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BEST UTILITIES OF IMPROVING WATER EFFICIENCY THROUGH LEAN METHODOLOGIES IN INDUSTRIAL SECTOR

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Abstract

Water is a crucial resource for the world economy. Today, every industrial sector is facing with a lot of environmental regulations. Lean is one of the production strategies whose fundamental principles drive the industry towards a more effective production of goods and services. Lean provides a framework in which organizations can address water waste while saving costs, reducing risks, and adding customer value. The aim of this paper is to identify the areas of water wastage and usage and explore in achieving process excellence through water efficiency by lean strategies for water facilities in industries.

Keywords *– Facilities, Kaizen, Lean management, Water Efficiency.*

I. INTRODUCTION

Companies worldwide identify water issues as a critical business concern. Water is essential for a range of industrial processes and support functions, facility operations and as an ingredient for many products. Water use is increasing much faster than population growth, and regional and seasonal differences in water availability can lead to shortages and even water related conflicts. Water is one of the most crucial resources in the world, and is necessary for all types of industries like agriculture, apparel, beverages, biotechnology, pharmaceuticals, electric power, forest products, high-tech manufacturing, mining works, wood products, food processing, ceramics making and silicon wafer companies etc. Water is required in substantial quantities to create goods from food products to silicon chips. Water waste can cause harm to health and well-being of people and ecosystems by delivering water from other needs and beneficial uses. Reducing water waste can help ensure that present and future generations have access to sustainable water supply.

II. LITERATURE REVIEW

The world economic forum reports that 44%(2.8 billion) of people currently live in areas of the world that are water stressed, and if present trends continue, water scarcity will affect the livelihood of one-third of the world's population by 2025[5].Corporations are recognizing the important role they play in addressing water resource

challenges, and companies are responding by engaging in efforts to measure, report and reduce their water waste. In survey conducted by the carbon disclosure project of 302 of the world's largest 500 companies,89% of responding companies had developed specific water policies, strategies and plans, and 67% indicated that responsibility for water related issues lies at the Board or executive committee level[4]. The United Nations' CEO water mandate, launched in 2007, is designed to help companies develop, implement, and report on water sustainability policies and practices. Industry-led associations such as the world business council for sustainable development and the global environmental management initiative also have major water initiatives.

III. LEAN MANUFACTURING

Lean manufacturing is an efficiency based system on optimizing flow to minimize bring the wastage and using advance methods to improve manufacturing system by modified or change pre-existing ideas [3]. Another definition say that Lean Manufacturing is a philosophy that aims to maintain smooth production flow by continuously identifying and eliminating waste resulting in increasing value of activities in the production process. Lean Manufacturing aims for Identification and elimination of waste (any activity that does not add value to customer) [1]. Lean manufacturing aims to continuous flow of all manufacturing processes with minimum as minimum wastage. The Basic Elements of Lean Manufacturing System are [2]: KANBAN, TPM (Total Productive Maintenance), JIT (Just In Time), KAIZEN (Change For Better), Quality Circles, TQM, Employee Involvement and 5's.The Main benefits of Lean Manufacturing System are [6]: Improve productivity, Overall wastage reduction, Cost reduction, Reduce defects, and Overall quality improvement.

IV. ADDRESSING WATER WITH LEAN PRINCIPLES

Lean provides powerful tools for delivering value to customers in a manner that minimizes wastes and risks from unnecessary waste use. Explicit consideration of water waste during lean implementation can create significant value for an organization, helping to deliver quality products and services that customers want, when they want them. There are three key benefits of addressing water with lean [6].

4.1. Uncover cost savings and operational improvements

Learning to see and eliminate waste is a cornerstone of lean initiatives. Water waste is often a sign of inefficient production and non-value added activity, and it frequently indicates opportunities for savings cost and time. For production processes that are highly dependent on water or that have water intensive support processes such as waste water treatment. The other uncovered water waste and costs include: raw material costs which measures to ensure that purchased water supply is of sufficient quality for the use of facilty.Water treatment costs associated with deionized water and reverse osmosis can be substantial. Energy costs which are required to heat and cool water, pump or transfer water, operate water consuming equipment etc. Pollution control costa paid to a utility and industrial pretreatment costs for the energy, labor, materials and chemicals need to treat waste water before discharging it for the facility. Regulatory compliance costs such as completing permit applications and tracking and reporting wastewater discharges to regulatory agencies.

