DESCRIPTION FOR
SEAWGE TREATMENT PLANT
ON
SEQUENTIAL BATCH REACTOR TECHNOLOGY
FOR MUNICIPAL SEWAGE TREATMENT

INTRODUCTION
This is the Detailed description for the Sewage treatment plant on SBR technology is as below;
The treatment scheme consists of
A) Raw Sewage Receiving and Pumping Station
B) Primary Treatment Units,
C) Secondary Treatment Units,
D) Disinfection Arrangement
E) Sludge Dewatering (Solid liquid separation)
TYPICAL RAW SEWAGE PUMP HOUSE

PROCESS DIAGRAM

INLET CHAMBER OF SEWAGE TREATMENT PLANT → PRIMARY TREATMENT → SECONDARY TREATMENT SBR → DISINFECTION ARRANGEMENT

- Stilling Chamber
- Fine screen Channel
- Grit Chamber
- Distribution Chamber

Flow measurement → SLUDGE HANDLING SYSTEM → Nalla/drain
Description of Process Offered:

The Plant is based on Sequential Batch Reactor Technology popularly known as SBR Technology. Unlike various processes of treatments the raw sewage as obtained for the treatment undergoes Physio-Chemical & Biological Treatments. The first part treatment is the Primary Treatment to the raw sewage, which covers the physical activities like screening, de-gritting, flow measurement, flow distribution and primary sludge settling Tanks in which about BOD @ 30% - 45% and SS about 45% - 60% is removed. The plant is designed in accordance with the characteristics of influent/effluent as provided and according to the guidelines set up by the ‘CPHEEO Manual’, published by the Govt. of India and book on Wastewater Engineering Treatment and reuse published by Metcalf & Eddy, (fourth Edition). The detailed description of individual units & their functions are given below.

PRIMARY TREATMENT

Primary Units:

The first unit of Primary treatment is the Inlet / receiving Chamber, in which the discharge from Common Rising main through Raw Sewage Pumps is received. The inlet chamber is mainly used to control the velocity of raw influent and also for its smooth distribution of flow to the fine screen channel. Suitable channels 50% standby capacity are provided after inlet chamber, each channel is designed for to handle Design flow. All working screen channels will be equipped with mechanically operated fine screen with 50% capacity manual screen channel will be used as stand by. Screen channel are designed velocity of 1.2 m/s (max.) at peak flow. Necessary sluice gates are provided upstream/downstream of the channel to isolate the screen when it is under maintenance. Further the screenings is conveyed to the disposal through a belt conveyor. The screening will be disposed of by suitable arrangement.

The screened influent then flows to Grit chambers. Grit chambers each designed for Peak flow. The grit separator is designed to remove inorganic matter of specific gravity more than 2.65 and grit particle size more than 0.15 mm. The settled grit is removed from the chamber by screw conveyor / mechanism provided to the side channel. Accumulated grit is collected from the screw conveyor taken to bottom through chute. Organic wash water pump is provided for washing of grit to separate organic matter attached to grit if any.
SECONDARY TREATMENT

SBR Process: -

SBR is a SEQUENTIAL BATCH REACTOR process. It provides highest treatment efficiency possible in a single step biological process.

SBR – System is operated in a batch mode in sequence which eliminates all the inefficiencies of the continuous processes. A batch reactor is a perfect reactor, which ensures 100% treatment. Two basins are provided to ensure continuous treatment and the flow is distributed by providing weir in splitter chamber. To maintain the cycle Gate at inlet of anoxic zone of basin is provided controlled on PLC. The complete process takes place in a single reactor, within which all biological treatment steps take place sequentially. The SBR basins are equipped with air blowers, diffusers, Excess /Waste Activated Sludge (WAS) pumps, Decanters, Auto valves, PLC etc. All cycles will be automatically controlled using PLC. Excess sludge at a consistency level of approx
0.8% - 1.0% will be pumped intermittently from WAS pump to the sludge sump. The sludge from sludge sump is taken for dewatering to centrifuge units and finally for its ultimate disposal. The treated effluent from the SBR Basins will conveyed to Chlorine contact tank for disinfection NO additional settling unit / secondary clarifier are required.

