RECENT TRENDS IN TECHNOLOGIES IN SEWERAGE SYSTEM

MINISTRY OF URBAN DEVELO T

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FOREWORD

As per Census 2001, 30.66 million urban households which form 35.49% of the urban households suffer inadequate access to sanitation. According to the report of the Central Pollution Control Board (2009), the estimated sewage generation from Class - I Cities and Class - II Towns is 38254.82 million litres per day (MLD) out of which only 17787.38 MLD (35%) is being treated and the remaining is disposed into the water bodies without any treatment due to which three-fourths of surface water resources are polluted. The Ministry of Urban Development conducted a rating of class I cities on sanitation related parameters in 2009-10.Out of 423 cities, only four were in the blue category scoring more than 66 points out of 100. No city achieved the distinction of being a green city i.e. a city scoring more than 90 out of 100.

According to the Constitution of India, water supply and sanitation is a State subject and the States are vested with the responsibility for planning, implementation of water supply and sanitation projects including O&M and cost recovery. The 74th amendment envisages transfer of this function to the urban local bodies. However, the Govt. of India supplements the efforts of the states in various ways – sanction of funds for the implementation of projects, technical guidance, capacity building etc. As on date, 111 sewerage schemes at a total estimated cost of Rs. 14,834.14 crores have been sanctioned under the UIG component of JNUURM. 96 sewerage schemes at an estimated cost of Rs. 2862.29 crore have been approved under UIDSSMT component of JNNURM. In recognition of the need for a special focus on sanitation, the National Urban Sanitation Policy was adopted in October 2008 with a focus on elimination of open defecation, integrated city wide sanitation, proper Operation & Maintenance of all sanitary installations etc. The initiatives under the policy include rating of cities, awareness generation and support to cities for preparation of city sanitation plans.

The Ministry has adopted service level benchmarks for the water and sanitation sector with a view to shift the focus of urban development projects from infrastructure creation to improvement of service levels. The handbook of service level benchmarks can be accessed at http://www.urbanindia.nic.in/programme/uwss/slb/slbhandbook. The 13th Finance Commission has made it mandatory for all cities having municipalities and municipal corporations to disclose their performance in terms of these benchmarks annually. The Ministry is committed to mainstreaming these benchmarks through its various schemes.

The enclosed note on sewerage and sewerage technologies has been envisaged in the above context. The Manual on Sewerage and Sewage Treatment published by the Ministry in 1993 emphasises conventional sewage treatment technologies such as Activated Sludge Process (ASP), Waste Stabilization pond (WSP), Upflow anaerobic Sludge Blanket (UASB) Reactor etc. Over the last two decades, many new technologies for sewerage and sewage treatment have emerged. These technologies which are being used in other parts of the world have not been deployed in India on a large scale. Therefore, their techno-economic viability under Indian conditions needs to be proven and will depend on prevailing local conditions, urban settings, community acceptability etc. Each of these technologies has its own merits and demerits.

Currently, most sewerage projects are bid out on Engineering Procurement and Construction (EPC) basis and have a limited role for the EPC contractor in operation and maintenance of assets. In many instances, the assets are of relatively poor quality, and are inadequately maintained. In order to ensure optimum utilization of funds deployed and proper creation and maintenance of assets, it is desirable to explore the option of Build-Own-Operate-Transfer (BOOT) contracts wherein there is a likelihood of long-term commitment of the Private Sector Partner. The different PPP models for implementation of these technologies have also been suggested in the Advisory Note.

It is hoped that this advisory will encourage the implementors in the field to innovate and explore new technologies as well as PPP models without compromising on the basic safeguards both technical and financial.

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1.1. Sewage Collection System

The practice of conventional centralized sewerage system with deep sewers and manholes in middle of roads is an inheritance from advanced countries with high water usages. Due to high capital and O&M costs and large quantity of water usage, such technologies, though technically feasible are not economically viable especially in O&M under Indian conditions. Almost all local bodies are not financially self sustainable and look up to the State & Central Governments for financial assistance. Also, in the initial years, the emerging urban layouts are predominantly served with septic tanks and the partly treated sewage flows uncontrolled onto streets or kutcha drains, meandering aimlessly and even stagnates here and there causing many avoidable environmental hazards. The sparse occupancy of these layouts defy a full-fledged sewerage due to the financial position of the local body and the logistics of maintenance of a system for the entire layout. Moreover, the existing per capita water supply in most of the small and medium towns, periphery areas of big cities and slum areas is less than the minimum per capita water supply of 135 lpcd to ensure self cleansing velocity in sewers and therefore conventional sewerage system is not feasible in such situations. There is an acute need for intermediate optional/alternative systems pending an eventual full-fledged sewerage. Therefore some of the alternative technologies for collection system are proposed as under.

1.1.1. Small Bore Sewers / Shallow Sewers / Simplified Sewerage / Twin Drains

The options of small bore sewers and shallow sewers have already been discussed in the Manual on Sewerage and Sewage Treatment by MoUD. Simplified sewerage is a technology widely known in Latin America, but much less known in Africa & Asia and has been successfully demonstrated in the Orangi habitation of Pakistan (having a population of about 7.50 lakh, where per capita water supply is about 27 lpcd) and since adopted there in situations similar to the status in the preamble here. The system provides for smaller bore shallow sewers along property boundaries with chambers and encourages community participation and ultimately connected to interceptor sewers and treatment and thereby avoids road cuts and deep manholes etc. The design guidelines are available in *http://www.efm.leeds.ac.uk/CIVE/Sewerage/manual/pdf/simplified_sewerage_manual_full.pdf.* The *twin* drain system comprises of a integral twin drain on both sides of the road, the drain nearer to the property carrying the septic tank effluent & the grey water and the drain on the road side for storm water and the sewer drains are interconnected to flow out to treatment. This system is in use in coastal areas of Tamil Nadu particularly in Tsunami affected habitations.

