An Effluent Treatment Plant's Procedure Improved by Employing the Kaizen Approach

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Abstract. Industrial waste management, environmental compliance, and public health depend on ETPs. Though vital, many such institutions fail to operate efficiently and effectively. The study of Kaizen techniques implementation is done in Effluent Treatment Plant (ETP) in a SSI unit in Nagpur city, in INDIA. Here, the working of this process is done over Effluent Treatment Plant of the filtration unit in the industry. Here kaizen process is implemented in filtration of sludgy water. To overcome this problem the kaizen process was implemented in the filtration unit. Now in newer process air cylinder is placed in the process. The pump partially fills the air cylinder with sludgy water. The sluggish water is then pumped to the ETP unit. Earlier the process was not manually controlled it totally depended over the pressure of pump which was manually operated. To avoid all the mishaps happening in the industry new process was implemented. After application of kaizen technique all the problems which were a rising during filtration of sludgy water were overcome. Kaizen improves industrial wastewater management by lowering treatment costs and increasing plant capacity. This article describes Kaizen implementation and offers practical suggestions for optimizing wastewater treatment in other facilities.

1 Introduction

Effluent treatment Plant (ETP) purify wastewater and industrial effluents before release. These plants neutralize pollutants to reduce water pollution and safeguard health [1]. ETPs are crucial to reducing river, lake, and ocean pollution. They purify wastewater for toxins, heavy metals, and organic pollutants to preserve water resources. ETPs meet strict discharge regulations to avoid legal penalties and encourage sustainable industrial operations [2]. Waterborne disease and drinking water contamination are reduced via wastewater treatment, improving public health. ETPs maintain aquatic life and biodiversity for ecological balance by limiting industrial discharges [3]. Despite their usefulness, modern ETPs face operational issues. Rapid industrialization and urbanization have increased wastewater volume and complexity, making several contaminants challenging to treat and requiring unique, adaptive treatment technologies [4]. Many ETPs have old infrastructure that cannot handle modern

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effluent, resulting inefficiency and greater costs. Another issue is high energy, chemical, and labor costs [5]. Compliance with changing environmental rules may require process changes and investments. Sustainability requires managing or reusing treatment sludge. Last, equipment dependability, process control, and operator training affect treatment efficiency [6].

Kaizen, meaning "continuous improvement," is a management style that emphasizes progressive process and system changes [7]. Kaizen believes modest, continuing adjustments increase performance and efficiency. This strategy implies all employees, regardless of function, may suggest improvements. Kaizen stresses continuous improvement, which allows organizations to improve their operations and eliminate inefficiencies using small, incremental changes rather than big overhauls [8]. Kaizen encourages collaboration and creativity by encouraging organization-wide participation. Standardize recognized improvements with new or updated procedures for consistency and sustainability. Waste reduction cuts time, resources, and labor, saving money [9]. Kaizen improves product and service quality by addressing root issues. Kaizen promotes systematic problem-solving utilizing root cause analysis and the "5 Whys" technique. Kaizen's structured yet flexible foundation for operational excellence makes it relevant to process improvement [10]. Kaizen helps wastewater treatment plants resolve issues and increase performance. Kaizen improves ETP efficiency, efficacy, and cost by continuously refining treatment operations. Progressive Kaizen improves ETPs progressively and sustainably. ETPs need staff involvement since operators and staff know the processes well and can make improvements. Successful changes are standardized for long-term gains. Kaizen's waste elimination and problem-solving assist ETPs save costs, improve treatment efficacy, and comply with environmental standards [11]. Kaizen helps effluent treatment plants adapt to changing problems, optimize processes, and achieve wastewater management sustainability.

