Optimization of STP at Ajeenkya D.Y.Patil University and Proposals to improve it using Six Sigma

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***Abstract*— The wastewater industry is one of largest consumers of energy with an estimated 20% of total global electricity consumption used for treatment of wastewater. It is therefore in the best interest of the environment and economics of STP to conserve it. Electricity conservation is necessary because conserving electricity reduces both its costs and the associated environmental impacts, leading to less pollution and greenhouse effect.**

The parameters which evaluate the performance of the plant are BOD, COD, TSS. This study is based on incorporating Six Sigma principles and applying them to reduce the variance of these parameters and to have positive impact on the performance. This study identified aeration equipment as the major energy consumer and suggested to apply time management techniques to it. Reducing the aeration time generated savings of 17%. The BOD and COD levels were also found out to be within the permissible limit by applying time management to the blowers. It is found that the blower had been hackneyed and needs to be optimized for conserving the energy of the STP plant at ADYPU College.

Index Terms: **Six Sigma, Define-measure-analyze-improve-control (DMAIC), Biochemical Oxygen Demand (BOD)**

I.INTRODUCTION

In this new era of post-covid life, with the energy consumption back to their usual levels, energy efficiency has become a higher priority within the wastewater treatment sector. People are back working to the offices and a sense of normalcy has resumed in the world. In India, where the population gradient is always on the increasing curve, there is an urgent need to assess the energy consumption of Sewage treatment plants. Despite being an emerging economy, the STPs are only able to treat more than one third of the sewage generated in a day according to the Central Board of Pollution Control. Many existing wastewater treatment plants do not operate to full capacity. Additionally, the availability of land for installing sewage systems and wastewater treatments plants is becoming limited in India's rapidly growing urban centres.

Sewage treatment is the process of removing contaminants from waste water primarily from household sewage. Physical, chemical and biological processes are used to remove contaminants and produce treated wastewater that is safer for the environment. The treatment process has a series of process and operation units which are categorized under primary treatment, secondary treatment and tertiary treatment.

II.LITERATURE REVIEW

2.1 Mau Teng Au, Jagadeesh Pasupuleti, Kok Hua Chua, "Strategies to improve energy efficiency in STPs" (2013) Power Engineering Centre, 2 Centre for Power System Simulation, 3 Institute of Energy Policy Research, University Tenaga Nasional, Jalan IKRAM-UNITEN, 43000 Kujang, Selangor, Malaysia

There are various types of STPs out there, in that conventional activated sludge, extended aeration, oxidation ditch and sequence batch reactor are presented and strategized to reduce energy consumption based on their influent flow. Influent flow could be used as a parameter to relate energy efficiency of STP. Strategies to reduce electricity consumption by using energy saving devices, working time of motors, automation in the control of

STP and make the possible modification in the processes of sewage treatment plant processes. By implementing these initiatives, we can save about 20-30% of total energy. Additionally, there is great potential to harvest renewable energy such as solar, biomass, biogas and hydro from the STP.

2.2 Nurul Farhana Aziz, Nor Azuana Ramli, Mohd Fairuz Abd Hamid "Energy efficiency of wastewater treatment plant through aeration system" (2019)

It has been observed that the highest energy consumption in the STP is the major contributor to the operational expenditure cost base by the operator company. Hence to reduce the amount of bill to be paid by the operator company, they need a proper and effective solution to decrease the consumption of energy during operation. Energy audit was conducted which gave the energy consumption of all processes, among which aeration was the major contributor. To reduce the energy consumption in aeration system, high speed turbo compressor is proposed to replace the air blowers. This idea was taken from the case study in one of STPs in Malaysia. Through the usage of High-speed turbo compressor, it has been proven that the energy consumption might be reduced up to 42%.

