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<th>S. No</th>
<th>Parameter</th>
<th>Relevance</th>
<th>SBR</th>
<th>FBBR</th>
<th>Inference</th>
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<td>1</td>
<td>Technology</td>
<td>Seawage treatment technology has rapidly and exponentially evolved in the past two decades, resulting in better treatment processes with considerably lesser footprints.</td>
<td>SBR is a modified form of the conventional activated sludge process and is in existence since 1940s. It works in sequences where multiple processes occur in a single basin. In terms of treated sewage quality, it works just like ASP albeit in sequenced phases. The intensity of the bacterial activity, which is the core of this treatment, remains the same as in ASP.</td>
<td>Fluidized Bed Bio Reactor is a continuous flow reactor (CFR) with enhanced bacterial activity through the introduction of special bio media. A relatively new technology, FBBR sustains higher biomass concentration with smaller footprints. The core process advantage of FBBR is the availability of high specific area for micro organisms which expedites aerobic biodegradation processes and maximizes the metabolic potential of microorganisms. (Brief write-up attached)</td>
<td>While SBR may be a better technology when compared with the conventional ASP, FBBR technology is much superior and has distinct advantages vis-à-vis SBR in terms of process efficiency and user friendliness.</td>
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<td>2</td>
<td>Influent Characteristics</td>
<td>Sewage treatment has to be designed keeping in mind the possibility of varying organic characteristics. While the scope for variance in the organic characteristics of the sewage influent is limited, the design has to factor in this condition since the output quality needs to be consistent owing to environmental concerns and regulations.</td>
<td>The ability of SBR technology to tolerate variable organic characteristics of the influent is very limited on account of its simple air-induced treatment process. The only way this can be circumvented is to increase the duration of aeration which warrants increased time consumption.</td>
<td>FBBR technology uses special bio media (higher specific area for microorganisms) in addition to air diffusion which significantly increases / expedites the aeration process. The enhanced bacterial activity helps in managing volatile organic characteristics of the influent.</td>
<td>FBBR enjoys a tangible advantage in this aspect.</td>
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<td>3</td>
<td>Plant Footprint and Civil Cost</td>
<td>Given the growing demand for space and associated constraints, plant footprint for sewage treatment has become one of the important / decisive factors. Smaller footprint also reduces the cost of civil work substantially.</td>
<td>Though multiple processes happen in a single basin / reactor, SBR requires a minimum of two reactor basins to allow for redundancy, high flows and seasonal variations. In the event of a single basin, overflow / septicity of raw sewage at the primary collection tank is a distinct possibility. Regardless of whether there is a single or multiple reactor basins, the total volume of the reactor basin is based on the total volume of sewage generated per day (SBR is designed on 24 Hours HRT). This negates the footprint and cost benefit of having a single tank / basin for multiple processes.</td>
<td>FBBR works on very short HRT (Hydraulic Retention Time) cycles. This is typically between 8-12 hours. This greatly reduces the space required for the plant and therefore the civil cost is also reduced.</td>
<td>Total plant footprint and civil cost involved is much less for FBBR than SBR.</td>
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<td>4</td>
<td>Sludge Settling and Separation</td>
<td>Sludge settling and separation plays a vital role in the overall efficacy of the treatment process. Sludge settling and separation have to be proper, timely and proportionate for efficient treatment process and maintenance of optimum MLSS levels.</td>
<td>Activated sludge is allowed to settle naturally under quiescent conditions in SBR. Quiescent settling within a short time reduces the efficacy of solid separation process since solids do not settle rapidly as it is required. This leads to sludge being drawn off during the decant phase thereby degrading the treated effluent quality.</td>
<td>In FBBR, settling tank is separate and hence independent of the aeration / reactor tank. Settling tank in FBBR is generally designed with hopper / conical bottom floor. This enables the sludge to rapidly settle on sets of flocculent mass. The same gathers into the centre of this conical bottom with higher sludge compaction thus facilitating easy suction of the same through a sludge pump.</td>
<td>Settling is effectively expedited in the FBBR process through unique tank design and equipments. This leads to avoidance of sludge bulking issues, gives better quality of supernatant and lesser load on the tertiary units.</td>
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There is no additional mechanism or tank design to favorably modify the settling velocity. This also adversely impacts the sludge separation which in turn leads to excessive dependence and usage of coagulants.

The settling velocity is favorably modified and turbulence is retarded by using time-tested mechanisms such as tube settlers / clarifiers.

Sludge wasting is very easy in FBBR. Periodic and proper sludge wasting is the main parameter in controlling the effluent quality and maintaining optimal MLSS concentration.

In SBR, there is a potential possibility of floating or settled sludge passing on to the next treatment stage during the draw / decant phase.

In SBR, since aerobic and anoxic phases occur in a single basin recurrently in pre-determined cycles, the presence of oxygen in the sewage during these phases needs to be closely monitored. Most of the time spill overs spoil the efficacy / adequacy of these processes.

In FBBR, aerobic and anoxic phases are physically separated. Aerobic environment occurs in the aeration tank and anoxic phase occurs in the settling tank permanently. There is no interference / overlap between these two distinct phases. Nitrification and denitrification processes happen simultaneously in two separate chambers independent of each other.

FBBR also permits effective return sludge process which helps in maintaining optimal MLSS, a key to high efficient treatment. Net final sludge generated by FBBR is much lesser in quantity, chemical-free, environmentally safe and very organic.