Technological advances and industrial wastewater complexity have changed effluent treatment [12], [13]. Increased treatment efficiency, environmental preservation, and regulatory compliance are goals. Strong oxidants in advanced oxidation processes (AOPs) decompose persistent organic pollutants that previous approaches miss[14]. Complex wastewater streams are treated using ozone oxidation, UV/H_2O_2, and Fenton's reagent. MBRs, nanofiltration, and reverse osmosis improve water reuse [15]. Municipal and industrial treatment systems use pathogen and dissolved sediment removal methods more[16]. Automation and smart technology are also important. Data analytics, sensors, and real-time monitoring improve treatment. Systems optimize treatment parameters and eliminate manual work. Reusing treated water and recovering valuable materials from effluent streams reduces waste, making resource recovery and zero-liquid discharge (ZLD) appealing. ZLD processes all wastewater and discharges no liquid waste for sustainability and the environment. Despite improvements, wastewater treatment plants are inefficient and problematic [17]. High upfront and recurring expenditures make operating and maintaining advanced technologies difficult. Modern wastewater streams may contain pharmaceuticals and personal care goods, making removal difficult and needing specific technology or treatment [18]. Consistency is difficult since influent characteristics like flow rate and pollutant content affect treatment efficacy. Tightening environmental requirements necessitates resource-intensive treatment and monitoring system improvements, making compliance challenging. Many wastewater treatment plants' outdated infrastructure makes it hard to adopt new technology and adapt to changing needs, requiring costly upgrades [19].

Kaizen has helped several companies improve process efficiency and performance [20]. Toyota and General Electric improved production quality and productivity with Kaizen. Toyota's Toyota Production System (TPS) utilizes kaizen, waste reduction, and employee interaction to improve operations. General Electric improved procedures, product quality, and continuous improvement culture with Kaizen [21]. Nestlé and Unilever optimize quality

and output with Kaizen. Kaizen reduced waste and improved manufacturing efficiency for Nestlé, saving money and creating uniform products. Kaizen in Unilever's supply chain management cut lead times and increased efficiency. Kaizen is successful in Japanese municipal wastewater treatment plants. Kaizen addresses process inefficiencies and high operational costs at the facility. Gradual modifications cut energy use and operational costs at the factory. This taught us the importance of including all employees in improvement and monitoring and making adjustments. Kaizen helped an Indian textile manufacturer improve dyeing[22]. Poor product quality and failure rates hampered the company. Kaizen helped the company identify and fix these issues, boosting product quality and lowering errors. Systematic problem-solving and staff participation improved processes in this achievement. Pharmaceutical case study indicates Kaizen enhances operational efficiency[23]. Kaizen helped a pharmaceutical company boost output and reduce downtime. Continuous improvement reduced production cycle times and increased productivity. Kaizen's ability to optimize complex production processes and the necessity to standardize successful improvements for sustainability were shown in this scenario. These case studies and research show Kaizen's success across industries and provide valuable insights for continuous development. These examples stress staff interaction, ongoing monitoring and adjustment, and systematic inefficiency reduction. Industry performance, efficiency, and operational excellence can improve with these principles.

This research studied at the SSI unit in the Hingna MIDC area, Nagpur, India. This work is done in the filtration unit of the industry. The main problem studied in the project is the filtration of sludgy water in the Effluent Treatment Plant (ETP). During the process of filtration of sludgy wa-ter, the main issues came across were the bursting of pipes, tripping of the pump, and wear and tear of nylon sheets of ETP. Also in the worst-case scenario, there was a blowing up of the ETP unit. These problems caused safety concerns among the operators and other operators working around the industry. So the main goal of the project is to eliminate all the problems which were occurring during the operation of the filtration Plant. So after studying the problems that arose during the filtration process, the research for various solutions to minimize and sort out the problems was tried. While researching the aforementioned issue, the author came across the Japanese concept of kaizen, which translates to "smaller and continuous improvements." As a re-sult, various facets of kaizen were utilized in an effort to resolve these issues through "small and continuous improvements. This research will also identify and evaluate Kaizen implementation lessons, including best practices, successful methods, and development areas. The study will finish with Kaizen recommendations for effluent treatment plants on sustainability, staff engagement, and performance.