1.2. Pipe Material in Centralized Collection System

The collection system for its desired performance by way of transporting the solids and liquids simultaneously assumes that adequate liquid is available. The existing manual lays down the required slopes at which the pipeline is to be laid and the minimum per capita lpcd to sustain the required velocities in the pipeline. The real world issues are the following.

- First of all it is time to give up the century old stoneware pipe sewers This is because, these pipes are available only in lengths of 90 cm at best and the joints need caulking with yarn soaked in cement mortar and packing in the spigot and socket joints which requires intense manual skilled labour and working sometimes at dangerous depths of even 6 m below ground level. Nowadays it is difficult to get the required labour and sometimes the laid joints are prevented from leaking more by the refilled earth than the joints per se. These joints can also allow soil water to infiltrate during rainy seasons and thus cause many problems of a water polluting nature.

- It is also a fact that there is no worthwhile data on infiltration and exfiltration to justify or contend the continuance of this pipe material.

Time has come to move ahead in pragmatic practices and regularize the use of recent pipe materials as;

(a) RCC pipes offer a viable option in diameters exceeding the availability of SW pipes. Though the spigot / socket joints with O rings are adequate, these pipes need protection against corrosion from sulphides on the inside and from sulphates on the soil side. Inside coating with high alumina cement conforming to BIS 6452, or made of sulphate resistant cement conforming to BIS 12330 and sacrificial additional thickness over and above the mandatory cover are the answers.

(b) Double Walled Corrugated Polyethylene (DWCPE) pipes are produced globally and in India following the EN 13476-3 standard which is holistically adopted from the ISO 21138-3 standard. This standard is currently being reviewed by BIS and this will take some more time to be published. The piping system can be adopted for non-pressure underground Sewerage system. It has a corrugated profiled outer surface wall and a smooth inner wall which allows the easy transport of fluids, non-corrosive and a better overburden protection. In India, DWC PE pipes are produced from the sizes 75mm ID to 1000mm ID with a standard length of 6 (six) meters for easy transportation and handling and to reduce the number of joints required. However, in the case of such pipes, the uplift during high groundwater conditions above the pipe level is a problem specifically in high ground water and coastal areas. The concrete surrounds or venteak piles shall be used to hold these in place in such conditions, where ground water can rise above the sewer. Quality control at factory and random checks on receipt before laying shall be mandatory.

(c) HDPE manholes with EN 13598-2:2009 and ISO (ISO 9001:2008) specifications are recent entrants. But the Indian standards are yet to be brought out by BIS. These being ready made can speed up the construction as compared to brickwork manholes. However, they are to be safeguarded against the uplift pressure due to high ground water table and also crushing under high traffic load etc. by suitably anchoring and if desired for a specific location, the cost shall not be compromised.

1.3. Emerging Sewage Treatment Technologies

The conventional sewage treatment technologies such as Activated Sludge Process (ASP), Waste Stabilization pond (WSP), Upflow Anaerobic Sludge Blanket (UASB) Reactor etc., are commonly adopted in sewerage system to treat wastewater up to secondary level as per the effluent standards.

There are a number of newer treatment technologies that have come into practice in recent times and they do merit attention in their own way as under, but the difficulty is the design basis which is necessary to be standardized for adoption in projects funded by Governments. The following are some of the relatively better known technologies. Recently, the following technologies such as Sequencing Batch Reactor(SBR) and Moving Bed Biofilm Reactor (MBBR)/ Fluidized Aerobic Bioreactor have been approved under JNNURM projects due to their advantages such as less requirement of land, high effluent quality etc. Small scale plants have been set up using MBR technology in Bangalore and Commonwealth village complex, and Akshardham in New Delhi.

1. Sequencing Batch Reactor (SBR)
2. Moving Bed Bio Reactor (MBBR) / Fluidized Aerobic Bioreactor (FAB)
3. Membrane Bio Reactor (MBR)

There are other emerging treatment technologies that have come into practice in recent times in other parts of the world, but they have not come into practice in India at large scale. Therefore, the following technologies though these have been randomly tried out so far, need to be investigated and possibly demonstrated/piloted under Indian conditions to arrive at their techno-economic viability. There is a need for generic design criteria under

Indian conditions to avoid vendor guidelines without adequate basis.

4. BIOFOR Technology (Biological Filtration and Oxygenated Reactor)
5. High Rate Activated Sludge BIOFOR-F Technology
6. Submerged Aeration Fixed Film (SAFF) Technology
7. Fixed Bed Biofilm Activated Sludge Process (FBAS)
8. Rim flow Sludge Suction Clarifiers/Bio Tower
9. Improved Circular Secondary Clarifier (HYDROPLUME®)
10. Eco-Bio Blocks

These technologies are briefly described as under.

1.3.1. Sequencing Batch Reactor (SBR)

This variant of ASP technology is essentially a batch treatment by combining, primary settling, aeration, secondary settling and decanting the treated sewage in a series of sequenced and or simultaneous reactions in the same basin on a time deferred cycle. Thus, multiple basins are used whereby when one basin is in one part of the cycle such as aeration, another tank will be settling and discharging the treated sewage in a cyclically repeated operation. High efficiency fine bubble non-clog membrane diffused aeration is preferred. As different from the well known reaction kinetics of continuous flow steady state ASP for our sewage characteristics, the biokinetic reaction rate in this non-steady state batch process needs to be evaluated for its higher rate or otherwise. Schematic diagram of Sequencing Batch Reactor process is presented in Fig. 1.

