Sewage Treatment Plant (STP) : Industry 4.0 Case Study switch from Breakdown to Predictive Maintenance

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Abstract: *Sewage Treatment Plant(STP) in any organization/establishment is 24 x7 running utility system that works for conservation and recycle of water to be used for other that portable usage. The sewage treatment plant installed at Indira college of engineering and management (ICEM) is of 50,000 liters capacity and works continuously. The STP treats the water coming from various sources and makes it reusable for gardening and flush water purposes in academic wing and hostel block of the institute. The STP was studied in details to locate the reasons of common failures and frequent needs of maintenance. Few operating parameters were constantly observed. The system was upgraded from breakdown maintenance to preventive maintenance with series of observations and then upgraded to predictive maintenance as per the Industry 4.0 principles. The article presents the case study in view of predictive maintenance practices of Industry 4.0.*

Keywords: STP, Maintenance, Schedules, practices, upgradation

1. INTRODUCTION

Sewage treatment plant (STP) is a type of wastewater treatment plant whose primary objective is to separate pollutants from sewage (waste water) to produce an effluent that is suitable for discharge to the surrounding environment or else can be intended for reuse application, thereby preventing water pollution from waste water or contaminated (untreated) discharges into the environment. [1] Sewage contains wastewater from various processes and possibly pre-treated industrial wastewater. There are numerous sewage treatment processes to choose from decentralized systems (including on-site treatment systems) to large centralized systems involving a network of pipes and pump stations (called sewerage) which convey the sewage to a treatment plant. Sewage treatment often involves two main stages, called primary and secondary treatment, while advanced treatment also incorporates a tertiary treatment stage with polishing processes and nutrient removal. Secondary treatment can reduce organic matter (measured as biological oxygen demand) from sewage, using aerobic or anaerobic biological processes. A large number of sewage treatment technologies have been developed, mostly using biological treatment processes. Engineers and decision makers need to take into account technical and economic criteria, as well as quantitative and qualitative aspects of each alternative when choosing a suitable technology. [2] Often, the main criteria for selection are: desired effluent quality, expected construction and operating costs, availability of land, energy requirements and sustainability aspects. The treatment of sewage is part of the field of sanitation. Sanitation also includes the management of human waste and solid waste as well as stormwater (drainage) management. [3] The term "sewage treatment plant" is often used interchangeably with the term "wastewater treatment plant". [4] The sewage treatment can be processed by two methods

I. **Low tech, extensive or nature-based processes** : They often use little or no energy. Some of these systems do not provide a high level of treatment, or only treat part of the sewage (for example only the toilet wastewater), or they only provide pre-treatment, like septic tanks. On the other hand, some systems are capable of providing a good performance, satisfactory for several applications. Many of these systems are based on natural treatment processes, requiring large areas, while others are more compact. In most cases, they are used in rural areas or in small to medium-sized communities. Due to their technical simplicity, most of the savings (compared with high tech systems) are in terms of operation and maintenance costs.

II. **High tech, intensive or mechanized processes** : Examples for more high-tech, intensive or "mechanized", often relatively expensive sewage treatment systems are listed below:

a. Activated sludge systems
b. Aerobic granulation
c. Aerobic treatment system
d. Enhanced biological phosphorus removal
e. Expanded granular sludge bed digestion
f. Extended aeration
g. Filtration
h. Membrane bioreactor
i. Moving bed biofilm reactor
j. Reverse osmosis
k. Rotating biological contactor
l. Sequencing batch reactor
m. Trickling filter
n. Ultrafiltration
o. Ultraviolet disinfection

Broadly speaking, the activated sludge process achieves a high effluent quality but is relatively expensive and energy intensive [4]

2. STP at ICEM

The sewage treatment plant at ICEM is High Tech with Mechanized processes, The STP was installed in collaboration with Deccan Environmental consultants and Deccan Water Treatment Private limited, Pune on 29th August 2007. The STP includes following major components:

