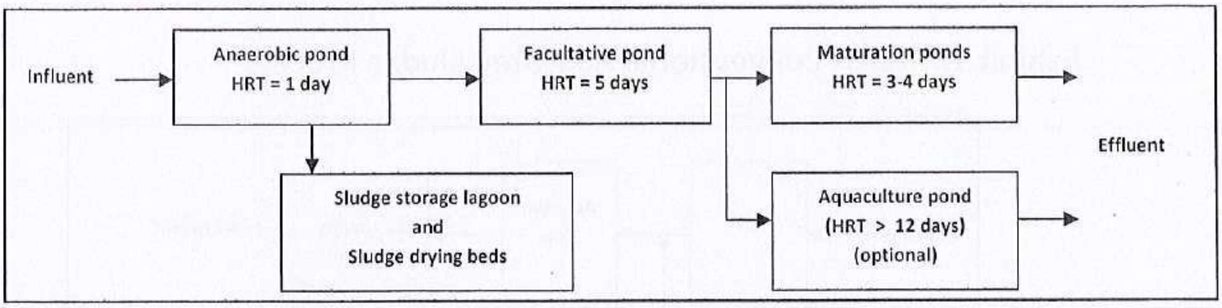
Merits

- Good process flexibility
- Reliable operation
- Proven track record in all plant sizes
- Less land requirements
- Low odor emission
- Energy production
- Ability to withstand nominal changes in water characteristics

Demerits

- High energy consumption
- Skilled operators needed
- Uninterrupted power supply is required
- Requires sludge digestion and drying
- Less nutrient removal

Exhibit 6: WSP - Waste Stabilization Pond (Combination of Anaerobic and Aerobic Pond)



Schematic Diagram of a Waste Stabilization Pond

Sewage is treated in a series of earthen ponds. Initially after screening and de-gritting it is fed to an anaerobic pond for initial pretreatment; depth of anaerobic pond is usually 3 to 3.5 m; as a result the lower section of pond does not get oxygen and an anaerobic condition is developed. BOD reduction takes place by anaerobic metabolism and gases like ammonia and hydrogen sulphide are produced creating odor problems. After reduction of BOD by 40% it enters the facultative/aerobic pond, which is normally 1 - 1.5 m in depth. Lesser depth allows continuous oxygen diffusion from atmosphere; in addition algae in the pond also produces oxygen.

Though BOD at the outlet remains within the range, sometimes the effluent has green color due to presence of algae. The algae growth can contribute to the deterioration of effluent quality (higher total suspended solids) from time to time. Moreover, coliforms removal is also in 1-2 log order. The operating cost of a waste stabilization pond is minimum, mostly related to the cost of cleaning the pond once in two to three years. A waste stabilization pond requires a very large land area and it is normally used for small capacity plant, especially where barren land is available.

