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Changes in physico chemical characterstics of waste water after using by SBR technology

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Abstract: - This paper covers the short portrayal about the 130 MLD sewage treatment and reuse plant which is atomized and SBR technology type situated at Bhandewadi Nagpur. In recent years, SBR has been applied as an efficient technology of waste water treatment. Present study deals with the monitoring of Physico chemical characteristics i.e. BOD_5, COD, Suspended solids (SS), Total Nitrogen, Total Phosphorous and performance evaluation of SBR municipal waste water treatment at Bhandewadi Nagpur. The process modification is very easy due to flexible nature of the SBR. The overall efficiency of SBR is higher than ASP at low cost in less space for continuous flow and for intermittent flow. Along with minimum time required to produce end products, which provides preference to SBR in selection of technology for biological treatment of waste water.

Key words: -Sequential batch reactor, municipal waste water, organic removal, nutrient removal, removal efficiency, Biological process

1. INTRODUCTION

Waste water treatment is a process used to convert waste water, which is highly polluting into an effluent that can either returned to water cycle with minimal environmental issues or reused safely. Sewage is a combination of water and waste water product, the waste product can be organic/inorganic in nature some sort of treatment is required before discharging them to different sinks so that they don't cause any water borne disease. Treatment and safe disposal of wastewater is necessary and this will facilitate protection of environment and environmental conservation. There are various technologies used in the treatment of wastewater in the present times. The best technology can be selected for a particular based on various parameters like space requirement, initial cost of the plant, operation and maintenance cost, power requirement, quantity and quality sludge producedand their performance efficiency and suitability etc. so for treatment of such kind of wastewater sequential batch reactor technology is used. The SBR represents a modern approach to waste water treatment. Unlike the traditional continuous flow activated sludge, where different reactions are carried out in separate tanks, SBR allows using a single tank for the whole process. SBR is a modified activated sludge process used to treat the variety of wastewater. In recent years SBR has been employed as an efficient technology for waste water treatment, especially for municipal wastewater because of simple configuration and high efficiency in removal of BOD_5, COD, suspended solids (SS), nitrification, de-nitrification and phosphorous. The quality and quantity of influent wastewater are floating with season, temperature and weather. In this system, waste water is added to single batch reactor, treated to remove undesirable components, and then discharged or reuse. Equalization, aeration and clarification can all be achieved using a single batch reactor. The efficiency of sewage treatment plants can evaluate by concentration of pollutant in the influent and effluent. For examination off plants design and efficiency of operation can only be used the results from waste water analysis at the inlet and outlet of the already constructed plant during its exploitation. Monitoring and performance evaluation will also helps in better understanding of design and operating difficulties in WWTP and also assess to reuse potential of treated waste water.

1.1. 130 mld sewage treatment and reuse plant bhandewadi nagpur

130 MLD STP is the India's first sewage treatment and reuse plant located at Bhandewadi, Nagpur. It is a joint project venture of SMS Limited, Nagpur Municipal Corporation (NMC) and MAHAGENCO. Entire treated waste water is supplied to MAHAGENCO's 1,980 MW Koradi Thermal Power Station.

Figure No 1

1.2. Operational conditions of sequential batch reactor

- Number of SBR Tank = 8nos.
- Area of SBR tank = (43m×35.20m×5.50m)
- SBR tank volume = 8325m^3
- Total SBR tank volume = 8nos.× 8325m= 66600m^3
- SBR tank depth = 6.5m
- Average influent flow rate =130,000 m^3/day
- Total cycle time = 240min , i.e. 6 cycles/ day
- Total fill time = 120 min (60 min fill, 60 min aeration)
- Aeration time = 120 min
- Settling time = 60 min , Decant time = 60min
- Waste sludge time = 10min
- Influent wastewater = 5417 m^3/hr
- Decant flow rate =2.7MLD/hr
- Waste sludge flow rate =250m^3/hr
- Mixed Liquor Suspended Solids(MLSS) = 3500mg/lit
- Mixed Liquor Volatile Suspended solids (MLVSS) = 2100 mg/lit

2. TREATMENT PRPOCESS

2.1 STP plant are divided into three parts:-

- Primary treatment:- Include Inlet chamber, mechanical fine screen, grit chamber, parshall flume, primary clarifier.
- Secondary treatment:- SBR (Sequential Batch Reactor), gravity sludge thickener and its distribution chamber, thickened sludge pumping station, anaerobic sludge digester, gas holder, sludge dewatering unit, digested sludge dewatering unit pumping station and Chlorine contact tank.
- Tertiary treatment:-It consists of deep bed media filter, back wash system, and tertiary treated sewage sump.

