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# Modernization of Existing 27 MLD Sewage Treatment Plant at Brahmpuri, Jaipur, India: A Model Study

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## Abstract

*The renovation and modernization work for 27 MLD STP at Brahmpuri, Jaipur was taken up after it becoming defunct in year 2000-2001. Besides renovating the civil structures, modern day state of the art and energy efficient mechanical and electrical machineries were installed with man-machine interface for efficient and effective operation and maintenance of the treatment process. The treatment process is based on extended aeration with introduction of energy efficient fine bubble diffused aeration system instead of outdated and energy intensive surface aerators. Sludge is being handled in aerobic digesters. Digested sludge is pumped to centrifuge unit where it is converted to semi solid form having consistency of approximately 22% solids to be used as manure for agriculture purposes by nearby farmers. The STP was commissioned after renovation and modernization work with the full plant capacity flow of 27 MLD. The main aim of modernization was to take care of effective removal of inorganic material as primary treatment unit which was a major reason for the plant to be defunct due to carrying over of inorganic to the reactor tank and to use energy efficient machinery for energy saving. The power saving is mainly achieved through the running of air blowers on variable frequency drive controlled by the level of dissolved oxygen in the reactor.*

**Keywords:** Fine bubble diffused aeration system, variable frequency drive (VFD), detritor, centrifuge.

## Introduction

The existing Sewage Treatment Plant at Brahmpuri, Jaipur was constructed in late 1980s with the aid of World Bank through Public Heath Engineering Department (PHED) under State Government. The Operation and Maintenance of the STP was since its construction was with PHED only and in late 1990s and 1996 the revamp of the STP was taken up by PHED wherein the major work of replacement of defunct surface aerators was taken up along with refurbishment of grit separator unit. But, soon the operation of the plant degraded and was almost defunct by 2000-2001. The treated water from the STP was discharged into the nearby man made Mansagar Lake, thereby polluting the Lake with creating unhygienic conditions in the Lake surroundings. The almost defunct STP was thus selected for Renovation and modernization[1,2] with discharge[3] of better quality effluent into Mansagar Lake. Rajasthan Urban Infrastructure Development Project (RUIDP) took up the renovation and modernization of almost defunct Sewage Treatment Plant[4] which was a first step towards rejuvenation of Mansagar Lake[5], to recoup the evaporation losses and maintain its water level after rainy season. The modernization work of the STP was completed in 2008 and since then the STP is in Operation and maintenance for 5 years with the same contractor who has done the renovation work, through Jaipur Municipal Corporation. The STP caters to around 2.5 lac population of walled city area with subhash chowk, chaugan stadium and Mount road as the delineating boundary the STP caters to. The topography of the area is such that it permits the conveyance of sewage through gravity only and the outfall sewer of 1100 mm diameter reaching at STP is almost on ground (partly above), which avoids the requirement of raw sewage pumping required at most of the STPs in other parts of the state or country. The salient features of STP are given below in table-1.

**Table-1**
**Salient Features of 27 MLD STP**

| Particulars | Details |
|---|---|
| Capacity | 27 MLD |
| Work cost | Total Rs. 699 lacs in year 2004-05. OandM cost for 5 years is Rs.90 lacs. |
| Process | Extended Aeration Process with aerobic Digester and centrifuge unit ( no sludge drying beds) |
| Size of outfall sewer at STP | 1100 mm |
| Design flow for outfall sewer | 54 MLD |

## Methodology

The STP is functioning on extended aeration technology[6-7] with aerobic digesters. The key feature of modernization work is the replacement of outdated surface aerators with energy efficient fine bubble[8-11] diffused aeration system. Sludge is being handled in aerobic digesters. Digested sludge is pumped to centrifuge unit where it is converted to semi solid form having consistency of approximately 22% solids and used as manure for agriculture purposes by nearby farmers[12-14]. The STP was commissioned after renovation and modernization work with the full plant capacity flow of 27 MLD.

Main features of Renovation and modernization work included: Replacement of existing surface aerators with more energy efficient tubular fine bubble diffused aeration System with air blowers along with VFD.

**Figure-1**
**Diffused Aeration System**

Installation of Programmable Logic Control (PLC) for effective operation of the Treatment Plant.

Construction of new detritor unit for effective removal of inorganic materials thereby preventing silting up of the reactor which was the regular and major cause of non-functioning of the Sewage Treatment Plant to the desired effluent parameters.

Replacing the existing Fine screen with more efficient Step type fine screen. Introducing coarse screen upstream of fine screen.

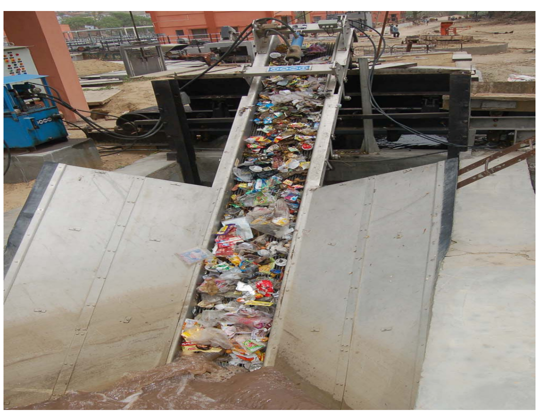

**Figure-2**
**New Step Type Fine Screen**

Introducing Ultrasonic flow meter for measurement of inflow into the treatment plant for effective and efficient operation and maintenance of the Plant. Replacement of the clarifier mechanism, excess and return sludge pumps.