2 Materials and Methodology

The Japanese word kaizen literally translates to "good change," "change for the better," or "improvement."[24]. Kaizen is a way of thinking as a philosophy that encourages making small, incremental changes over time to have an effect [25]. As a method, kaizen improves specific parts of a business by getting top management and regular employees to start making small changes every day, knowing that small changes can make a big difference. Kaizen is the Japanese word for "good change" or "improvement," and it is made up of two words. Nonetheless, Kaizen has come to imply "nonstop improvement" through its relationship with lean strategy and standards. The premise of kaizen, a method of continuous improvement, is that even small, ongoing improvements can result in significant advancements. The 6 steps in Kaizen were studied and implemented as explained in method [26].

- Identifying objective
- Explore new ideas

- Breakdown Objective
- Plan the tasks
- Conduct tests, track developments, and modify the timetable
- Proceed to the following goal.

2.1 Problems Studied in ETP unit

The main problem studied in the project is the filtration of sludgy water in the Effluent Treatment Plant (ETP) as shown in figure 1.

- Bursting of pipes
- Blowing of Effluent Treatment Plant Unit
- Tripping of Pump
- Wear and Tear Nylon Filtering Sheets

Fig. 1. Wastewater Tank on which work was identified

2.2 Methodology

2.2.1 Before implementation of new method

Before the application of the new technique, the process of filtration of water was carried out normally using the help of a simple water pump as shown in figure 2.The sludge tank has three sections:-

- 1st part contains CuSo4 and other acids
- 2nd part contains LPP and Rinzin water
- 3rd part is a mixing tank where the mixture from both parts of the tank is done.

And lime is added to the mixture of the solutions. After the mixing up of the lime in the solution, the pump directly pumps the water to the Effluent Treatment Plant unit where further filtration is done. This was a very basic working procedure in the plant.

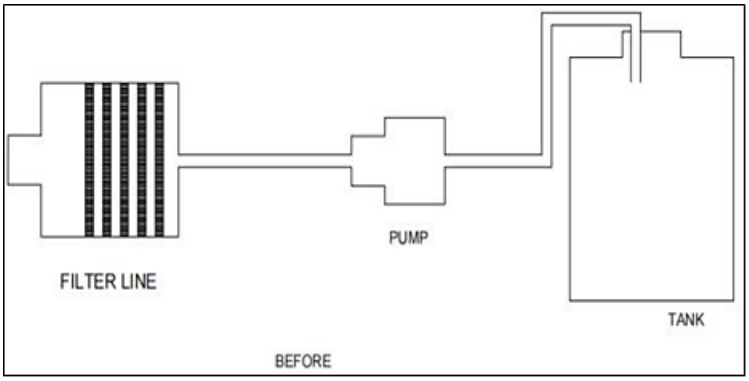


Fig. 2. Methodology before implementation of new method

2.2.2 After implementation of new method

After the implementation of the new technique, the process of filtration is done with the help of an air compressor and cylinder as shown in figure 3. Now after the implementation of the new procedure the wastewater from the waste water tank is pumped not to the Effluent Treatment Plant, but to the cylinder. The capacity of the cylinder is between 250-1000 liters. Up to around 80% of the waste water is pumped to the cylinder by the water pump.

After the partial filling of the pump, the water is now pumped to the Effluent Treatment Plant. The compressor now applies pressure over the water that is to be sent to the Effluent Treatment Plant. The pressure is now regulated manually. Hence after the applications of new method, we can reduce the hazards.