1. Bar screen : The tank which acts as a feeder of the contaminated or waste water to STP (T-01)
2. Equalization Tank: 35784 Liters capacity (T-02), Air Grid (AG-01), (M-01)
3. Aeration Tank: 38304 Liters capacity (T-03), Air Grid (AG-02), Aeration Tank Media (M-01)
4. Settling Tank: 14400 Liter capacity (T-04), Settling Tank Media (M-02)
5. Filter Feed Tank : 18480 Liter capacity (T-05)
6. Sludge Digester :23760 Liter capacity (T-06)
7. Garden Tank: 15000 Liter Capacity
8. Hypo. Dosing Tank : 100 Liter (T-07)
9. Sludge Pump: 4.5 cubic meter per hour capacity (P-03)
10. Air Blower: 120 cubic meter per hour capacity (AB-01/02)
11. Filter Feed Pump: 9.5 cubic meter per hour capacity (P-04/05)
12. Transfer (Feed)pump : 8.5 cubic meter per hour capacity (P-01/02)
13. Pressurized Sand Filter : 1meter diameter cylinder (SF-01)
14. Activated Carbon Filter Tank : 1meter diameter cylinder (CF-01)

The process and the layout of the STP is as shown below in Fig.1

The overall capacity of the STP is 1,30,728 Liters and is capable of providing treated water free of effluents to around 50000 Liters per day.

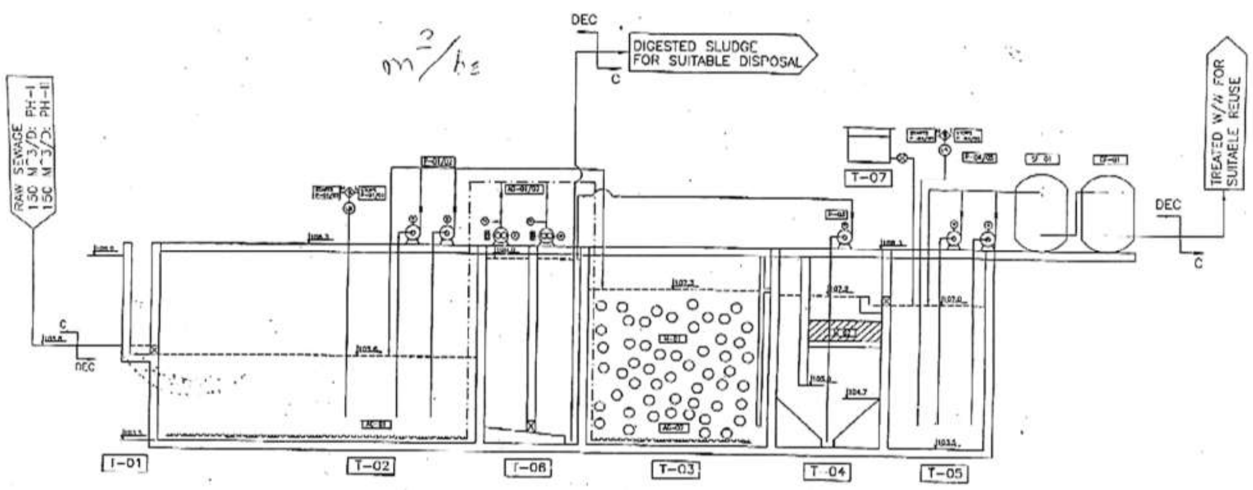

Figure 1 Sewage Treatment Plant at ICEM

The STP at ICEM takes contaminated and waste water generated from various facilities at the campus which includes the 24 washrooms in academic block, the waste water generated in cleaning processes on daily basis through floor cleaning, utensil cleaning at canteen and food process waste water from canteen, the washrooms in Hostel block and admin block and the waste water generated from clothe cleaning areas in hostel block. All this is brought together through pipelines to central STP located at one corner of ICEM and is collected in feed tank (Bar screen,T-01). From Bar screen all the waste water is transferred at steady rate to equalization tank (T-02), The equalization tank is the first collection tank in an STP. Its main function is to act as buffer: To collect the incoming raw sewage that comes at widely fluctuating rates, and pass it on to the rest of the STP at a steady (average) flow rate. During the peak hours, sewage comes at a high rate. After the equalization tank the sludge is passed on to aeration tank (T-03), the biological treatment of the wastewater takes place in the aeration tank. Before the wastewater gets to this tank, it is mixed with activated sludge. This contains countless microorganisms, such as bacteria, that are able to break down the colloidal, organic contaminants dissolved in the waste water. In the aeration tank floating plastic carriers (media, M-01) is suspended within the aeration tank to increase the number of microorganisms available to treat the wastewater. The microorganisms consume organic material.