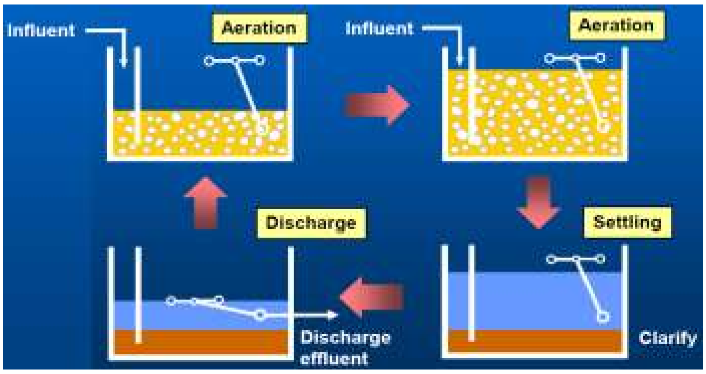

Fig.1: Schematic diagram of Sequencing Batch Reactor (SBR) process

1.3.1.1. Advantages

- Can remove N and P concurrent with BOD
- Absence of odour and corrosive gases
- Improved aesthetics
- Does not require separate secondary clarifiers and major return sludge pumping stations, good use of common walls, simple square, rectangular or circular structures, can reduce the footprint compared to

conventional activated sludge process.

- Capability to manage and treat variable loading conditions; such as normal, diurnal, dilute monsoon and shock loads.
- Less manpower due to automatic control and easy to operate and to maintain.
- High quality effluent for reuse without separate nutrient removal and fine filtration.
- Can be expanded as a modular system.
- Can also be used with primary clarifiers and conventional F/M ratio for bio-methanation and energy recovery.
- The system can generate a stabilized sludge.
- Track record for treating 27 MLD diluted sewage at Haridwar and 11.5 MLD at Goa

1.3.1.2. Disadvantages

- No provision for sludge management
- No provision of primary treatment to moderate pollution load variations
- Higher energy input if used without bio-methanation
- Requires at least semi-skilled manpower
- Patented process technology and decanters defying local cannibalization

1.3.2. Moving Bed Bio Reactor (MBBR)/ Fluidized Aerobic Bioreactor FAB

This technology is essentially the same as activated sludge except that the media suspended in the reactor offers additional surfaces for the microbes to grow and this in turn maximizes the growth of microbes in a given volume of aeration tank compared to the conventional aeration without the media and to that extent, it does appear preferable. Diffused aeration is of course needed. FAB technology is akin to MBBR except that instead of the media in suspension, the media is kept stationary and fluidized in the aeration tank. Schematic flow diagram of Moving Bed Bio Reactor process is presented in Fig. 2.

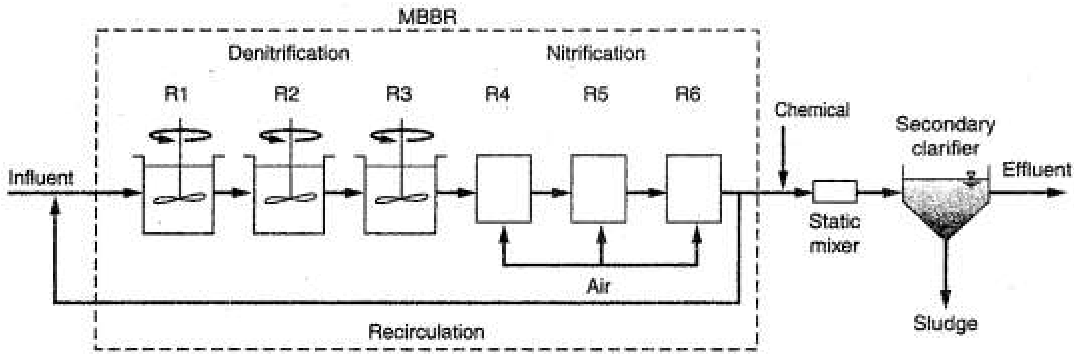

Fig.2: Schematic flow diagram of MBBR process

1.3.2.1. Advantages

- There are no limitations of height as long as compressors can be suitably used
- Circular structures can be used to economize on construction costs & time
- The structures can be easily covered for indoor air quality when needed.
- Requires lower footprints compared to conventional activated sludge.
- Easy to operate and maintain

1.3.2.2. Disadvantages

- The area per unit volume of the media offered by various vendors are different and also each vendor advocates his own criteria for the relative ratio of volume of media to volume of aeration tank, which makes it difficult to bring about a common and validated standard design criteria. The quality of plastic of media varies.
- The verification of whether the media is moving about the entire volume of the tank or merely clumping at the top layers and if so the method of mixing it up through the tank volume without shearing of the biomass on it are issues of infirmity and which may need gentle movers of the media through the volume of the tank.
- Furthermore, the media is a patented product.
- Higher energy input if used without biomethanation

1.3.3. Membrane Bio Reactor (MBR)

This technology combines the aeration and secondary clarifier in one and the same tank by sucking out the aerated mixed liquor through membranes instead of settling in a separate downstream tank and to that extent, it does yield a treated sewage with practically no BOD and suspended solids and hence being clear and virtually transparent besides its claimed ability to hold and sustain mixed liquor suspended solids (MLSS) of three to four times than what is possible in the conventional aeration tanks which in turn offers minimization of the footprint of the treatment plant. Diffused aeration is of course needed. The membrane is a matter of proprietorship and the throughput per membrane module offered by various vendors are different and also each vendor advocates various shapes of the membranes as flat sheet, cross flow, dead end flow etc, which makes it difficult for common validated standard design criteria. Schematic flow diagram of Submerged Membrane Bioreactor process is presented in Fig. 3.