2.3Tariq Abdelhamid, "Six Sigma in Lean Construction Systems: Opportunities and Challenges" Assistant Professor, 207 Farrall Hall, Construction Management Program, Michigan State University, East Lansing, MI 48824-1323. Email: tabdelha@msu.edu

Adopting the lean paradigm, they were able to reduce the effects of variability in the work flow. This approach increased the throughput yield and quality level. This paper considered the tip of the iceberg when it comes to the ever expanding and evolving area of Six Sigma. Additional research is needed to investigate the implementation of Six Sigma methods in Lean Construction. Some researchers may consider starting with the LPDS-identified areas as presented in this paper. Others may choose other avenues. In general, in any implementation effort of Six Sigma it must be recognized that it is a tool among many and that it is suited for a particular type of business problems while entirely useless for others. Six Sigma is a great tool for problems that are 'hard to find but easy to fix'. Lean tools are great for 'easy to find but hard to fix' problems.

2.4 Michael J. Bodoh (2006)- "Reduction of Chloride in Wastewater effluent with utilization of Six Sigma" The Graduate School, University of Wisconsin-stout, USA.

He attempted to implement a Six Sigma on company's wastewater treatment system. He sought to find whether the application of Six Sigma tools would result in reduction of the chloride concentration. It incorporated the DMAIC pattern to reduce the chloride levels. Michael and his team used Fishbone diagram and Pareto chart to locate the major contributor of Chloride source which turned out to be Brine Chillers, and defined Key Process Output Variable (KPOV) as mg/l. They also made corrections to measure parameters in Brine chiller 7 and 8, with the further use of Root cause analysis they were able to control the brine concentrations. Overall, the results were beneficial showing a drop of 25.8% in brine concentrations compared to concentrations at the start of project.

2.5Mintu Boruah et al. (2015), "Application of Six Sigma Methodology in Effluent Treatment Plant" By Department of Mechanical Engineering. International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 IJERTV4IS090618 www.ijert.org.) Vol. 4 Issue 09, September-2015

An attempt was made to reduce the phenol ppm in oil refineries in Assam. The study asses the advantages of Six-sigma and concludes to replace the current tech. From the study it is seen that Six- Sigma is a proven and well and good methodology for quality improvement purpose. It is seen that after application of Six-Sigma the process variability reduces and thereby reduces the quality cost. From this study it may be concluded and accepted that the existing technology in the Effluent Treatment Plant was suitable and adequate to perform well in the Refinery configuration. Though minor modifications are needed for the adjustment of the process the company may save a huge amount of investment or expenditure instead of upgrading the existing plant or by going for new technology

III. METHODOLOGY OPTIMIZATION OF STP

Location of site – Ajeenkya DY Patil University, Knowledge city road, Charholi Budruk, Lohegaon, Pune.

3.1 DMAIC

Six Sigma applies statics to define, measure, verify and control process. Six Sigma has two methodologies known as DMAIC & DMADV to accomplish improvement develop controls for process. DMAIC stands for Define, Measure, Analyze, Improve & Control. These are the five phases of a Six Sigma project to improve a process that already exists. The DMAIC improvement cycle is core tool used to drive six sigma projects. Based on DMAIC which consist of 5 stages play items

3.1.1 Define

In this phase, several processes of the Sewage treatment plant like screening, aeration, CC filter media and disinfection were observed. After examining the process, aeration process was found to be the highest consumer of energy for this given STP. Here the concerned problems are as follows:

1.High Energy consumption which eventually increases the cost of electricity.

2.Maintaining the parameters of water BOD & COD to its permissible level.

3.Corrosion of bar screens is affecting efficiency of Sewage treatment plant.

4.Lack of management & improper hierarchy of power.

3.1.2Measure

In this phase, data was collected of different equipment by taking into account their electricity rating. List of data collected:

(I)Air Blower

(II)Feed Pump

(III)Sludge Pump

BOD and COD testing

Samples were collected from the inlet and outlet of the Sewage treatment plant for both the 12-hour and 9-hour cycle of Aeration devices. These were submitted for testing at a NABL accredited testing lab in Pimpri known as Microtech lab.

Note: It was observed that E-coli Test was not done which is an indication of Covid-19, there was no such system in place for E-coli test.