After this step the sludge is passed on to settling tank (T-04), the settling tank allows suspended particles to settle out of water or wastewater as it flows slowly through the tank, thereby providing some degree of purification. A layer of accumulated solids, called sludge, forms at the bottom of the tank and is periodically removed . Proper coagulants and flocculants such as lime and alum are utilized to convert the amount of dissolved matter into suspended solids and act as settling tank media (M-02). The treated water to some extent is then pumped and passed on to filter feed tank (T-05), In this chamber, the suspended solids accumulate at the bottom of the tank which is then eliminated into the sludge holding tank with the help of sludge transfer pump. Then clarified water overflows from settling tank to clear water (Filter Feed) tank. The supernatant (clear water) will be pumped and passed through sand filter (SF-01) and activated carbon filter (CF-01) and this treated water will be used for gardening, toilet flush etc. The sludge which settles down is pumped into sludge digestor: Thickened waste activated sludge (WAS) along with fermented primary sludge and scum, are pumped to the digesters. The digesters are closed circular tanks. The digestion uses the naturally-occurring anaerobic (i.e., living without oxygen) microorganisms to break down organic materials into methane and carbon dioxide. The sludge is heated to 37 degrees C in the primary digester to improve the rate of digestion. The sludge then enters the secondary digester. Anaerobic digestion is a biological process which breaks down a significant quantity of organic solids in the sludge. The sludge collected can be disposed as manure once in a year.

3. Maintenance Practices of STP

The STP is operating as detailed above daily without break has some maintenance needs and shall be identified in real time. Although the maintenance practices earlier since the installation of plant since 2007 were always breakdown based. This many times has hampered the watering requirements for gardening and flushing. The STP has the capacity to deliver 50000liters of treated water on daily basis. This much water is required for the maintenance of garden, shrubs and washrooms in campus. In case of breakdown of the plant the water requirements were to be fulfilled using the water tankers, supplying 50000 liters of water daily during breakdown period was a costly affair. Then it was suggested to identify the frequent failure components. The components identified were reported to be:

A. Foot valve (2 monthly)
B. Flanges of Pump (3 months)
C. Gaskets of Flange couplings (monthly)
D. Plummer block gasket
E. Air blower belt (bi monthly)
F. Air blower pipe (annual)
G. Pump impellers (2 to 3 years)
H. Motor rewinding (9 -15 months)
I. Flow control valve (2-3 months)
J. Blower oil change (monthly)
K. Butterfly valves carbon filter (annual)
L. Carbon and sand replacement (annual)

In the next step of this observation a format was provided to the STP operators to note the failure, replacement time and total run time. The format provided is as shown in Table 1.

Table 1 the form for noting the breakdown schedules

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001

Breakdown Chart for STP

Month: **Year:**

Sr. No.	Component/ Chemical Replaced	Time and Date of Breakdown	Time and Date of Replacement	Total run time	Sign of Operator
1					
2					
3					
4					
5					

*to be submitted on monthly basis to administrator office

Administration Officer **Principal**

The major purpose of proving the form is to collect data and to install preventive maintenance schedules based on analysis. The data collection started in May 2017. The data collected over a year was analyzed for installing preventive maintenance schedule.