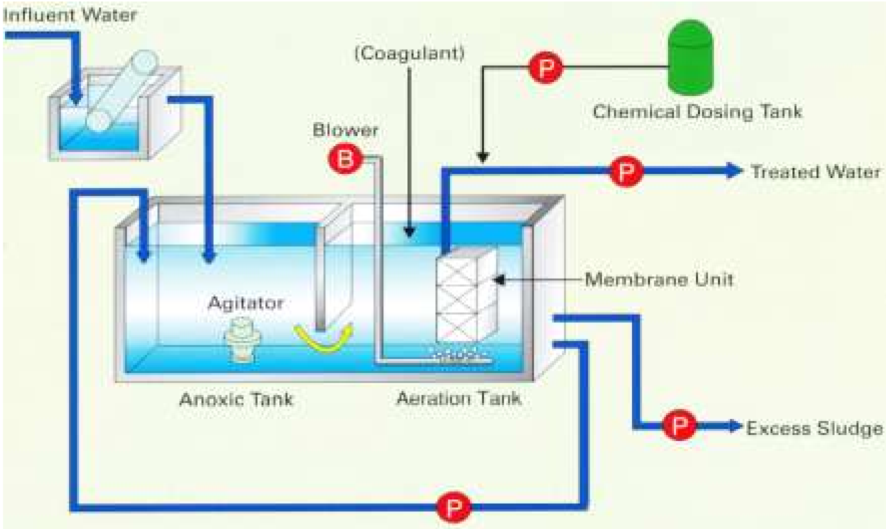

Fig.3: Schematic flow diagram of Submerged Membrane Bioreactor process

1.3.3.1. Advantages

- High quality effluent for reuse without separate nutrient removal and fine filtration
- Compact system, reduces plant footprint by 25-40% compared to a conventional STP.
- These membranes are stated to be durable to ensure reliability and long membrane life, and low membrane replacement frequency. .
- The modular system is expandable
- Higher stability to organic shocks /upsets due to higher MLSS concentration.
- The process operates under low suction, the ideal filtration method for small to large-scale membrane facilities, hence low power consumption.
- Automated system makes the process operations easier to operate.

1.3.3.2. Disadvantages

- Each vendor advocates his own criteria for the membranes and their types which makes it difficult to bring about a common and validated design criteria
- It is not possible to cannibalize the system between different manufacturers.
- High reliance on energy input in the absence of biomethanation
- Patented process technology and decanters defying local cannibalization
- Detailed evaluation of existing plants required either by IITs, CPCB or NEERI.

1.3.4. Cost comparison and Land Requirement

As per the Compendium of Sewage Treatment Technologies issued by National River Conservation Directorate (NRCD), Ministry of Environment & Forests, published in August, 2009, the cost aspects based on capital cost, O&M cost, reinvestment cost, energy and land cost based on data of STPs in the Ganga river basin and elsewhere in India indicates that unlined WSP has the lowest treatment cost (Rs 1/kL) but the highest land requirements (20000 m^2/MLD), while SBR/ will have high treatment cost (Rs 5/kL) but low land requirement (-600 m^2/MLD). The conventional ASP is somewhere in the middle, with moderate treatment costs (Rs. 3.5/kL) and moderate land requirements (-2000 m^2/MLD). Similarly, among treatment options that produce effluent of recyclable quality (i.e., BOD_5 < 5 mg/L, SS < 5 mg/L), the ASP + C-F + RSF/DMF process has the lowest treatment cost (Rs 6.50/kL) but the highest land requirements (3000 m^2/MLD), while the MBR process will have highest treatment cost (Rs 9/kL) and the lowest land requirements (600 $m^{2/}$MLD). The SBR + C-F + RSF/DMF process will have an intermediate treatment cost (7.50/kL) and also an intermediate treatment area requirement (1200 m^2/MLD). It is however necessary to evaluate these on a case by case basis depending on the specific situation on hand before arriving at an inference. Inclusion of biomethanation and energy recovery for use in the STP itself will change the above cost comparisons.

1.3.5. BIOFOR Technology (Biological Filtration and Oxygenated Reactor)

1.3.5.1. Key features of the technology

- Enhanced primary treatment with addition of coagulants and flocculants
- High rate primary tube settlers and integrated thickening offering space economy
- Two stage high rate filtration through a biologically active media and with enhanced external aeration
- Co-current up flow movement of wastewater and air enable higher retention and contact
- Treatment scheme excluding secondary sedimentation but recycling of primary sludge
- Deep reactors enabling low land requirements
- A compact and robust system

The process flow diagram of BIOFOR technology is presented in Fig. 4.

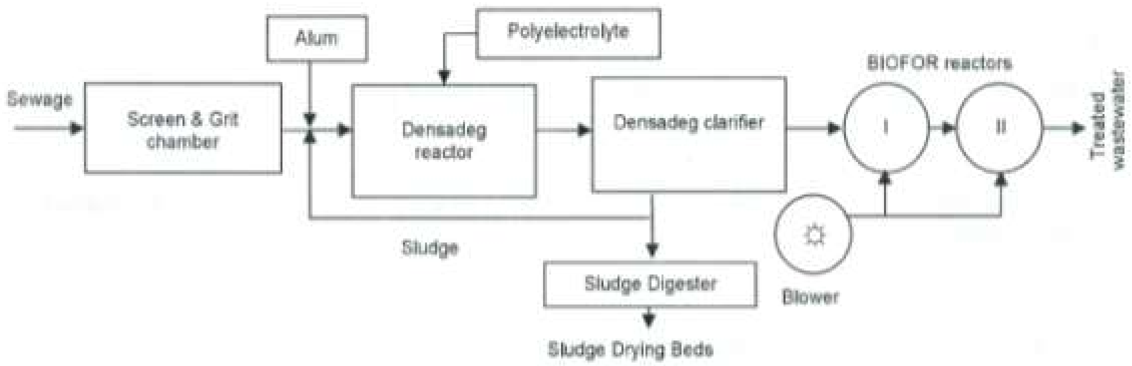

Fig. 4: Process flow diagram of BIOFOR Technology

1.3.5.2. Advantages

- Compact layout as a result of high rate processes.
- Higher aeration efficiency through co-current diffused aeration system
- Space saving as secondary sedimentation is dispensed
- Able to withstand fluctuations in flow rate and organic loads
- Compliance with stricter discharge standards
- High quality effluent for reuse without separate nutrient removal and fine filtration
- Effluent suitable for UV disinfection without filtration
- Absence of aerosol and odour nuisance in the working area
- Absence of corrosive gases in the area
- Lower operation supervision enables lesser manpower requirement

