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REVIEW PAPER ON PERFORMANCE EVALUATION OF AEROBIC STP AND SUGGESTIONS TO IMPROVING BY USING SIX SIGMA

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Abstract – *The observed inefficiency of the Sewage treatment plants in India and their sub-par standards of performance and quality yield calls for a inspection of these plants. Owing to these problems, the amount of untreated sewage has risen and has a negative environmental impact on the surroundings. To solve this issue, we have read Review papers pertaining to the topic of STP process and DMAIC technique. Different review papers use different tools of Six Sigma, use of DMAIC with QFD, root cause analysis and more. The parameters which evaluate the performance of the plant are BOD, COD, TSS. The study is based on incorporating Six Sigma principles and apply them to reduce the variance of these parameters, to have positive impact on the performance*

Key Words: **Six Sigma, Define-measure-analyze-improve-control (DMAIC), Bio-chemical Oxygen Demand (BOD), Quality Function Deployment (QFD)**

1.INTRODUCTION

Humans and their subsequent projects generate tons of sewage each day, this sewage comprises of industrial waste, domestic waste, storm water and many more. The presence of both inorganic and organic waste gives rise to a mixture which can be toxic for the environment. Wastewater when discharged into water bodies can cause various diseases and contamination of land and water. Therefore, it is imperative that wastewater is treated before it is released into the environment and, if possible, treated it to make it potable. In India, the continual rise in population and urbanization has led to an increased demand of water and the authorities are finding it difficult to meet the daily requirements of water. To help mitigate this crisis, it is important for the Sewage Treatment Plant in the region to be functioning at 100% capacity. Surveys taken up by the Central Pollution Control Board for evaluating performance of STPs, it was found that more than 60% of the STPs did not meet the working standards. This is a major problem, which if not solved can prove to have some devastating effects.

2. LITERATURE REVIEW

2.1 D.D. Basu et al. in their report "PERFORMANCE EVALUATION OF SEWAGE TREATMENT PLANTS UNDER NRCD (2013) CENTRAL POLLUTION CONTROL BOARD OF INDIA" mentions that himself and his companions analyzed over 150 STPs spread over 15 states in India. The total treatment efficient treatment of the STPs was found to be 60%. A report was generated by the Scientists at CPCB on each of the STPs, that included remarks and suggestions to improve the efficiency of the plant. Considering the Maharashtra region, the defects observed in 6 STPs were the poor condition of oxidation ponds, vegetation growth observed on Sludge drying beds and maturation ponds. D.D Bose argued that the defects were due to the lack of attention and concentrated focus. The equipment efficiency also must be questioned, which in turn gave poor results.

2.2 S. K. SINGH et al. in their paper – "PERFORMANCE EVALUATION OF SEWAGE TREATMENT BASED ON ADVANCED AEROBIC BIOLOGICAL FILTRATION AND OXYGENATED REACTOR (BIOFOR) TECHNOLOGY"- A CASE STUDY OF CAPITAL CITY DELHI, INDIA (2014) illustrates that the study conducted by Delhi Technological University, in which him and his counterpart utilized the BIOFOR technology as an alternative to conventional aerobic treatment technologies. Results of STPs based on BIOFOR technology show that BOD, COD and Suspended Solids removal efficiencies were noted to be 95.2%, 93.4% and 97% respectively. This indicates the efficient removal of the parameters. Thus, BIOFOR systems open up further possibilities for a more economically and secure sewage process in India.

2.3 MICHAEL J. BODOH, UNIVERSITY OF WISCONSIN-STOUT- "REDUCTION OF CHLORIDE IN WASTEWATER EFFLUENT WITH UTILIZATION OF SIX SIGMA" (2006) 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.

2.4 TARIQ ABDEIHAMID- "SIX SIGMA IN LEAN CONSTRUCTION SYSTEMS: OPPORTUNITIES AND CHALLENGES", (2003) shows the balanced working of Six Sigma and Lean System represent a potent framework in eliminating the process variation. Tariq in his paper conveys the fact that lean system creates a standard and Six Sigma examines and dispose of any variation from the standard. This approach increased the throughput yield and quality level.