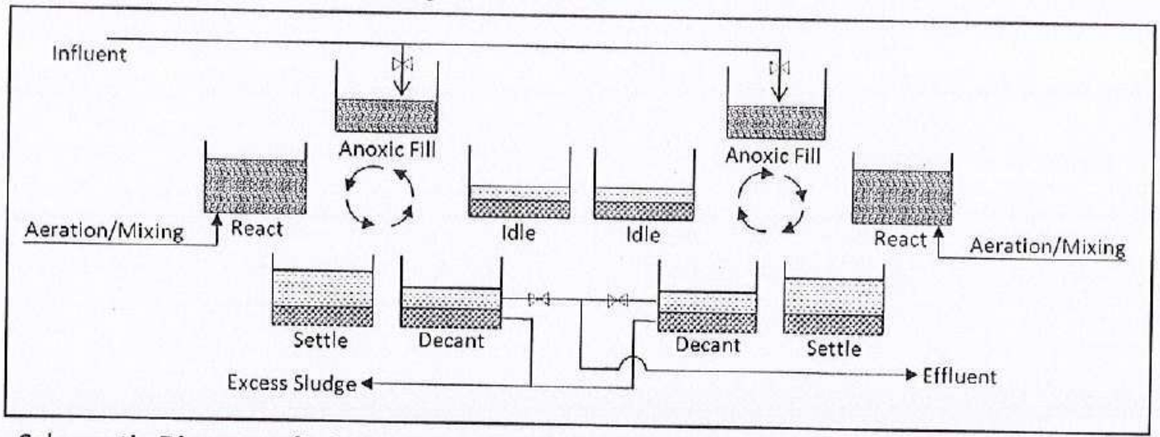
Merits

- Simple to construct and operate and maintain
- Low operating and maintenance cost
- Self sufficiency, ecological balance, and economic viability is greater
- Possible recovery of the complete resources
- Good ability to withstand hydraulic and organic load fluctuations

Demerits

- Requires extremely large areas
- Large evaporation loss of water
- If liner is breached, groundwater is impacted
- Effluent quality may vary with seasons
- No energy production
- Comparatively inferior quality of effluent
- Less nutrient removal
- High chlorine dosing for disinfection
- Odor and vector nuisance
- Loss of valuable greenhouse gases to the atmosphere

Exhibit 3: SBR - Sequencing Batch Reactor



Schematic Diagram of a Sequencing Batch Reactor (A Continuous Process "In Batch")

It is a fill-and-draw batch aerobic suspended growth (Activated Sludge) process incorporating all the features of extended aeration plant. After screening and de-gritting, sewage is fed to the batch reactor. Reactor operation takes place in certain sequence in cyclic order and in each cycle, following operations are involved

- Anoxic Filling tank
- Aeration
- Sedimentation/clarification
- Decantation
- Sludge withdrawal

A number of large-scale plants exist around the world with several years of continuous operation. In India also, there are large scale plants operating efficiently since more than a year. Hundreds of full-scale plants operated on Sequencing Batch Reactor Technology are under successful operation in Japan. Some parts are patented and not available in the open market, leading to single supplier conditions which limit or deny price competition.

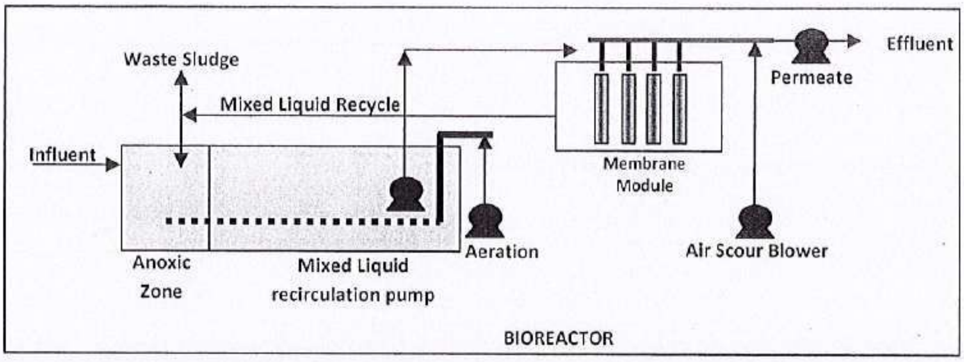
Merits

- Excellent effluent quality
- Smaller footprint because of absence of primary, secondary clarifiers and digester
- Recent track record available in large applications in India also
- Biological nutrient (N&P) removal
- High degree of coliform removal
- Less chlorine dosing required for post disinfection
- Ability to withstand hydraulic and organic shock loads

Demerits

- Comparatively high energy consumption
- To achieve high efficiency, complete automation is required
- Highly skilled operators needed
- No energy production
- Uninterrupted power supply required

Exhibit 5: MBR - Membrane Bioreactor



Schematic Diagram of a Membrane Bioreactor

It is a biological reactor with a suspended biomass. The solid-liquid separation in membrane bioreactor is achieved by a microfiltration membrane with pore sizes ranging from 0.1 to 0. 4 µm. No secondary clarifier is used and has the ability to operate at high MLSS concentrations. Membranes are patented and not available in the open market, leading to single supplier conditions which limit or deny price competition.