1.3.5.3. Disadvantages

- Continuous and high chemical dosing in primary clarification,
- Large sludge generation due to the addition of chemicals
- Undigested sludge from primary clarification requiring post treatment.
- Yet to be validated on reasonable number and sizes of STPs in India

1.3.6. High Rate Activated Sludge BIOFOR-F Technology

1.3.6.1. Key features of the technology

- In general, high level of mechanisation and sophistication
- The flow scheme excludes primary sedimentation tank
- Superior aerated grit chamber and classifier
- Circular aeration tank with tapered air diffusion system
- Second stage aeration and rapid sand filtration through a biologically active filter media
- Dissolved air floatation for sludge thickening
- Digester heating and temperature controlled anaerobic sludge digestion

- Mixing of digester contents through biogas
- Dynamic cogeneration of electrical and thermal energy through gas engines

The process flow diagram of High Rate Activated Sludge BIOFOR-F Technology is presented in Fig. 5.

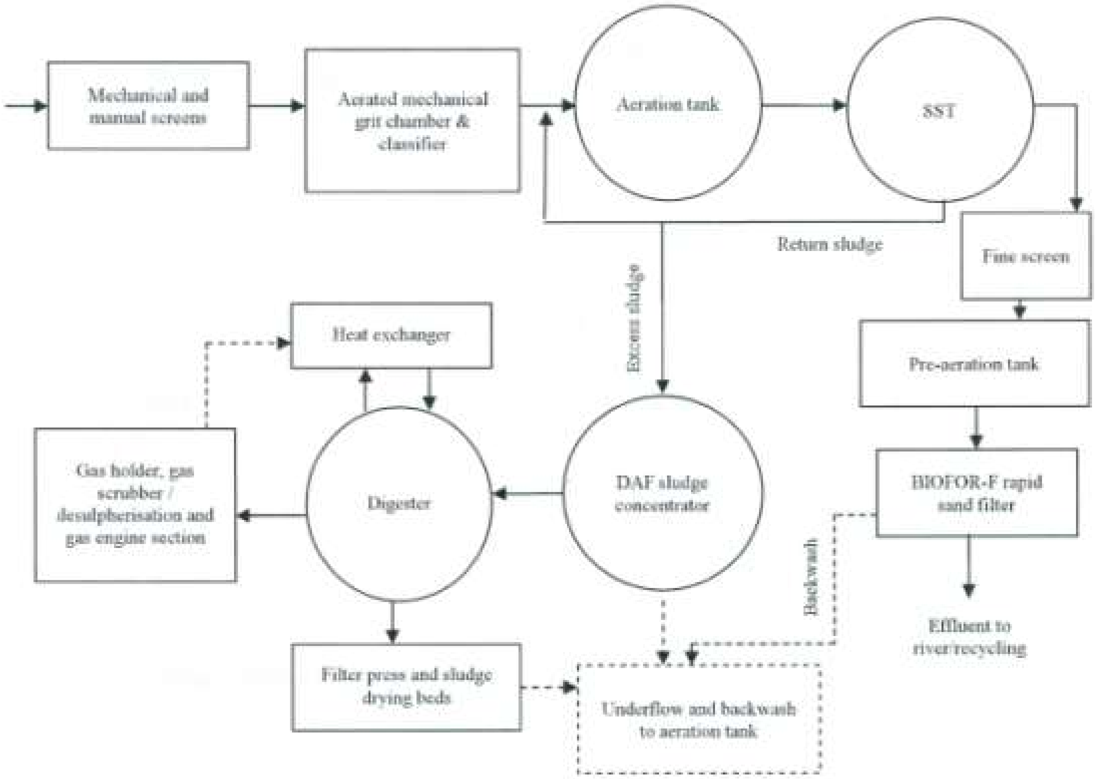

Fig. 5: Process flow diagram of High Rate Activated Sludge BIOFOR-F Technology

1.3.6.2. Advantages

- Compact layout as a result of high rate processes
- Higher aeration efficiency through diffused and tapered aeration system
- Space saving as primary sedimentation is dispensed
- Compliance with stricter discharge standards
- Effluent suitable for high end industrial applications
- Stable digester performance and consistent gas production
- Almost self sufficient in energy requirement due to gas engine based cogeneration system
- Absence of aerosol and odour nuisance in the working area

1.3.6.3. Disadvantages

- None, except high cost

1.3.7. Submerged Aeration Fixed Film (SAFF) Technology

1.3.7.1. Key features of the technology

- Essentially a fixed film media with enhanced oxygen supply through submerged aeration
- Unconventional plastic media offering high void ratio and specific area compared to stone and aggregates
- Large biomass and long solid retention time in the reactor leading to low 'food to micro-organism ratio' and higher organic removal
- Two stage biological oxidation
- Treatment scheme excluding primary sedimentation and sludge digestion
- Reactors up to 6 m deep enabling low land requirements
- Tube settlers again offer space economy
- Many plants based on such technology are functioning in industrial wastewater applications. Pilot study is required for municipal wastewater applications.

Process flow diagram of Submerged Aeration Fixed Film (SAFF) Technology is presented in Fig. 6.