  Especially in Module-A, B, C

2.2 Process Description & Design Considerations of SBR based STP

130 D STP divided into 3 Modules: Module-A, Module-B & Module-C

2.2.1 Module-A Raw SewagePumping Station, Hiwari Nagar, Nagpur.

RCC dam is constructed on the Nag river and raw sewage water is collected. Two gates are provided to divert the flow of water and two gates are provided inlet to the sump. Two coarse type mechanical screens of Johnson make inhibit the debris of size more than 50 mm to enter the pumping station. The screen can be operated on pulse mode (time based) or on the level-based mode in which differential sensors sense the difference in water levels on both the sides of screen and accordingly operate it. Pumping station having capacity of 995m^3/hour and head of 33 m for taking sewage from Nag River. Transmission pipe line of 1200 mm diameter for transporting water from pumping station to Bhandewadi STP is 2.3 kilometers away. There are total 8 submersible pumps of Kishore Private Ltd. (6 working + 2 standbys) which pump the water from Hiwari Nagar pumping station to Sewage Treatment plant (STP) Bhandewadi.

2.2.2 Primary Treatment:-It consists of Inlet Chamber, Mechanical fine Screens, Grit Chambers, Parshall Flume, and Primary Clarifiers.

Inlet Chamber: The inlet chamber is provided at higher ground level to receive raw sewage through transmission pipelines. The purpose of providing inlet chamber is to reduce the velocity of sewage coming via pumping so as to achieve better efficiency in screening.

i)Design Flow = 130 MLD
ii) No of units = 1 no.

Mechanical Fine Screen: The Raw sewage from the inlet chamber flows by gravity into the mechanical fine screen channels. It is step type screen with automatic mechanism to remove the floating and oversized material more than 6 mm size such as plastic, debris, paper and cloth rags which could foul the downstream units. These screenings mechanically collected in a conveyor Belt and conveyed through chute to wheel barrow/trolley positioned at ground level. Mechanical screen operation will be controlled depending upon the head loss across screen which will be monitored by level transmitter provided in the screen channel. Each screen is designed for 25% of the design flow.

i) Design flow =130 MLD
ii) Mechanical Screen Type = Step type screen.
iii) No. of units = 5 nos. (4 working + 1 standby)
iv) Angle of Inclination of Screen = 35˚ to horizontal
v) Make of the equipment = Johnson

Grit Removal Chamber: The Screened Sewage from fine screen flows to inlet channel of Grit Chamber for removal of grit and small inorganic particulates. Grit chamber is equipped with Grit scrapper mechanism, Grit classifier mechanism, and organic return pump. Scrapper at the bottom of the chamber throws grit at the periphery from where it is collected by the classifier mechanism and carried above the water level and dropped on a trolley. An organic return pump is provided to send the return organics collected in the pocket back into the main chamber. The grit is settled in the main chamber and after de-gritting the sewage over flows into the outlet channel.

i)Design Flow = 130 MLD
ii)No. of Units = 4 nos.
iii)Detention time = 1min
iv)Make of equipment = Voltas Limited

Parshall Flume: After the grit is separated from the sewage, the flow measurement is done with the help of ultrasonic flow meter. The degritted water flows through the Parshall flume which is equipped with ultrasonic flow meter of Endress+Hauser Company. Sewage from parshall flume goes to clarifier through baffle walls. Alum dosing is also done to increase the BOD of raw sewage .For a 130 million liters per day (MLD) plant a flow of approximately 5400 cubic meter per hour is required.

i) No of units = 1 no.
ii) Type of flow meter = Ultrasonic Flow Meter

Primary Clarifier: The primary clarifier is used only when the BOD of incoming raw water is more than 250mg/lit. There are 4 such clarifiers with 4m depth and 32.4m diameter. The water will enter to the central portion of the clarifier till it fills the tank. Settling is done and the scrapper at the bottom collects the heavy particles easier to settle at the centre. The retention time of scrapper is 45 mins for single round. There is a pump house between the primary clarifier which pumps the sludge from the bottom of the tank and forward towards the sludge thickeners. Screw pumps are used for this purpose.

i) No of units = 4 nos.
ii) Type of flow = Radial type
iii)Retention period = 2.45 hrs
iv) BOD Removal = 50%

Wastewater overflows out of the primary clarifier to the sequential batch reactor, where the BOD of incoming water is in the range of 140-160 mg/lit, so because of this primary clarifiers are currently not in use.