Merits

- Low hydraulic retention time and hence low foot print (area) requirement
- Less sludge production
- High quality effluent in terms of low turbidity, TSS, BOD and bacteria
- Stabilized sludge
- Ability to absorb shock loads

Demerits

- High construction cost
- Very high operation cost
- Periodic cleaning and replacement of membranes
- High membrane cost
- High automation
- Fouling of membrane
- No energy production

Exhibit 7: CW - Constructed Wetlands

Wetlands are natural processes similar to stabilization ponds. Wetlands are shallow ponds comprising of submerged plants and floating islands of marshy species. Natural forces including chemical, physical, biological and solar is involved in the process to achieve wastewater treatment. Thick mats of vegetation trap suspend solids and biological process takes place at the roots of the plants. It produces the desired quality of treated sewage but land requirement is very high, though it is less compared to waste stabilization pond. Running cost is comparatively low.

Wetland process have not yet established compared to other processes. There are two types of systems; surface and subsurface distribution of sewage. The type of vegetation grown varies, in some cases there is regular tree cutting and plantation as a part of maintenance work. Plants like Typha, Phragamites, Kattail can be used in India. Another type of wetlands use a plant called duckweed for treatment. This weed has a very fast metabolic rate and absorbs pollutants very quickly.

Merits

- Simple to construct and operate and maintain
- Low operating and maintenance cost
- Self sufficiency, ecological balance, and economic viability is greater
- Possibility of complete resource recovery
- Good ability to withstand hydraulic and organic load fluctuations

Demerits

- Requires large area
- Large evaporation loss of water
- Not easy to recover from massive upset
- If liner is breached, groundwater is impacted
- Effluent quality may vary with seasons
- No energy production
- No nutrient removal
- Odor and vector nuisance
- Loss of valuable greenhouse gases to the atmosphere

ANNEXURE-I

EFFLUENT DISCHARGED STANDARDS FOR SEWAGE TREATMENT PLANT

Sl. No.	Parameters	Parameters Limit (Standards for New STPs Design after notification date) *
1.	pH	6.5-9.0
2.	BOD (mg/l)	Not more than 10
3.	COD (mg/l)	Not more than 50
4.	TSS (mg/l)	Not more than 20
5.	NH_4-N (mg/l)	Not more than 5
6.	N-total (mg/l)	Not more than 10
7.	Fecal Coliform (MPN/100ml)	Less than 100

Note:

(i) These standards will be applicable for discharge in water resources as well as for land disposal. The standards for Fecal Coliform may not be applied for use of treated sewage in industrial purposes.

(ii) * Achievements of Standards for existing STPs within 05 years from the date of notification.

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BWC 05.04

Expansion of lab behind the Electrical Engineering Department

NIT Uttarakhand is running at its temporary campus at two different clusters, first is ITI Campus and other is Polytechnic Campus.

Labs of Engineering Departments are at ITI campus. At present the number of students is in peak and the labs are also need to be developed, therefore Expansion of labs may be done by creating prefabricated structure behind the Electrical Engineering Department.

Total available area for construction= 650 Sqmt (Approximately)

Considering only ground floor of prefabricated structure.

Approximate Rate= Rs. 15,000/- per sqmt on the basis of previous similar building estimates.

Total Cost= 650*15000= **97.5 lacs**

A copy of drawing of available area is attached as Annexure-I.

The design and proper detail estimates may be availed from CPWD and other Government construction agencies.