2.5 JEA COMPANY-LEAN SIX SIGMA AND ENVIRONMENT CASE STUDY, FLORIDA, USA (2008) reports the advantages of using Lean Six Sigma and the savings generated by them since 1999. In 2008, JEA added a "Green It Up" step to the DMAIC process, inventing "DMAGIC"; this step addresses the environmental concerns coming up during the project. In the "GREEN" phase of the project, the team explores areas such as air quality, water quality and ecosystem-related issues. The company applied this "DMAGIC" technique to overcome the problem of Nitrogen Discharge Fluctuation into St. Johns River. In the Green phase, JEA used the byproducts of a biodiesel production to keep the microbes alive and reducing the nitrogen discharge to the river.

2.6 MARYAM DABBAGHI TEHRANI-PERFORMANCE IMPROVEMENT IN CONSTRUCTION PROJECT BASED ON SIX SIGMA PRINCIPLES, (2010) wrote her Master thesis for university college of Boras which incorporated the study of DMAIC technique and stressed on the flexibility of it. She offers a systematic strategy to control and coordinate effectively. In her paper, she studied the idea of applying Six Sigma principle on construction industry theoretically and explored the advantages of DMAIC procedure and its potential to enhance the quality level and efficiency of the construction projects. Appropriate definition of all critical items in any construction project, more emphasize on CTQs, proper metrics, suitable coordination scheme between all prerequisite to major processes and commitment of all involved people are desired for a successful application of Six Sigma in construction industry.

2.7 MINTU BORUAH et al. "APPLICATION OF SIX SIGMA METHODOLOGY IN EFFLUENT TREATMENT PLANT", (2015) attempted to reduce the phenol ppm in oil refineries in Assam. These study asses the advantages of Six-sigma and concludes to replace the current tech. From her study it is seen that Six-Sigma is a fine-tuned methodology for quality improvement purpose. It is also established that after application of Six-Sigma the process variability reduces and thereby reduces the quality cost. 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 adopting a new technology.

2.8 L.D. ROBESUE et al. "APPLICATION OF CONTINUOUS IMPROVEMENT STRATEGY FOR REDUCING ENVIRONMENTAL IMPACT OF A WASTEWATER TREATMENT PLANT "(2016) infers to the Continuous Improvement (CI) principles which outline an integrated strategy for process improvement, by searching and removing the causes of defects and variables. CIS concept corresponds to the need of regional operators and WWTP managers to obtain a better monitoring of treated wastewater, costs reduction, identification of time-consuming activities and beneficiaries satisfaction. He presents the pilot CIS project in Romania with the main objective to reduce environmental impact and operational costs of the WWTP Cernavoda. Application of CIS concepts leads to a solution for reducing sludge production, power consumptions, polymer consumption and consequently for reducing operational costs of the WWTP.

2.9 RICARDO BANUELAS et. al "AN APPLICATION OF SIX SIGMA TO REDUCE WASTE" (2005) presented a case study illustrating the effective use of Six Sigma to reduce waste in a continuous film line. It illustrates in detail how the project was selected, and how the phases of the Six Sigma DMAIC methodology were carried out. Several tools and techniques were employed during the course of the project. The success of their Six Sigma case study can be attributed to the management involvement and commitment, project selection and its link to business goals**,** training and teamwork and project progress tracking and monitoring. As a result, significant financial benefit was achieved in a relatively short period of time by the team. This allowed material waste to be reduced by nearly 50K pounds per year. In addition, the waste reduction created a chain reaction in which runtime was increased, quality was improved and inspection reduced.

2.10 KAVITA CHOKSI et al. "TO EVALUATE THE PERFORMANCE OF SEWAGE TREATMENT PLANT: A CASE STUDY" (2015) selected a waste water treatment plant with Activated Sludge Process as biological treatment method for performance evaluation. The overall performance of the existing was satisfactory. The removal efficiency as per SMC Data of BOD was found to be 94.84% and that of TSS was 90.75%. The team argued that individual units are also performing well but the removal efficiencies of the primary clarifier system were reported sub-par standards at 57% and 53%. The removal efficiency as per the sample tested in laboratory of BOD was found to be 93.42% and that of TSS was 90.61%. Thus, with comparing the data with SMC and the sample tested in laboratory the plant is working satisfactory and the individual unit.