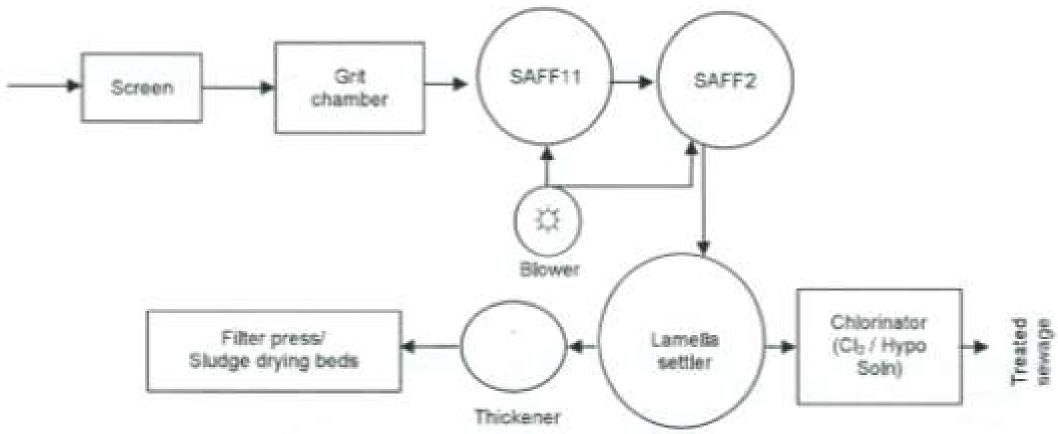

Fig. 6: Process flow diagram of Submerged Aeration Fixed Film (SAFF) Technology

1.3.7.2. Advantages

- Deep reactors enabling small space requirements
- Ability to effectively treat dilute domestic wastewaters
- Low and stabilised sludge production eliminating the need for sludge digestion
- Absence of odour and improved aesthetics
- Absence of emission of corrosive gases

1.3.7.3. Disadvantages

- Clogging of reactor due to absence of primary sedimentation.
- Reliance on proprietary filter media.
- Strict quality control on media.
- High reliance on external energy input.
- Requires skilled manpower.
- Yet to be validated on reasonable number and sizes of STPs in India

1.3.7.4. Applicability

The SAFF technology based system is particularly applicable for :

- Small to medium flows in congested locations
- Sensitive locations
- Decentralised approach
- Reliving existing overloaded trickling filters

1.3.8. Fixed Bed Biofilm Activated Sludge Process (FBAS)

The FBAS process is an essentially an activated sludge attached growth process where the plant roots provide the area for the biofilm to develop and grow. The aeration system is divided into a series of biological reactors where fixed biofilm is maintained in every stage of the process. Biodegradation of influent contaminants takes place mainly with the help of fixed biological cultures, where plant roots are used as biofilm carriers; additional textile media is used in the reactors as additional biofilm carriers. As a standard feature of the technology the reactors are covered by a shading structure or a greenhouse. As the influent travels through the cascade, the available nutrient quantity is consumed and as a result, the composition of the ecosystem fixed in the biofilm changes from reactor to reactor, gradually adapting itself to the decreasing nutrient concentration. In each cascade stage a specially adapted ecosystem will form, thus maximising the decomposition of contaminants. As reported, some plants with such technologies have been set up in different countries including Hungary, China and France etc in last 10 years. However, it will be useful to demonstrate this project under Indian conditions.

1.3.8.1. Advantages

- The process requires much lesser land area than conventional activated sludge
- The process is odorless and hence the plants can be easily built in urban area with no negative impact on the value of adjoining areas.
- It can operate at a much lesser loading rates during initial days of setting up the plant in new habitations. Due to small area requirements this technology can offer decentralized solutions and recycling water in local areas.

- The technology allows for design flexibility and can be adopted for nutrient removal such as P and N, which are today the major concern of pollution in rivers.

1.3.8.2. Disadvantages

- In colder climates where the temperature drops to sub normal, the plants have to be protected with a greenhouse otherwise the biota may freeze up.
- Because of higher automation the technology is not attractive for smaller sizes of plants
- The technology requires more qualified operators than in other technologies.
- Yet to be validated on reasonable number and sizes of STPs in India

1.3.9. Rim flow Sludge Suction Clarifiers/ Bio Tower

These are clarifiers with inlet along the rim and sludge sucked out at the floor through suction boxed arms instead of scrappers and is reported to save on foot print and denser sludges and quicker return to aeration tank without analysis of the live sludge.

1.3.9.1. Advantages

- It is claimed that given the same clarifier volume as conventional center feed clarifiers, these type of clarifiers can handle much higher throughputs and the rising sludge phenomenon is minimized
- The need for a buried central feed pipe in large central feed clarifiers is avoided
- The sludge is sucked out as soon as it settles on the floor and transferred to aeration tank and thus avoiding cell lysis.

1.3.9.2. Disadvantages

- Here again, each vendor advocates his own criteria for the equipment and their types which makes it difficult to bring about a common and validated design criteria
- The sludge suction arrangement if it gets into repair necessitates the emptying of the clarifier for repairs.

1.3.10. Improved Circular Secondary Clarifier (HYDROPLUME®) – CSIR-NEERI

NEERI has secured a US Patent of the clarifier configuration which avoids virtually the need for the bridge and sludge scraper as shown hereunder. It will be useful to pilot this in smaller STPs to start with in consultation with NEERI.

Since the conventional secondary clarifiers do not take hydraulic energy dissipation into account, they are either too large or often fail in giving the efficient solids-liquid separation. Therefore, CSIR-NEERI has developed an improved circular secondary clarifier called HYDROPLUME® with following improvements.

Hydronamics

- Optimization of velocity gradient and hydraulic energy dissipation to ensure natural flocculation.

Geometry

- Provision of an improved inlet design and bottom to enhance the solids-liquid separation and facilitate sludge removal.

Sludge Removal Mechanism

- Development of an improved sludge removal suction mechanism to remove the settled sludge.

Advantages of HYDROPLUME®

- Improved solids-liquid separation ensures minimum suspended solids (SS) concentration in the treated effluent.
- High underflow solids concentration minimizes pumping rate, and maintains desired active biomass concentration in aeration tank.
- Requires less surface area and operates at low hydraulic retention time (1.5 – 2.0 hrs. HRT), thereby facilitates savings in capital cost.
- HYDROPLUME® does not require a separate sump-cum-pump house for sludge recycling/removal, thereby saves capital and recurring costs.
- HYDROPLUME® provides natural flocculation and does not require separate flocculation facility, thereby reduces capital and recurring cost.