4.2. Reduce water related business risks

Lean provides an effective platform for reducing facility water use and the associated water related business risks. In water scarce regions, there may be challenges with meeting basic human needs for clean water and sanitation. Companies respond to water risks can also have important implications for how local communities and customers perceive those companies. By engaging employees in teams to identify and eliminate sources of water waste in the facility, alongside other production wastes such as over processing, defects, and delays a facility can proactively reduce water risks while also supporting operational goals. Proactively engaging with local utilities and communities to collaboratively address water resource challenges can provide additional opportunities to reduce business risks and increase value. These efforts will make the facility less vulnerable to risks and better positioned to succeed given changes in water supply, demand and quality.

4.3. Deliver value for customers and employees

Reducing water use and risks through lean and other process improvement methodologies can foster a competitive advantage for some business. People around the world view water issues as a key sustainability challenge. For businesses that manufacture water using appliances, parts or products, companies to cater to the steadily growing markets form green products. Reducing facilities water use and the water that the products require during use can add value for downstream customers; saving them water and energy costs and helping them meet their water efficiency goals [6].

V. INITIATION WITH LEAN AND WATER

There are many ways for any Industry to get started with reducing water waste and finding lean and water improvement opportunities. While the possibilities are daunting, the important thing is to begin, even if the effort is small. Any facility have to start to start out with small steps, such as tracing water use as a metric with a goal of reducing use which can be a great strategy for small facilities[6]. Here are the some of the ideas for initiating a lean and water effort.

5.1 Knowing more about how a facility uses water

It is a key first step to know and identify the process areas, support functions, and facility operations that have the greatest water waste and improvement opportunities. It includes beginning to track water metrics as part of lean and process improvement activities and installing water meters on processes that use large amount of water. It is helpful for managers and lean champions to track the water usage regularly, and share the information with shop floor staff and regular monitoring water use data can help to determine the impact of peak periods. To be most effective operations manager should connect with environmental and facilities personnel early on to discuss plans for lean and water efforts.EHS personnel can assist with developing water balances and other assessments of facility and process water use, including gathering data on water use and costs as well as helping prioritize lean and water activities.

TABLE1: Information of water metrics use at a company ABC

Sl.No	Description	Water Metrics
01	Facility-Wide Metrics	• Volume of water used each month or other appropriate time period(e.g., gallons/month or gallon/shift) • Volume of wastewater (e.g., gallons/month or gallon/shift) • Water used for specific end uses (e.g., gallons/month for outdoor irrigation, cooling water evaporation, heated process water, bathrooms and kitchens etc.)
02	Metrics Normalized to Production	• Volume of water used per product(.eg., gallons/pound of product, gallons/product.) • Volume of waste water discharged per product. (.eg., gallons/pound of product, gallons/product.)

After completing an initial assessment, managers can consider it in the context of other planned lean events and prioritize opportunities for involving EHS personnel in value stream mapping and kaizen events based on when their environmental expertise will add the most value.

5.2. Engage Employees in Lean and Water Improvements Efforts

Lean provides a solid framework to empower cross-disciplinary employee teams to identify and eliminate excess water use and other production waste, thereby realizing both environmental and lean gains. Here are some of the ideas which could include water efficiency and to improve water-intensive processes. A significant benefit of involving employees throughout the industry in lean efforts is the opportunities to create a culture of continuous improvement.

TABLE 2: Improving water-intensive processes

Idea Making
➢ Motivate employees and managers by communicating corporate sustainability goals and incorporating water efficiency into performance targets and incentives. ➢ Consider trying out some of the lean and water improvement ideas, but don't limit employee teams to those ideas and encourage their creativity and initiative. ➢ Train employees on how to identify water waste and improvement opportunities, building their capacity to problem solve and help meet the facility's water use reduction targets. ➢ Actively solicit employee suggestions for kaizen events or other imprudent projects, by inviting ideas in meetings and conversions.

5.3. Connect Lean and Water Efforts to Sustainable Water Management Strategies

Lean provides operational tools that can support a broader corporate water sustainability strategy. Lean's focus on performance measurement, continual improvement through employee engagement, waste elimination, improved efficiency, increased profits and customer satisfaction can be leveraged to support corporate water management efforts to measure and report water use and implement the practical and effective solutions.