C-Tech/SBR Distribution Chamber: Here, the incoming wastewater from primary clarifier is equally distributed to all 8 C-tech Basins & distribution are as follows:

1st Chamber =1-2 no Basin
2nd Chamber = 3-4 no Basin
3rd Chamber = 7-8 no Basin
4th Chamber = 5-6 no Basin

2.2.3 Secondary Treatment: - It consists of SBR (Sequential Batch Reactor), sludge pumping station, gravity sludge thickener and its distribution chamber, thickened sludge pumping station, anaerobic sludge digester, gas holder, sludge dewatering unit, digested sludge dewatering unit pumping station and Chlorine Contact Tank.

Aerobic Biological Process-(C-Tech/SBR Basins): There are total 8 no of sequential batch reactor basins equipped with air blowers, diffusers, Surplus Activated Sludge(SAS) pump, Return Activated Sludge (RAS) pump ,decanters, sensors, DO sensors, Temperature sensors, Level transmitter & MLSS sensor, auto valves, PLC etc.

One cycle in the SBR basin takes 4 hours. The complete biological operation is divided into various cyclic modes, each cycle consist of:

2-hours filling and aeration
1-hour settling (sedimentation)
1-hour Decanting

All cycles are automatically controlled by Programmable Logical Control (PLC)

Dimension of tank is (43m×35.2m×6m).Water enters the SBR through the selector basin. The RAS pump having capacity of 450 m^3/hr provides sludge to the selector basin with a recirculation ratio of 60%. This sludge mixes with the water through the overflow/underflow baffle provided near the inlet of the SBR. This process is done to ensure the bacteria do not become inactive. There are Nitrosomonas and Nitrobacteria present in the selector basin. The first one converts nitrogen to nitrate and the second one converts nitrate to nitrite which is then released into the atmosphere. These bacteria require only 10 minutes of aeration in the whole cycle. During 1st hour of fill & aeration mode, water is filled up to the level of 5.5m. Aeration is done to provide oxygen to the bacteria breeding in water assisting the bacteria to consume the unwanted organic materials in water. Total 24 (20 working + 4 standby) number of blowers of (Make-Swam Pneumatics) are provided for 8 basins, where each basin consist of 1058 number of diffusers& distance between each diffuser is 0.5m. During 2nd hour of fill & aeration mode, Ferric Chloride ($FeCl_3$) dosing is done for removal of phosphorus from the sewage water, presence of phosphorus causes scale formation in water distribution system. $FeCl^{3+} + (PO_4)^{3-} \longrightarrow FePO_4 + 3HCl$

This ferric hydroxide acts as a coagulant and a flocculent, meaning that it settles out ferric phosphate and other sulphide compounds as well as other suspended solids and microorganisms which digest suspended solids. During 3rd hour of settling mode, activated sludge is allowed to settle under quiescent conditions, no flow enters the basin and no aeration and mixing takes place. The activated sludge tends to settle as a flocculent mass, forming a distinctive interface with the clear supernatant. This phase is the critical part of the cycle, because if the solids do not settle rapidly, some sludge can be drawn off during the subsequent decant phase by means of Surplus Activated Sludge(SAS) Pump having capacity of 150 m^3/hr which is active for 10-15 minutes and undermining sludge is sent to gravity sludge thickener. Last hour is of decant mode, where clear supernatant can be decanted up to 3.7m. Once the settle phase is complete, a signal is sent to the decanter to initiate the opening of an effluent discharge valve. Here floating decanters are used to maintain the inlet orifice slightly below the water surface to minimize the removal of solids in the effluent removed during the decant phase. It is also important that no surface foam or scum is decanted. The vertical distance from the decanter to the bottom of the tank should be maximized to avoid disturbing the settled biomass. Treated water is then goes for disinfection process in chlorine contact tank (CCT). Thus (43×35.2×1.8) i.e. 2.7 million liters of water is decanted within four hours from one basin. Each basin completes 6 cycles per day and there are 8 such basins giving,(6×8×2.7)=130 MLD.

Chlorine Contact Tank (CCT): Treated water from SBR flows into chlorine contact tank (CCT) where chlorine is added for disinfection at a suitable dosing rate.8 ppm concentration is maintained for which dosing of 40 kg chlorine per hour is required. Chlorine is sucked from cylinders by usage of a diaphragm fitted in the chlorinator. Sucking mechanism is given so as even if there is a dent in pipes the air around it will be sucked rather than chlorine leaking out.Booster pumps with 55m head take water from the tank and pump it in the pipes for chlorination. A pipe through the chlorinator joins the outlet pipe of pump where pressurized water sucks the chlorine. The water being at a pressure greater than 2 kg/sq.cm helps the chlorine to get dissolved quickly. This chlorinated water is mixed with the water in the tank. Dimension of Chlorine Contact Tank is (14m×21m×3.35m), Overflow/underflow baffle walls are provided for hydraulic mixing. Reaction of 15 minutes is provided for proper disinfection. The water from CCT is pumped for tertiary treatment to deep bed media filters through pumps of Wilo Company of 45kW having a flow of 995m^3/hour and a head of 12m.