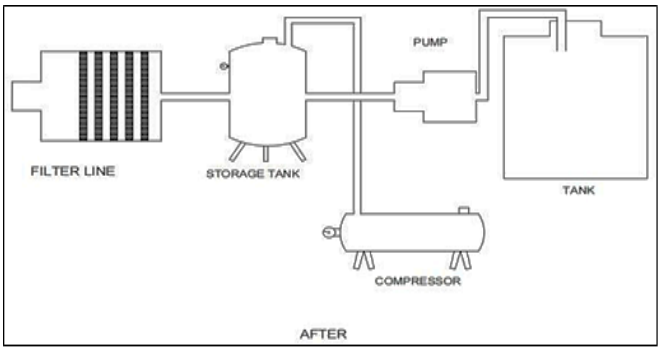


Fig. 3. Methodology after implementation of new method

3 Results and Discussion

The use of the "Kaizen" technique is completed after learning about these issues and investigating numerous novel approaches to making changes to the current process. The previous pump was used to directly transfer the sluggish water from the waste water tank to the ETP unit. The turbid water is now pumped into the air cylinder by the water pump, partially filling it. The air cylinder is now connected between the waste water reservoir and the ETP unit by means of an air cylinder. The air compressor is employed to transport the viscous water to the ETP unit for additional filtration. The pressure of the water that is supplied to the ETP unit can be manually adjusted. Consequently, we have successfully resolved all of the issues that operators have been experiencing for an extended period of

time since we implemented the kaizen technique, which involves the sludgy water being pumped by an air compressor and an air cylinder pump. The "kaizen" method is used in the workplace after getting good results. This shows that the Kaizen cycle has shown to be one of the most mind-blowing ways of rolling out steady improvements and dispose of the waste, as well as to lessen dangers and misuse of utilized minerals.

Table 1. Calculation of average life of sheets in days

S.N.	Pressure(in bar)	Average Life of sheets (in days)
1	10	* 25 Max
2	9	* 26 Max
3	8	~ 28
4	7	30
5	6	40
6	5	50
7	4.5	60

*represents: Not Certain; ~ represents: Approximate

3.1 Working Calculations

- The wastewater treatment plant was operated twice a week for water filtration.
- The sewage treatment plant worked almost 16 hours a week.
- A 1000 liter storage tank was placed to collect industrial effluents as the sewage treatment plant operated only twice a week.
- After starting the wastewater treatment unit, we found that we can almost get a maximum of 100 hours of sheet metal life at 10 bar pressure.
- 100 hours of continuous work can be calculated as approximately 25 days of work according to the industry's standard work routine. As a sewage treatment plant, it worked continuously 8 hours a day for 2 days a week.

3.2 Steps of Kaizen technique applied in SSI unit

3.2.1 Identifying objective

The main objective of our work was to identify problem where improvement is needed. After interacting with the plant manager and the operators working over there the problem in ETP process is identified. The problems to be studied and improved were

- Minimize wear-tear of nylon filter sheets.
- Avoid the bursting of pipes.
- Avoid the bursting of the Effluent Treatment Plant Unit.
- Avoid tripping of pump.

All these have to be covered for improvement of working of filtration unit.

3.2.2 Explore New Ideas

After understanding the filtration process of the Effluent Treatment Plant various methods were studied to cover objectives. They were: 1) Elongation of a piping system. 2) Using a lower horsepower motor as compared to the previous motor used in the company. 3) Using an air compressor, cylinder, and regulating valve.

All the methods were given detail thoughts. After discussion with Plant Manager the 3methods was selected to carry further results.

3.2.3 Breakdown of Objective

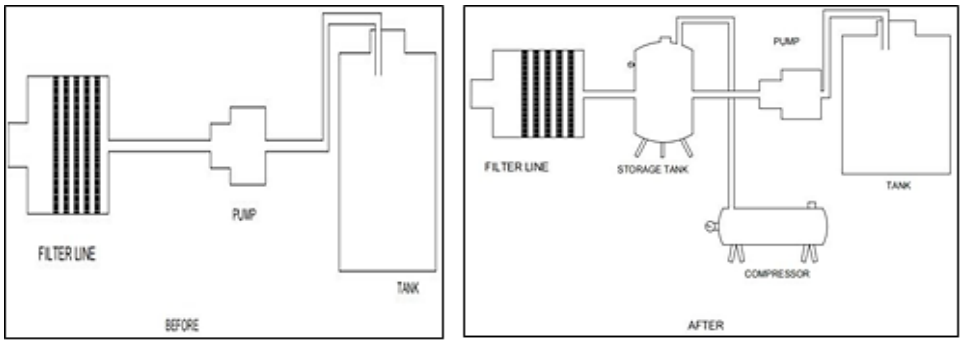
The objectives were broadly broken down to carry out the work efficiently. The tasks were to 1) Avoid pipe bursting. 2) Avoid the bursting of the Effluent Treatment Plant Unit. 3) To minimize wear and tear of nylon filter sheets. 4) Avoid tripping of the pump. Objectives were discussed properly with the officials in the company and after the conversation the 3rd method applied started to give effective results.