The complete biological operation is divided into cycles. Each cycle is of 3-4 hrs duration, during which all treatment steps take place.

**Explanation of cyclic operation:**

A basic cycle comprises:
- Fill-Aeration (F/A) – 1.5 Hrs
- Settling (S) – 0.75 .Hrs
- Decanting (D) -0.75 .Hrs

Typically total Duration of Each Cycle is 3.0 hrs

**A Typical Cycle**

During the period of fill/aeration cycle, the liquid is filled in the SBR Basin up to a set operating water level. Air Blowers are started for aeration of the influent. After the fill/aeration cycle, the biomass settles under perfect settling conditions. After settling cycle Settled the supernatant is removed from the top using a DECANTER. Solids are wasted from the tanks during the decanting phase.

The SBR Technology is configuration of activated sludge process which operates on extended aeration of activated sludge. This works on the principle for BOD reduction, Nitrification, Denitrification as well as biological phosphorous removal. This is equipped with energy efficient fine bubble membrane diffused aeration system, with automatic control of oxygen uptake rate, resulting in 20 – 30% power savings.

**Fully PLC Based Control for Operation:** - The complete operation of the SBR basin/reactor is controlled automatically through PLC system, which is a major factor in reducing operating costs. All key functions like, Recycle of activated sewage, sludge wasting, aeration control, batch cycle time control, decanting rate etc are automatically controlled along with data logging. Complete historical records of plant operation are available on SCADA system.

**Decanting arrangement:** - The supernatant after settling is removed from the basin using a stainless steel Decanter. During decanting there is no inflow to the basin. The moving weir DECANTER is motor driven and travels slowly from its “park” position to a designated bottom water level. Variable frequency drives are provided to control the rate of movement of the
Decanters. After the required level of supernatant is removed, the Decanter is returned to its “park” position through reversal of the drive. The basin is now ready for the next cycle to begin. Stainless steel fabrication ensures resistant to corrosion, long equipment life without any/no maintenance

**Aeration:** - The aeration system is equipped with high quality fine bubble membrane diffusers. With fixed type. This system is of most important core part playing major role of saving power in this technology.

**Process Chemistry**

i) Due to Extended aeration oxidation of organic matter in waste water, nitrification is enhanced.

ii) In anoxic zone (formed at bottom zone of basin) denitrification of nitrates is achieved by recirculation of activated sludge from aeration zone. The retention period and recycle ratio is designed as per Metcalf & Eddy.

**BOD removal and Nitrification in Aeration zone**

**i) BOD removal**

The aeration zone of SBR basin is provided with diffused aeration system to oxidize the organic matter by activated sludge. The activated sludge in aeration zone is capable of converting most organic wastes to stable inorganic forms or to cellular mass. In this process, the soluble and colloidal organic material is metabolized by a diverse group of microorganisms to carbon dioxide and water. At the same time, a sizeable fraction of incoming organic matter is converted to cellular mass that can be separated from the effluent by settling. Activated sludge comprises a mixed microbial culture wherein the bacteria are responsible for oxidizing the organic matter, while protozoa consume the dispersed un-flocculated bacteria and rotifers consume the unsettled small bio-flocs in the treated wastewater, performing the role of effluent polishers. The utilization of substrate by a bacterial cell can be described as a three-step process:

a. The substrate molecule contacts with the cell wall.

b. The substrate molecule is transported into the cell.

c. Metabolism of the substrate molecule within the cell

However, as the bacteria require the molecule in the soluble form, colloidal, spherically incompatible molecules, which cannot be readily biodegradable, have to be first adsorbed to the cell surface and hydrolyzed or transformed externally to transportable fractions by exo-enzymes or wall-bounded enzymes. The organic matter will be utilized by the bacteria resulting in cell
synthesis and energy for maintenance. Nutrients available in the wastewater cater to the nutrient requirements of the aerobic microorganisms and to enhance the activity of the aerobic microbes. In addition to the nutrient requirements, the aerobic microbes require oxygen to sustain their microbial activity. Oxygen functions as a terminal electron acceptor in the energy metabolism of the aerobic heterotrophic organisms indigenous to the activated sludge process. In other words a portion of the organic material removed is oxidized to provide energy for the maintenance function and the synthesis function.