Safety System for CCT: Oxygen cylinders are provided in the case of any leakage of chlorine in CCT as inhaling chlorine is dangerous. Emergency bath and eye wash have been installed. Caustic soda tank has been provided just near to CCT. Chlorine sensors are installed this will give warning in case of any leakage. In such a case air in CCT will be taken to the caustic soda chamber through the pipes. Caustic soda (NaOH) has a property to absorb chlorine. The blowers will take the contaminated air inside the caustic soda chamber and pumps will circulate it within the chamber till chlorine is completely absorbed in NaOH thus ensuring full safety from leakage of chlorine.

2.2.4Tertiary Treatment:-It consists of deep bed media filter, back wash system, and tertiary treated pumping station

Deep Bed Media Filter (DBMF):- Treated sewage after CCT is fed to deep bed media filters which compromises of a bed of sand &anthracite over pebbles. There are 12 (10 working + 2 stand by) such deep bed media filters which filter out 130 MLD water. When treated water flows through the filter bed the suspended solids are left behind in filter beds. The retention time of DBMF is 8 hours. Size of one filter bed is (9.1m×7.5m×5.5m).

The layer of sand and pebbles is 2.5m are as follows-

200mm layer of pebbles of 25-40mm size,(bottommost layer)
150mm layer of pebbles of 12-20mm size,
150mm layer of pebbles of 6-12mm size,
240mm layer of sand of 4-8mm of size,
240mm layer of sand of 8-16mm of size,
1020mm layer of filter sand of 16-32mm of size,
500mm layer of anthracite (Activated charcoal) of 0.9mm size,

During treatment lot of dirt gets occupied on these layers which needs treatment otherwise it might get choked Backwash of the filter bed is taken when bed gets clogged by turbid particles. There are 3 air blowers are installed in the tertiary treatment building. While taking aback wash air through these blowers is forced from the bottom of the filter bed for about 10minutes. A part of treated water is stored in the overhead tanks. The size of overhead tank is (46.5m×10m×2.5m). Water through these tanks is forcefully passed through the media filters for 15-20 minutes, clearing all the particles which clog the beds. The impure water which results after backwash is sent to the dirty backwash collection tank having size of (2.92m×13.5m×4m).

Clariflocculator: Ferric alum is dosed in clariflocculator for settling of heavy particles way to settle the heavy particles. Supernatant overflows the chamber and is sent back to chlorination tank, thus ensuring zero wastage of water. The treated water is then pumped by using 8 Vertical Turbine pumps of Wilo Company (6 working + 2standby) to the Koradi Thermal Power Station (KTPS) via underground pipeline of diameter 1200mm of 19.5km. Specifications of the pump are:- 160 kW; Flowof995 m^3/hour; 1485 rpm Efficiency - 95.8%

2.2.5 Sludge Handling System:-

The sludge handling system consists of primary sludge pumping station, gravity Sludge thickener, thickener sludge pump, anaerobic sludge digester, gas holder, gas flaring and sludge dewatering unit.

Gravity sludge thickeners: **-** They are designed to thicken the sludge from primary clarifiers and SBR. The sludge gets settled on the sloping floor of the tank where it is mechanically thickened. Thickened sludge from the Gravity Sludge Thickener is pumped to the Aerobic Sludge digester using Thickened sludge Pumps. Supernatant is mixed with the water at intake.

Aerobic sludge digesters: - Two anaerobic sludge digesters are provided for digestion of thickened sludge. The retention time in a digester is 20 days. It increases the dewatering characteristics of the sludge.

Gas holder: - The biogas produced during anaerobic digestion primarily comprises of methane, carbon dioxide, and smaller amounts of Hydrogen Sulphide and ammonia. Two gas holders are given in the plant. The biogas from the gas holder is transferred to gas flare for burning.

Sludge dewatering unit:- Sludge dewatering is carried out by solid bowl centrifuge. There are 5 nos. Of sludge dewatering machines (decanters) of Hiller Company. The sludge is fed to solid bowl centrifuge and polyelectrolyte is dosed at the inlet of centrifuge to enhance dewatering efficiency.Aeration is done in sludge before feeding to centrifuge for proper mixing of polyelectrolyte with the sludge. The aerated sludge is sent to the dewatering unit on the first floor. The dewatered sludge is collected directly in the trolleys. The supernatant is fed to the inlet.