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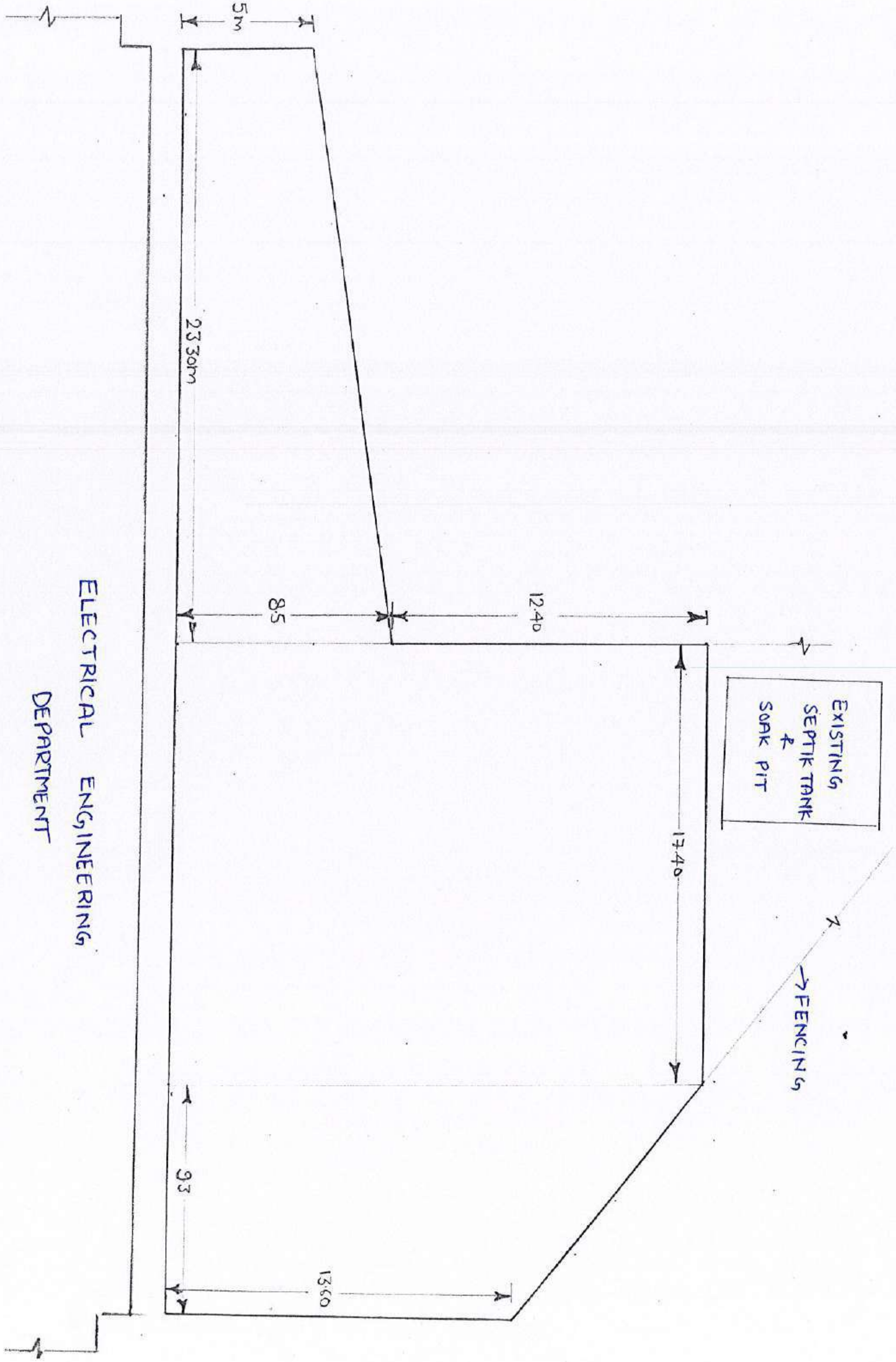
5m
23.30m
8.5
12.40
EXISTING
SEPTIK TANK
&
SOAK PIT
17.40
ELECTRICAL ENGINEERING
DEPARTMENT
→FENCING
9.3
13.60