**Figure-3**
**New Coarse Screen**

Refurbishment of the surface aerators in sludge digester Unit. Sludge drying beds were abandoned and mechanical dewatering unit (centrifuge with polyelectrolyte dosing) was introduced.

## Results and Discussion

The Treatment plant is generating outlet parameters of 20 mg/l of BOD5, 30 mg/l of SS and 250 mg/l of COD. The secondary treated water from the STP is thus taken as influent to 7.5 MLD Tertiary Treatment Plant (TTP) with physico-chemical treatment facility along with Bioremediation near Mansagar Lake to discharge the effluent into water body with outlet parameters of 3 mg/l of BOD5, 5 mg/l of SS and 100 mg/l of COD.

Excess Sludge Thickener is provided to concentrate the excess sludge to a level of 5%-6% consistency through gravity. Excess sludge is then digested in the aerobic digester wherein the consistency of sludge is further brought down to the level of 7%-8% and is then ultimately dewatered in the newly installed mechanical dewatering unit i.e. centrifuge and finally the sludge of 22% consistency is used as a manure by the farmers.

Operation and Maintenance for 5 years is with the same Contractor who has done the modernization work. Power Guarantee of 6400 KwH/day is given by the contractor throughout the O and M period of 5 years. O and M cost includes the cost of Man power, wear and tear of machinery, chemical and maintenance of the plantation (to maintain 33% green area). O and M expenditure of STP is given in table -2.

The operating cost comes to around Rs. 40,000-43,000 per MLD up to secondary level treatment.

The average Characteristics of wastewater received at STP and those of the treated wastewater are summarized in table no.3, which are based on the data obtained from the records of STP for a period (all values are shown in terms of average+-SD with number of samples).

**Table-2**
**Operation and Maintenance**

| **Expenditure on O and M** | **Cost per month (Rs.)** | | |
|---|---|---|---|
| | **Power charges / Month ( Borne by the Government)** | **OandM cost per Month** | **Total Oand M Cost** |
| 1st year( 2008-09) | 9.10-9.60 lacs | 1.5 lacs | 10.60-11.10 lacs |
| 2nd year( 2009-10) | 9.25-9.75 lacs | 1.5 lacs | 10.75-11.25 lacs |
| 3rd year( 2010-11) | 9.30-9.75 lacs | 1.5lacs | 10.80-11.25 lacs |
| 4th year( 2011-12) | 9.50-10.08 lacs | 1.5 lacs | 11.0-11.58 lacs |
| 5th year( 2012-13) | 9.60-10.17 lacs | 1.5 lacs | 11.10-11.67 lacs |

**Table-3**
**Sewage Characteristics**

| **Parameters** | **Designed Raw Sewage parameter** | **Guaranteed Parameter for Treated Waste Water** | **Parameters of treated wastewater** |
|---|---|---|---|
| BOD | Up to 300 mg/lit | 20 mg/lit or less | 18-20 mg/lit |
| COD | Up to 700 mg/lit | 250 mg/lit or less | 165-230 mg/lit |
| Suspended solids | Up to 600 mg/lit | 30 mg/lit or less | 26-30 mg/lit |
| pH | 7.2 to 7.9 | 6 to 9 | 7.2-7.9 |
| Ammonnical Nitrogen | Up to 35 mg/lit | No treatment at present. | - |
| Total Nitrogen | Up to 55 mg/lit | No treatment at present | - |
| Total Phosphates | Up to 16 mg/lit | No treatment at present | - |
| TDS | Up to 1500 mg/lit | No treatment | - |

## Conclusion

Considerable power is saved through newly installed Air Blowers which are run on Variable Frequency Drive (VFD) which in turn is governed by minimum Dissolved Oxygen (DO) levels maintained in the aeration reactor. DO analyzer installed in the aeration tank (reactor) is connected to VFD through PLC. The VFD is controlled by signals generated by the DO Analyzers, in proportion to the dissolved oxygen content in the mixed liquor exiting the aeration tank compartments. The air blowers fitted with VFD to maintain the required dissolved oxygen concentration in the aeration and effectively control the required airflow rate. The air in the aeration tank is provided through the retrievable type membrane (EPDM) diffusers, placed nearly six inches above the reactor floor level, covering the entire floor area, for uniform distribution of air.

The existing monthly power consumption of the plant was around Rs.10,12,500 before renovation work which after completion of modernization was brought down to Rs. 9,60,000, with guaranteed power consumption of 6400 Kw/ day and guaranteed outlet parameters by the operation and maintenance contractor.

Thus, the direct savings in the power consumption of around 5% was achieved by merely installing the energy efficient diffused aeration system. The consistent secondary outlet parameter from the STP is further treated in 7.5 MLD TTP (Tertiary Treatment Plant) through wetlands and Bioremediation before discharging into the Lake.

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