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5 Biological Nutrient Removal

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<th>Maximum removal / reduction of biological nutrients such as nitrogen and phosphorous are of vital importance because they lead to problems such as eutrophication and undesirable changes in the receiving environment.</th>
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<th>FBBR enables better removal of biological nutrients without excessive usage of chemicals.</th>
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<td>Nitrification and denitrification are important processes in the removal of nitrogen present in the sewage. Nitrogen appears in raw sewage as organic nitrogen and ammonia. Conversion of ammonia in to nitrates is called nitrification and subsequent conversion of nitrates in to nitrogen gas is called denitrification.</td>
<td>SBR also uses coagulants (generally lime or alum) to remove phosphate from sewage which potentially increases the sludge volume.</td>
<td>While phosphorous gets reduced / released in the anoxic phase in the settling tank, the removal potential of phosphorous is more with FBBR on account of its shorter cycles and precise sludge wasting (SRT)</td>
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<td>Nitrification occurs in an aerobic environment and for this process to be efficient adequate oxygen uptake is required. Nitrate, the end product of nitrification can have deleterious effects on the environment. Hence, denitrification becomes an indispensable part of this treatment process.</td>
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<td>Denitrification occurs in an anoxic environment where the nitrate is converted into gaseous nitrogen. In this form, total nitrogen present in the sewage is inert and gets released into the atmosphere.</td>
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<td>Different treatment environments are required for effective nitrification and denitrification processes.</td>
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Apart from the plant design, optimal process efficiency of a sewage treatment plant depends on operational accuracy, friendliness and ease. Flawed or incorrect operations can render the treatment plant ineffective.

Except flexibility in treating varying influent flow loads due to batch treatment, SBR works on a tightly controlled operating environment thus necessitating sophisticated and full-scale automation. Automation becomes all the more critical / necessary since SBR is relatively complicated on account of diametrically opposite processes being carried out in a single chamber.

While automation can certainly reduce human failures and dependence on man power, the operations must have a manual back up as exigency arrangement given the critical utility / requirements of a sewage treatment plant.

While FBBR is very advanced in terms of process efficiency, the plant is highly operator-friendly thereby obviating the need for automation. Generally, suppliers of SBR in India don’t offer full-scale automation to keep the costs down and this results in process compromise, impaired data acquisition and therefore the process efficiency.

SBR automation involves cycle programming with PLC or SCADA (this ensures flexibility in cycle programming) with various process controls, automated switches / valves, online sensors to monitor levels of pH, DO, ORP, nitrates, sludge blanket level etc. This means the operating parameters are pre-defined which severely restricts the plants ability to handle varying organic loads and other similar variable factors.

SBR completely rules out the possibility of manual intervention / operation mode as a back-up. This kind of sophisticated automation also translates into higher maintenance expenses and associated operational hindrances in the long term.

FBBR is a no-frills treatment plant in terms of automation and highly reliable due to the operator-friendliness.

Operational cost is a vital factor in the sustained / economical usage of a sewage treatment plant and hence needs to be optimized. The key factors which determine the operational costs are electricity, consumables, operator salary and maintenance expenses.

The number of pumps used in SBR is the same as in FBBR namely raw sewage transfer pump, sludge pump and filter feed pump. SBR also requires blowers like in FBBR. The power consumption of these pumps and blowers is based on the total load (seawage generated) regardless of the process / technology used. SBR additionally uses a decanting mechanism which also adds to the total power consumption.

With respect to consumables, Urea and DAP are used during the process stabilization periods to counter possible nutrient deficiency issues. Later, SBR uses coagulants (lime or alum) in the process continuously. Sodium Hypochlorite (liquid chlorine) is used to disinfect the water at the last stage.

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The number of pumps used in FBBR is the same as in SBR namely raw sewage transfer pump, sludge pump and filter feed pump. FBBR also requires blowers like in SBR. The power consumption of these pumps and blowers is based on the total load (seawage generated) regardless of the process / technology used. But FBBR does not use a decanting mechanism like in SBR and the supernatant is taken out through a naturally controlled flow process.

With respect to consumables, Urea and DAP are used during the process stabilization periods to counter possible nutrient deficiency issues. Later, FBBR does not use any coagulants in the process. Operator cost is generally the same. However, it may be slightly lesser with FBBR since the operations are highly simplified which even a school drop out can manage under professional supervision.

With respect to consumables, Urea and DAP are used during the process stabilization periods to counter nutrient deficiency issues. Sodium Hypochlorite (liquid chlorine) is used to disinfect the water at the last stage.
Having an operator to run / monitor the plant continuously is a must for the successful operations of the plant. Regular bar screen cleaning, backwashing of tertiary filtration units, checking the running condition of rotary equipments (motors/pumps), checking automation controls are essential activities carried out regularly.

SBR uses a wide array of electronic instruments to automate the plant and that calls for regular calibration and replacement of components if required. FBBR uses very limited electronic/electrical instruments since the operations are by and large manual.

Chemical cost is lesser with FBBR vis-à-vis SBR since usage of coagulants is avoided.

Maintenance cost of SBR is higher vis-à-vis FBBR on account of the complicated automation processes involved and usage of delicate electronic / electrical accessories.

FBBR being a continuous flow reactor, the design needs a minimum flow to operate. However, some designs can handle as low as 30% of the design capacity. This quantity limitation can be further reduced by splitting the single reactor tank into multiple smaller tanks with multiple smaller capacity blowers if the situation requires so.

FBBR is mainly preferred in places where the influent flow is seasonal, volatile, intermittent and therefore consistently uncertain in terms of quantity. SBR loses its relevance in the event of guaranteed minimum influent flow after the incipient period variance.

Even this advantage of load flexibility of SBR can be effectively neutralized in FBBR by opting for multiple smaller reactor tanks with multiple blowers of smaller capacity.

Flexibility of a sewage treatment plant in handling low or varying flow patterns or intermittent discharge is a distinct advantage in certain specific situations. In the event of such low or varying flow patterns or intermittent discharge, the plant design needs to factor in this load variance.