3. METHODOLOGY

The various techniques used by authors are illustrated here, Mr. SK Singh utilized the BIOFOR (Biological Filtration and Oxygenated Reactor) technology as an alternative for conventional aerobic technique. He compared both the technologies and concluded that ASP involves high investment and maintenance costs while BIOFOR filters prove to be cost and area-wise effective. JEA company innovated a new type of DMAIC to address environmental concerns of the project, called "DMAGIC". They applied this technique to solve the problem of Nitrogen discharge in St. Johns River. The use of byproducts of biodiesel proved to reduce the nitrate contents of water and kept the sludge-treating microbes alive.

Tariq Abdel Hamid in his paper defined the statistical approach of Six Sigma and pointed out its limitation. He analyzed the adoption of Lean techniques to overcome these limitations. Both these techniques complement each other very well and increased the throughput yield and quality level. The team of Assistant Professors in Surat used the Benchmarking technique to evaluate the performance of STP in Summer and Winter season. Parameters used were BOD and TSS which were compared with the data of Surat Municipal Corporation (SMC). Richardo and his management team in UK, employed the Six Sigma to reduce the amount of waste in continuous film line. They analyzed the benefits of DMAIC and observed a decrease of 50K in material waste.

Michael Bodoh of University of Wisconsin used Six Sigma tools to lower the chloride levels in water. DMAIC was thoroughly adopted along with fishbone diagram and further research was done by root cause analysis. Mintu Boruah and Dr. Thuleswar Nath presented a study on the problem of increase in phenol ppm which adopted the same DMAIC technique and concluded that these problems can be tackled by Six Sigma alone rather than adopting a total change in technology for the Sewage treatment plant.

4. RESULTS AND DISCUSSIONS

1.S.k Singh, Delhi Technological University, Performance Evaluation of Sewage Treatment based on (BIOFOR) technology Delhi city -Results of STPs based on BIOFOR Technology indicate that BOD, COD & Suspended Solids removal efficiencies were viable for the given economical standard.

2. JEA Company, Lean Six Sigma And Environment Case Study USA -The results obtained from Nitrogen Discharge Reduction Project were successful in curtailing nitrates discharge, recycling of biodiesel and additional savings to JEA.

3. Ricardo Banuelos, Jiju Antony and Martin Brace, An Application of Six Sigma to reduce waste -The case study illustrated the use of six sigma to reduce waste in a continuous film line industry. Waste was reduced by 50K Pounds per year, furthermore a chain reaction of advantages was observed.

4.Kavita Choksi, Margi Sheth, Darshan Mehta, to evaluate the performance of Sewage Treatment Plant: A Case study-The paper throws light on importance of checking the parameters like (BOD, TSS) at regular intervals, so as to maintain the quality consistent. Samples were collected each season and compared with BIS and GPCB standards. Overall, the plant is rated sufficiently good and individual units working well.

5.L.D. Robescu, C. Sillivestru, A. Presura, A. Pana and R. Mihai , Application of Continuous Improvement Strategy for reducing environmental impact of a wastewater treatment plant-The study shows that with the help of DMAIC technique and Quality function deployment tool, they were able to suggest the solution of bio-augmentation which improved process, reduced operational costs and sewage production

5. CONCLUSION

The technologies and processes used to enhance the quality treatment of STP solve the issues occurring in a Sewage Treatment Plant and gives various examples of the usage of Six Sigma and its tool to identify and rectify the defects. Many tools like Six Sigma, root cause analysis, QFD were used to identify and solve the problems associated with the Sewage treatment plant functioning. The various steps taken by the authors as mentioned above have had a positive impact on the environment, like reduced levels of harmful chemicals present in water, less sewage production and improved treated wastewater quality. Rendering to the standards maintained in the research paper, we wish to apply them to our -college Sewage treatment plant and look for defects in the process and provide the necessary solution for the plant.

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