3.1.3Analyze

In this phase, the actual consumption of electricity was calculated by using the data from the electrical ratings. Electricalconsumption was calculated for the normal 12-hour cycle and the reduced 9-hour cycle, with ratings of 99.48 kWh and 74.61 kWh were observed respectively. The following table enlists the savings generated by the 9-hour cycle

Name	Electricity consumption in 24 hours	Electricity consumption in 12 hours	Electricity consumption In 9 hours	Electricity saved
Air blower	198.96 kWh	99.48 kWh	74.61 kWh	24.87 kWh
Feed Pump	16.2 kWh	8.1 kWh	-	-
Sludge Pump	88.2 kWh	44.1 kWh	-	-
Total	303.36 kWh	151.68 kWh	74.61 kWh	24.87 kWh

Total energy saved in a day- 24.87 kWh

Rate of electricity- Rs 15 per unit

Daily savings- 15*24.87 = Rs 373

Monthly savings- 373*30 = Rs 11190

Annual saving- 1190*12 = Rs 134280

3.1.4Improve

As calculated the air blower consumed about 99.48 kWh in 12 hours, so in order to reduce the usage of electricity consumption of these air blowers, the working time was reduced by 3hrs. So, electricity consumed in 9hrs was 76.61 kWh, and savings of about 24.87 kWh of electricity were noted. Keeping the parameters of treated water such as BOD and COD within permissible level. The BOD and COD obtained after reducing the blower's time were on par with the suitable standards.

BOD < 5.00 mg/l COD = 24 mg/l

Other solutions suggested to improve the functioning of the equipment of STP were:

1.Optimized usage of Aeration system by time management

2.Enhance the capacity of septic tank, in case of peak flow to avoid flooding in the neighboring area.

3.Provide with updated models of the components of STP.

3.1.5Control

From the readings of BOD and COD obtained from the tests of treated water after reducing the time of working of air blowers, it can be inferred that the reading was within permissible limit considering that the treated water is used for gardening. Considering the unit per charge of electricity as Rs 11/ unit in the area, savings of Rs 273.57 were observed per day. These savings came with the cushion of acceptable BOD and COD levels, So the standard operation time for blowers was reduced without compromising on the quality. For the future, it was considered the optimum time for the college treatment plant.

To keep this plan in motion, following control measure can be employed:
1.It is suggested to the pump operator to adhere to his schedule and also have a deputy in place.
2.Proper time table and keep up with maintenance schedule.
3.Reporting to higher authorities on daily basis.
4.Take note of the design life of the components and opt for a replacement beyond it.

IV.RESULT AND DISCUSSIONS

Analysis of Energy consumption conducted for the components of Sewage treatment plant shows that, when the blower was used timely and efficiently, there were assured savings of Rs. 250 per day. While the savings were also a priority, the BOD and COD levels of water were also to be monitored and kept under control.
We conducted tests of BOD and COD levels before and after the aeration time was reduced to 9 hours per day. The reports suggested minimal change in the BOD and COD levels during the 12- hour cycle and 9-hour cycle.

V.CONCLUSION

- The energy consumption of the STP was reduced, after applying time management to the blowers. It resulted in 17% savings for a 9-hour cycle of the blower.
- It is observed that, the sand from sand filter is not changed for almost 10 years, due to which clogging of the sand filter has taken place. Water to be treated will not have a proper medium which eventually will impact the quality of water. So, the sand needs to be replaced to ascertain proper treatment of waste water.
- Activated carbon needs to be replaced in order to establish efficient working of activated carbon filter.
- The sludge tank should be cleaned after regular interval of time; cleaning of sludge tank should not be neglected because waste will be deposited over a period of time and ultimately can eat up more space of tank.
- Corroding of Bar screen leads to clogging in the feed pump, replacement to be done timely.
- Inspection of STP should be carried out regularly, so defects are known and can be rectified. Civil Engineering department should be responsible for this inspection.
- There are no proper records or archives maintained of STP, so proper records should be maintained by the team.
- The whole management of STP is managed and handled by one person. More staff members should be included, for equal distribution of work.

REFERENCES

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