5.4 True North Goals and Targets

Lean experts often extol the motivational power of setting goals and targets that represent the "True North" for operations. True North is what we should do, not what we can do, the ultimate ideal for the overall process, and for every sub-process within it[7].True North goals, targets, and metrics are powerful tools for inspiring and focusing employee attention and creativity to both continuously improve and find breakthrough solutions. For example, Nike, Inc. developed "North Star" goals and metrics to define what sustainable products and a sustainable company would look like, which includes a focus on water stewardship [8].

5.5. Examine the Full value Chain

To achieve sustainability goals, it is important to look beyond a facility's direct operations. Lean methods can support water use and risk reduction efforts not only at areas within the direct control of a manufacturing facility, but also throughout the lifecycle or extended value chain for a product or service from the extraction and processing of raw materials, through production processes, product distribution, use and disposition. The flowchart provides an illustration of how the content links to a value chain [6].

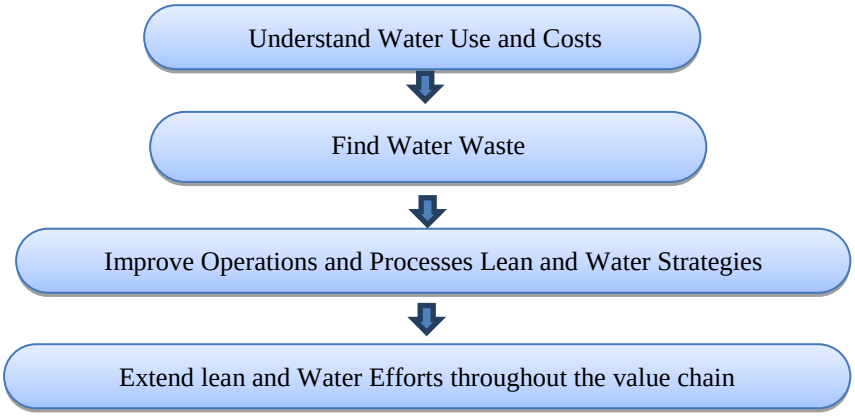

Fig.1 Lean and water strategies flow chart

VI. WATER END USES: AT FACILITIES

In order to reduce the water waste in industry, it is important to understand the many ways that water is used within the industries. Water use in most industries can be classified into the following broad end uses:

Production processing and in-product use, auxiliary processes (e.g., pollution control, labs and cleaning), cooling and heating (e.g., cooling towers and boilers), Indoor domestic use(e.g., restrooms, kitchens, and laundry) and landscape irrigation. Among U.S. industrial customers, cooling operations comprise the single largest category of industrial water end use, with more than 50% of industrial and commercial water demand combined going towards cooling[9].The amount of water required for the various end uses differs by industry to industry. Service and manufacturing facilities require the most water for washing and processing, while food and beverage facilities use most of their water intake in product preparation. The figure shows the examples of water end uses in the computer and electronics manufacturing industry and the food processing industry [10].

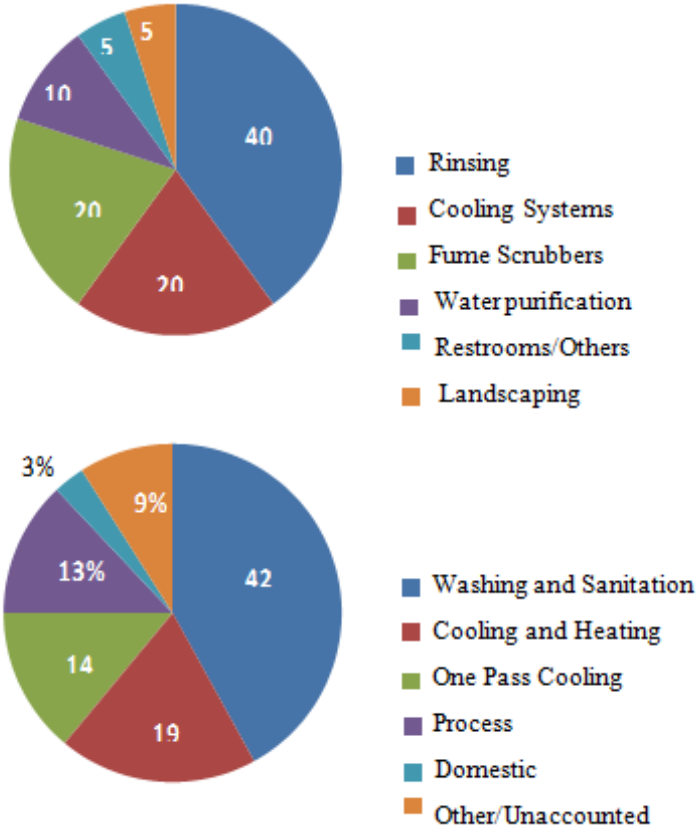

Fig.2 Breakdown of Water uses in A. Computers & Electronics B. Food Processors Industries