1.3.11. Eco-Bio-Blocks

These are stated to be exfoliated bricks of volcanic ash which do not degrade by themselves but offer microbes a chance to get into the crevices and stay there as immobilized habitats and these microbes further the aerobic or anaerobic or facultative activity based on prevailing oxygen conditions or septic conditions and are confined in application to small sized plants and polishing of sewage effluent from STPs. Here again, these are patented makes. This can be recommended for outfalls of secondary effluent prior to discharge in the water bodies for polishing of effluents wherever required to meet the discharge standards.. STP with Eco-Bio-Block has been installed and functioning at Indian Institute of Science Education and Research (IISER), Mohali in small scale and the same needs to be evaluated. Further piloting is required. Based on the performance, the same may be recommended for onsite and decentralized wastewater management systems.

However, the capital and O&M cots, land requirement and their applicability of some of the aforesaid all the technologies are given in the "Compendium of Sewage Treatment Technologies" issued by NRCD, Ministry of Environment & Forests in August, 2009 and the same be referred to for more details. Please refer to the website of Ministry of Environment & Forests (www.moef.nic.in)

1.4. Approach Towards Recent Technologies

With a view to promote new technologies in the sewerage sector, a way forward is needed to avail the advantages wherever beneficial for optimum utilization of public funds. Accordingly, it is proposed to approach these on the following lines.

1) While formulating the DPR for STPs, a techno-economic feasibility analysis may be carried out by considering all the conventional technologies such as Activated Sludge Process, UASB, WSP etc., and other technologies such as SBR, MBBR etc approved under JNNURM and most appropriate technology may be proposed in the DPR suiting to the local conditions. While carrying out the techno economic analysis, life cycle cost may be worked out for all these technologies taking into account the capital cost and O&M cost for a specified period, land cost etc., Other parameters such as influent quality, effluent quality standards, effluent quality for reuse, resource recovery (gas/electricity generation etc) may also be considered. For the purpose of estimation of the STP, detailed cost estimate may be prepared either based on the schedule of rates or the recently awarded cost of similar capacities of STPs (average cost of different STPs) based on these technologies in the concerned State. If the awarded cost is not available in the concerned State, the awarded cost in the neighboring State may be adopted.

2) While inviting tenders under EPC (Engineering Procurement & and Construction), the approved technology in the DPR may be considered, if the land is a constraint. In case land is not a constraint, tender may be invited considering all the suitable conventional technologies and other technologies approved under JNNURM in the past suiting to the local conditions**.** The requirement of land shall be determined by considering future expansion of STP, setting up of plants for power generation, sludge & septage treatment and recycling of wastewater etc. The contractor/technology provider may be asked to quote the rates based on the criteria such as influent quality, effluent quality for reuse of effluent and O&M cost and ease in maintenance of the STPs etc. Most suitable option may be decided based on the evaluation of technical and financial bids. However, it is suggested that BOOT model is preferred.

3) Other new technologies (listed under section 1.3 at page 4 of the note) which are not proven for municipal wastewater applications under Indian conditions, shall not be considered at large scale under EPC contract as the performance of the plants may not be guaranteed. Before any new technology is considered at large scale under EPC contract, pilot plants/ trial testing / demonstration plants (upto 3 MLD capacity for the technologies listed from Sl. 4 to 8 and upto 1 MLD capacity for the technologies listed at Sl. 9 & 10 under section 4 at Page 4) have to be set up and the same need to be evaluated by the State Govts/ULBs through IITs/NEERI/reputed Govt. Academic Institutions within a period of one year. Any of the aforesaid technologies set up already and functioning in any part of the country may also be considered for performance evaluation. However, based on the performance, STP at larger scale may be proposed under EPC contract/PPP model. In the meantime, if State Govts/ULBs intend to adopt other new technologies (listed from 5-8 under section 1.3 at page 4 of the note) at larger scale, these new technologies which have already been set up at large scale in India or elsewhere in the world and operated successfully may be considered under Build-Own-Operate-Transfer (BOOT) model in view of the fact that the part or full capital cost of construction of the plant based on new technology and its performance is guaranteed by the private firms and the annuity payment is linked with the performance of the plants. In regard to this, adequate provision shall be made in the BOOT agreement by ULBs. While inviting tenders on BOOT basis, all the available technologies may be considered.

4) Decision making between the offers shall be based on the capitalized cost for a 15-20 years period, being the life cycle of mechanical equipment, and the land cost of the foot print computed based on the prevailing market rates at that location, each being the lowest separately and not taken together.

5) Over the next few years, generic design criteria for the above said newer technologies including the technologies approved under Jawaharlal Nehru National Urban Renewal Mission (JNNURM) will be evaluated, validated to Indian sewage conditions and released by the Ministry of Urban Development and the STPs can be straightaway called for on EPC basis for those technologies as well based on the said design criteria.

6) The above interim approach is needed to ensure India does not lose track of advancements in technology from elsewhere in the world but at the same time ensure that investments of public money is on a logical basis while dealing with technologies yet to be validated for our country.

7) The cost at which the plant will be taken over shall be settled in the contract itself at the time of award and without any price escalation.

1.5. Standardised Service Level Benchmarks in Sanitation

The Ministry has proposed to shift focus on infrastructure in urban sanitation sector for improvement & efficiency of service delivery. The Ministry has formulated the set of Standardized Service Level Benchmarks for urban sanitation sector as per International Best Practices. The Service Level Benchmarks have already been circulated to the States in September 2008 for adoption in infrastructure development projects. The Standardized Service Level Benchmarks is also available in the Ministry's web site (www.urbanindia.nic.in).