3.2.4 Plan the tasks

During the visit to the company, the tasks were planned by setting up the correct assembly to carry out the process efficiently. Planning of tasks was done carefully to avoid hazards during the process of filtration. To achieve our objectives we have carefully selected the best suitable method to carry out the process

3.2.5 Test, monitor the progress and the and adapt the schedule

As discussed above the 3rd method was selected as the best for carrying out the process after careful testing. After carefully implementing the methods the process was monitored for the progress of the new method adopted. An air compressor, a cylinder and a regulating valve was placed, as shown in the figure 2.1. Figure 4 (a) shows the layout before implementation of the new changed method. Figure 4 (b) shows the layout after implementation of the new changed method.



(a) (b)

Fig. 4. (a) Unit before implementation, (b) Unit after implementation

After the application of new method, the process was regulated manually also. Hence the objective to minimize the hazards during the filtration process was achieved and implemented by the industry.

3.2.6 Move on to the next objective

We have met our objective to minimize the hazards caused during filtration and also 1) Avoid pipe bursting. 2) Avoid the bursting of the Effluent Treatment Plant Unit. 3) To minimize wear and tear of nylon filter sheets. 4) Avoid tripping of the pump.

After successfully adopting this method the amount needed to purchase filter sheets was minimized. Also the wear and tear of nylon filtering sheets were minimized. This helped to improve the productivity of the ETP unit.

3.3 Final Outcome

Before the application of any method or can be said as before working in the industry

- The sheets of the Effluent Treatment Plant got worn out quicker.
- The pump used to get tripped often.
- The pipes used to get burst out often
- Part of the Effluent Treatment Plant Unit used to get blown off.

After the application of the new method, we have achieved all the mentioned objectives above.

- Hence we saved the expenditure of the industry as earlier they had to purchase the sheets more frequently, as compared to the current scenario.
- Also, the expenditure of industry is saved which was done to replace the equipment of the industry after it breaks down.
- Moreover, we saved the time of industry which earlier they have to frequently change the sheets, and replace the broken equipment.
- Most importantly the good quality of sludge was obtained.

4 Conclusion

Kaizen greatly enhanced the wastewater treatment plant. Efficiency increases with simplified operations, decreasing energy costs. Treatment efficiency increased, eliminating contaminants faster and meeting regulatory discharge standards. Use of cost-effective solutions reduced waste and downtime, cutting operational expenses. Employees eagerly contributed ideas and solved problems when continuous development was promoted. Resource recovery and waste minimization improved sustainability, and optimized treatment processes maintained or increased regulatory compliance. Kaizen's wastewater treatment operational excellence and environmental responsibility are shown by these gains. Study contributions to wastewater treatment and Kaizen are substantial. Kaizen concepts work in wastewater treatment, laying the groundwork for other facilities to enhance efficiency and performance. In the case study, Kaizen helps overcome challenges and succeed. This research suggests implementing Kaizen into environmental management and improves our understanding of continuous improvement in complex industrial processes. The findings may influence wastewater management guidelines and encourage Kaizen. Kaizen benefits wastewater treatment plants. Kaizen incremental improvements improve process, treatment, and cost control. Permanent advantages and high operational standards can be achieved by supporting continual improvement and employee participation. By eliminating waste and recovering resources, Kaizen promotes environmental sustainability and regulatory compliance. Improvement of effluent treatment is promising. Kaizen's flexible and systematic approach will help wastewater managers adapt to new challenges and flourish as technology and laws change.

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