Major end uses of water often provide the greatest opportunities for water reduction and efficiency improvement. For example, in many food, beverage, and pharmaceutical companies, cleaning process equipment can account for as much as 50 to 70% of facility's total water use, and represents a substantial opportunity to save water[11]. The following figure shows how water flows through several different end uses at an industrial facility(note: not all reuse options, depends upon firm to firm).Beyond these categories of water end use, specific industries have processes that demand significant amounts of water. For example, in the textile industry, a typical continuous fabric bleach range machine can consume 11,000gallons of water per hour [12].

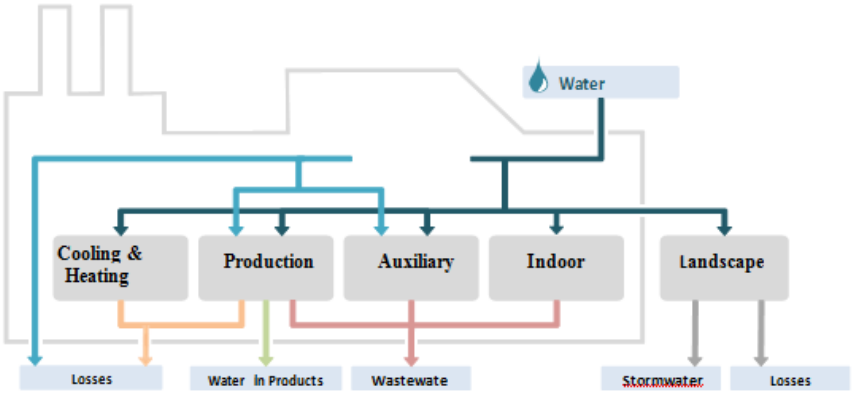

Fig.3 Water end uses at an Industrial facility

VII. MEASURING METHODS OF WATER USAGE

To gain a better understanding of water use patterns at a facility, it is almost always helpful to use water meters. Many lean methods rely on the availability of timely and accurate information on key performance metrics. By measuring water use and flows at the process level, it becomes much easier to identify water efficiency opportunities. There are two types of water meters: Source meters measure the amount of water being supplied to the facility, while sub meters measure usage for specific activities such as cooling towers, process sue, or landscape water use. Water meters can be either portable or fixed on specific equipment. Portable water meters measure water flows for processes or operations in a facility as a part of lean efforts such as kaizen events.Submeters can also help identify leaks and indicate when the equipment is malfunctioning. In some cases, it may also be useful to measure water pressure; a drop in pressure can indicate the presence of leak. Installing the correct meter and ensuring it functions properly are critical to accurate water measurement. There are many types and sizes of meters intended for different uses, so it is important to choose the correct one.Improrper sizing or type of matter can cause problems. For example, an undersized water meter can cause excessive pressure loss, reduced flow, and noise. Oversized meters are not economical and do not accurately measure minimal flow rates[13]. By metering water use at the facility and process levels, facility personnel can compile data to inform lean improvement efforts. There are some of the practical tips for using water meters as a part of lean efforts:1.Use flow meters and water quality or cleanliness standards to establish standard work for water usage, flow, and pressure levels, taking into consideration “set points” recommended by equipment specifications and facility operating procedures.2. Use data that meters provide to determine the appropriate frequency for aggregating and reporting water measures(hourly, daily, weekly) that best meets the facility’s needs.3.Show employees how to read and use water meters as part of lean activities such as kaizen events which can identify water saving opportunities. 4.Post water use reduction goals and water usage information on the factory floor on lean production control boards to raise the awareness of water use and efficiency among employees.5. Track data from water meters over time.