1.6. Implementation Structure of BOOT Models

Currently sewage treatment plant projects are bid out on Engineering Procurement and Construction (EPC) basis and have a limited role for the EPC contractor in operation and maintenance of assets. In many instances, the assets so created are of relatively poor quality, inadequately maintained and do not comply with the required effluent treatment norms stipulated by the Pollution Control Boards. In order to ensure optimum utilization of funds deployed and proper creation and maintenance of assets, it is desirable to explore the option of Build-Own-Operate-Transfer (BOOT) contracts wherein the long-term commitment of the Private Sector Participant (PSP) would be ensured due to continued deployment of his own funds. Under this structure, the PSP who invests in the project assets and recovers it over a project life cycle of say 15-20 years, is likely to ensure better management of project assets and delivery of committed service level parameters during the project term.

There are various technology options available for treating sewage. The technology option as well as the project cost would be outlined in the Detailed Project Report prepared for implementing the project. Irrespective of the technology chosen, STP projects could be developed on a long term commitment from the Private Sector Partner either on PPP/BOOT basis or on EPC plus O&M for 15 years where a part of the EPC cost is payable over a long-term O&M period. However, it is suggested that no new technologies will be considered under EPC contract.

The Central Government and the State Government together can fund at-least 50% - 60% of the project cost by providing grants for the project. The remaining 50% - 40% will be funded by PSP who will also operate and maintain the plant over the Concession Period, for which the PSP will be paid annuity over the concession period. The Annuity payable to the PSP will include the following.

1.6.1. Fixed Charges (capital cost)

These charges will be for recovery of capital expenditure for creating the project. This will include fixed costs such as interest, depreciation, investment returns.

1.6.2. Variable Charges (O&M cost)

This shall include all variable cost including consumables, chemicals, power etc and will be subject to indexation to reflect the change in prices.

The fixed charges component of the annuity will be paid out of the various Grants of the Central and State Government. The payment of variable charges component of the annuity will be the responsibility of the Urban Local Body implementing the project.

i. Option 1:

a) The Urban Local Body (ULB) will select a PSP for implementing the project on BOOT basis who will finance, implement, operate and maintain the project
b) The ULB implementing the project will avail the grant funds from both the State and Central Government – 50% - 60% of the project cost
c) This Grant could be paid to the PSP progressively over the construction period against specific project milestones or be paid in one full installment upon achieving commercial operations
d) The PSP will quote annuity only for the funding brought in by the PSP (i.e. non-grant component) and for O&M of the project over the concession period

ii. Option 2:

a) The ULB will select a PSP for implementing the project on BOOT basis who will finance, implement, operate and maintain the project
b) The ULB implementing the project will avail the grant funds from both the State and Central Government – 50% -60% of the project cost and invest the same with both the corpus and its earnings escrowed in favour of the PSP
c) The returns on such investment along with the corpus will be used for payment of annuity requirements of the selected PSP for

financing, implementing , operating and maintaining the project over the concession period

1.6.3. Analysis of Options

i. Option 1:

Since the grant funds, which have zero cost, will be brought in during the construction period, the project cost will be significantly lowered. The PSP will quote annuity only to the extent of the funding brought in by the PSP and the O&M of the project over concession period. In this case the annuity quoted by the PSP will be lower compared to the annuity quoted for a fully PSP funded project.

ii. Option 2:

The anticipated return on investment made by PSP while quoting the annuity are likely to be at least 50% more than the return on investment of grant funds of the ULB. Hence this option of investment of grant funds and paying the annuity to the PSP out of the investment and its returns will be sustainable only for a period of 3-4 years and thereafter the ULB has to mobilize its own funds for the payment of annuity for the remaining concession period.

Option 2 would be viable only in cases where the ULB is likely to generate increased revenues over a 3 to 5 year period and till then requires funds to make annuity payments.

1.7. Additional Requirement to be Considered by the State Govts/ ULBs

1. Where the proposed project may not cover the entire city, it should only be approved, if it is part of a comprehensive plan to cover the entire city and not an adhoc proposal.

2. Tender for underground sewer network should be called only when 50% of the households (covered by the proposed sewer network) have paid their connection charges to the city/utility.

3. The user charge shall be approved by the standing council/board (utility) and is published by the city/utility. The user charge could be a stepped tariff and be linked to the area of the property.

4. The project will be approved only if the user charge and/or other revenues from the sale of by-products is adequate to meet the O&M requirement or running cost of the plant. The by-products are power, fertilizer/soil conditioner, carbon revenue, etc. All cities/utilities would be

required to provide a note on revenue generation from the sale of by-products; assumptions, calculations, etc; for example for power generation there should be detailed calculations supporting the biogas and energy generation.

5. Wherever possible and demand exists, recycle and reuse of treated wastewater at least 20% of the treated effluent quantity for industry/agriculture would be actively promoted.

1.8. Financial Sustainability of Sewerage and Sewage Treatment Services

Most of the urban local bodies in India are financially weak for various reasons and have not been able to discharge their obligatory functions satisfactorily. The subject of sanitation including sewerage and sewage treatment has received low priority. As per the findings of a study conducted by NIUA, the sanitation services either generate no revenue or the revenue generated is not very significant. As the current sewage tariff levels are too low across ULBs in India and do not reflect the true economic cost of providing sewage collection and treatment and disposal services, increasing tariffs to a level to ensure that the sewerage system generates sufficient revenues to meet its capital and O&M costs and becomes self-sustainable may not be possible in one stroke. This could be achieved by increasing tariffs gradually over a period of time.

It is suggested that in the initial years, tariffs should be set to ensure that they recover at least the O&M costs of the sewerage system. Once operational efficiency is demonstrated with the infusion of private sector participation, the user acceptability of a tariff increase by ULBs would also improve. The tariffs can then be increased to recover the capital costs also in addition to the O&M.

In cases of PPP, the concession itself should be structured to accommodate a rising tariff scenario with obligations from the private partner to increase service levels as well as undertakings by ULBs to increase tariff accordingly at a later date.

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