Advantages

- Equalization, primary clarification, biological treatment and secondary clarification can be achieved in a single reactor vessel.
- Operating flexibility and control.
- Potential capital cost savings by eliminating clarifiers and other equipments

Disadvantage

- A higher level of sophistication, (compared to conventional system), especially for larger system, of timing units and controls is required.
- Higher level of maintenance (compared to conventional systems) associated with more sophisticated controls, automated switches and automated valves.
- Potential of discharging floating or settled sludge during the draw or decant phases with some SBR configurations.

3. RESULTS AND DISSICUTIONS

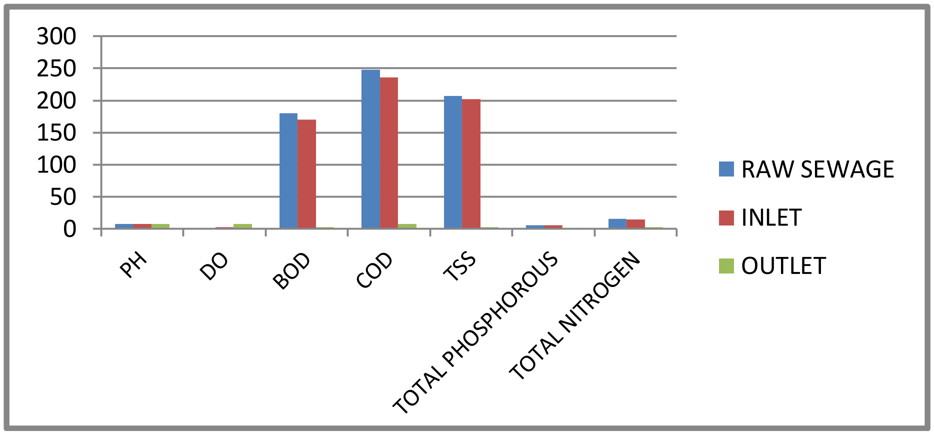
Results

In this project Sequential batch reactor is used for sewage treatment, during this study I found these results:-

Parameter	Unit	SBR technology (Avg. Results)				Designed outlet value
		Raw sewage	Inlet	Outlet	Efficiency %	
pH	Mg/l	7.75	7.67	7.68	-	6.8-7.8
DO	Mg/l	0.18	2.18	7.3	-	>2
BOD_5@20°C	Mg/l	180	170	3	98.33%	<5
COD	Mg/l	248	236	8	96.77%	-
TSS	Mg/l	207	202	3	98.55%	<5

Total phosphorous	**Mg/l**	**5.960**	**5.221**	**0.370**	**93.79%**	**<0.5**
Total nitrogen	**Mg/l**	**15.40**	**14.28**	**3.08**	**80%**	**<10**

Table no. 1



Graph no 1

4. DISSICUSSION

- The pH of water sample collected from different station was ranging from 6.8-7.8 .
- The treatment efficiency of the SBR based on BOD removal during rainy season is more which is 98.33% of the removal efficiency.
- As increase in BOD the DO of water gets depleted.
- The effluent COD obtained from SBR plant having removal efficiency of 97.66% respectively.
- For removal of phosphorous SBR system having higher efficiency that is 93.79%.
- The SBR system has higher ability to remove total nitrogen (TKN) concentration that is 80%.

5. CONCLUSION

The treatment of sewage has been a challenge throughout the years due to varying raw water characteristics. and strict effluent regulation. Based on the observation and result obtained from the study following points are concluded:-

- SBR system has high efficiency in removing BOD, COD, TSS, Total kjedhal nitrogen and total phosphorous.
- Minimum time required to produce end product as compared to ASP plant.
- Less chemical consumption.
- Conformity of BOD, MLSS, and DO as the plant operated though atomized system.
- Authorized chlorination system to destroy the pathogenic bacteria for controlling BOD.
- Fully atomized is advancement in SBR System to minimize manpower cost.
- SBR process have better MLSS to MLVSS ratio than conventional ASP.
- High potential to reduce TSS and Turbidity Through dual bed filter media as compared to rapid sand filter.
- Higher overall efficiencies with lesser cost and space requirement for SBR process provide itself the maximum probability in selection of technology for biological treatment of waste water.

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7. FUTURE SCOPE

- Generated methane gas from SBR process will be used as a fuel for domestic transport/public transport.
- Increases chances of employment.
- Water scarcity will somehow reduce.
- In future, treated effluent from SBR Will be distributed to people for household work like washing and cleaning.

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