The following reactions best describe the organic substrate utilization by the aerobic bacteria:

**Oxidation**
\[
\text{COHNS} + \text{O}_2 \rightarrow \text{CO}_2 + \text{NH}_3 + \text{C}_5\text{H}_7\text{NO}_2 + \text{Other end products}
\]
Organic matter    Bacteria    New cells

**Endogenous respiration**
\[
\text{C}_5\text{H}_7\text{NO}_2 + 5\text{O}_2 \rightarrow 5\text{CO}_2 + 2\text{H}_2\text{O} + \text{NH}_3 + \text{energy}
\]
New cells    Bacteria

**Synthesis**
\[
\text{COHNS} + \text{O}_2 + \text{Bacteria} \rightarrow \text{C}_5\text{H}_7\text{O}_2\text{N} \text{ (New Bacterial Cell)}
\]

It is to be noted that the activated sludge in SBR Basin operates in extended aeration mode. An extended aeration activated sludge process operates in the endogenous respiration phase of the growth curve where the microorganisms are forced to metabolize their own protoplasm due to the limited availability of food or substrate. During this phase, the nutrients remaining in the dead cells diffuse out to furnish the remaining cells with food.

This system has been developed for application where minimum bio-solids production is desirable. Less solids production is achieved by using a larger fraction of the entering organic material for energy rather than for synthesis. This means that more oxygen will be consumed per unit mass of organic material removal.

**ii) Nitrification**

Extended Aeration system, with high sludge retention time (\(\Theta_c\)) and DO > 2.0 mg/L ensures uniform nitrification. Nitrification results from the oxidation of ammonia present in the sewage by Nitrosomonas to nitrite and the subsequent oxidation of the nitrite to nitrate by Nitrobacter. The nitrifying organisms are strict aerobes and require more than 2 mg/L DO in the basin to avoid oxygen limitation. The nitrification of ammonia can be represented as given below:
The diffused aeration system is sized in such a way that sufficient oxygen is provided for carbonaceous oxidation, sludge stabilization, nitrification by maintaining the DO at the specified level of 2 mg/L. The capacity of diffused aeration in each SBR basin will be sufficient to ensure good and uniform mixing conditions during Fill - Aeration phase of the cycle of operation.

**Denitrification in Anoxic Zone**

The wastewater enters into the anoxic zone provided in front of aeration basin. / reactor, where anoxic conditions are maintained. To maintain anoxic condition 50-100% recirculation of activated sludge is proposed As microorganisms meet high BOD, low DO conditions in the anoxic zone.

This is very effective in containing all of the known low F/M bulking microorganisms and eliminates the problems of bulking and surface foaming. Also, due to the anoxic/anaerobic conditions in the anoxic zone, denitrification and phosphorous release occurs. The process of denitrification of nitrates is represented as:

\[
\text{NO}_3^- \rightarrow \text{NO}_2^- \rightarrow \text{NO} \rightarrow \text{N}_2 \rightarrow \text{N}_2\text{O}^- \rightarrow \text{N}_2
\]

Denitrification releases nitrogen which escapes off as an inert gas to the atmosphere.
SLUDGE DEWATERING SYSTEM

Sludge Handling System:

Sludge Sump :-
The digested sludge from anaerobic sludge digester is pumped to sludge sump. Sludge sump is designed as per CPHEEO manual Provisions. Stored sludge conveyed to centrifuge unit for dewatering. The necessary centrifuge feed pumps & Centrifuges will be provided. An arrangement of dosing polyelectrolyte to centrifuge is proposed as per tender requirement. Additional storage platform for storage of sludge is provided.

Centrifuge Unit:
The sludge collected in sludge sump is furthered dewatered with the help of centrifuge and the volume of sludge is reduced and sent for disposal in landfill or dumping yard.

DISINFECTION ARRANGEMENT:-
Chlorination arrangement is proposed for disinfection of treated sewage for reduction of Fecal coliform level as desired.
The *CHARACTERISTICS OF TREATED EFFLUENT WILL BE* :-

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