4. Analysis of Break down and Preventive maintenance Installation

Although the preventive maintenance is scheduled as per this it was observed that there remains uncertainty for component life and service availability. Hence it was decided to shift to predictive maintenance. The breakdown data was collected on daily basis for major components of the STP and after collecting the data over a large period. The Time between consecutive failures was estimated. The Fig. 2 shows the Time between consecutive failures for major components. The data is spread over 35 cycles. out of all 35 cycles of days, bi monthly data is considered for analysis.

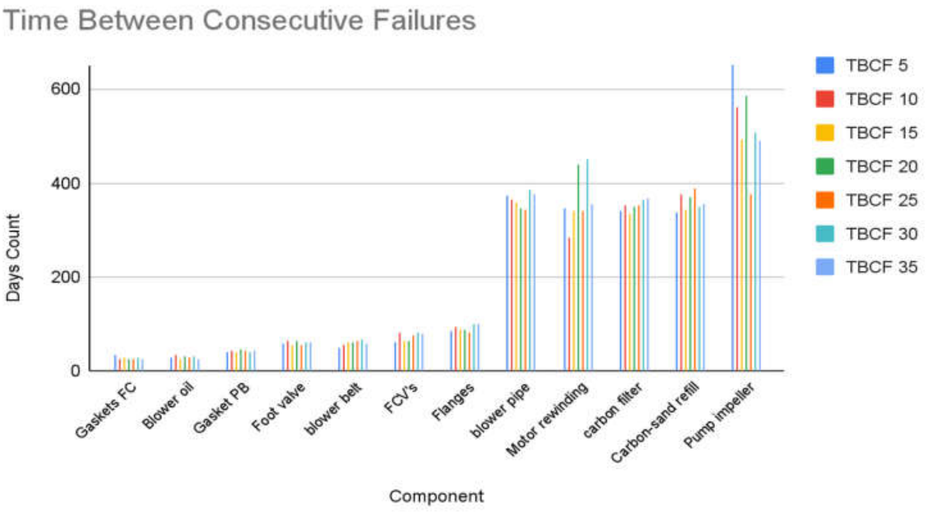

Figure 2 The failure days for various components

based on the data between consecutive failures, a time averaging method is used to establish the preventive maintenance schedule of various components. It is suggested to the operators to follow the schedule and order the part well in advance so that inventory can be reduced. The ordering schedule is prepared based on availability of the component in local market or distant market. The preventive and component procurement schedule is as follows.

Table 2 The preventive maintenance schedule

Component	Avg Run Time	Availability	Procurement
Gaskets FC	30	Local	25
Blower oil	31	Local	25
Gasket PB	45	Distant	30
Foot valve	61	Distant	45
blower belt	61	Local	50
FCV's	75	Distant	60
Flanges	91	Local	80
blower pipe	361	Local	350
Motor rewinding	373	Local	360
carbon filter	356	Distant	345
Carbon-sand refill	361	Distant	345
Pump impeller	540	Distant	525

This way the Breakdown maintenance practices were converted to preventive maintenance practices.

5. Preventive to Predictive maintenance

Because of the inherent uncertainty even in case of preventive maintenance, predictive maintenance is always well supported with reasons for replacement or possible maintenance. For implementation of predictive maintenance few of the major components were identified based on VED analysis and the parameters that indicate health status of the device are identified. For example:

Component			
Foot valve	Blockage %	Pressure drop	Suction pipe vibration
Gasket	Hardness	Cracking	
Blower belt	Hardness	Tension in belt	Slip ratio
FCV	Pressure drop	Hardness	Opening torque/force

These parameters if measured and monitored regularly can act as health indices for the device and would help to install predictive maintenance practices. The further scope of the article would be in discussing the ways and means to switch from preventive to predictive maintenance schedule with increased accuracy of predicting failures.

6. Conclusion

The manuscript has dealt with establishment of Sewage Treatment plant at Indira college of Engineering and Management and the maintenance practices and the loss incurred due to breakdown maintenance practices. In order to overcome these losses in terms of time , money and man hours, The breakdown maintenance practices were shifted to Preventive maintenance practices with consistent efforts and the next scope is to switch to predictive maintenance with online monitoring of few process and service component parameters.

7. References

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