VIII. COSTS OF WATER WASTE

The costs associated with water use include more than the direct costs you pay for water supply, but also the costs of water as it travels through processes and operations. Estimating the many components of total water cost for a facility can begin with the cost of water purchased form utilities, but should also include the costs of steps required to process, use and discharge the water. These costs can amount to a good deal more than what appears on a utility bill. When estimating water costs, it is important to consider these and other indirect costs throughout all functions of a facility. One have be sure to use estimated future rates when assessing water costs, in order to project the level of savings that will be possible when improvements are made.

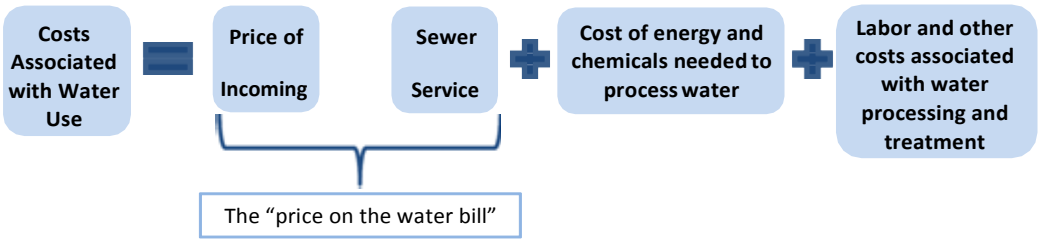

Fig.4 Costs associated with the water waste

The table gives the description of costs associated with the water use clearly [12]:

Sl.No	Category	Description
01	Raw material costs	• Water purchased from utilities; marginal costs of purchasing additional water vs. costa of conservation • Costs of water treatment, filtering, and softening before use • Costs of chemicals needed to treat and manage water
02	Energy Costs	• Cost of energy to heat water • Cost of energy to pump water from its source, or within the facility itself. • Energy & labor costs for operating & maintaining water-using equipment.
03	Pollution control costs	• Wastewater and stromwater service rates, including surcharges • Total cost of treating wastewater for disposal, including labor, energy, chemicals, equipment, and residual disposal. • Marginal costs of increasing effluent treatment capacity when water demand increases.
04	Regulatory Compliance costs	• Labor costs for regulatory compliance activities such as completing permit applications, monitoring compliance, and reporting wastewater discharges to regulatory agencies.

IX. WATER EFFCIENCY STRATEGIES WITH LEAN

Before implementing the strategies, the questions to be discussed are: Can we stop or prevent water losses e.g., leaks? Can we reduce water use (e.g. changing equipment, plumbing, processes)? Can we recycle or reuse water for another purpose (e.g. Circulating water)? There are number of ways to improve the strategies by lean methodologies [6].

9.1 Kaizen events and Just-Do-It to reduce water use

These are the powerful strategies for putting water efficiency into practice. A kaizen event also known as a rapid process improvement event is a2-5 day period when a cross functional team examines a process and makes rapid changes to improve it.The two types of kaizen events to reduce water use include:

9.1.1. Water kaizen Events

Consider concluding some kaizen events that are specifically designed to find and implement water efficiency opportunities. Good places to target include processes or areas of facility operations that use significant amounts of water. Some companies, such as GE, use kaizen events to look for water efficiency opportunities across a single facility. Water balances and value stream maps with water data provide good ideas for where to focus water implementation activities.

9.1.2. Kaizen events on Water-using processes

Even if the main objective of a kaizen event is not water efficiency, it's helpful to keep an eye out for water efficiency opportunities. There may be opportunities to reduce water waste, such as by adjusting equipment or reusing water, while also improving other aspects of the process There are five general types of water saving techniques in kaizen events and other lean efforts.Thery are consider water efficiency improvements in the context of other process improvements and lean performance, in order to get the best results. Evaluate how the process changes might affect waste water volume or quality, or have other important impacts. Consider which water efficiency best management practices and technologies make sense for the industries. Adopt visual controls, "mistake proof "devices on equipment and procedures to help ensure process changes are effective and can be easily maintained. After testing potential solutions, making changes, and evaluating actual performance to develop and update standard work for the activity so that workers can easily identify the current, best way to perform an activity. When evaluating water reuse opportunities, it is important to consider both water quality and quantity. The five water saving strategies are adjusting water flow, modifying existing equipment, change to more efficient equipment, reuse or recycle water and shift to a low-water or waterless process.

Consider an example for evaluating water reuse potential to identify possible ways to reuse water to meet the water quality and quantity needs of processes [6]:

Process/Operation	Water Need		Water Discharge	
	Volume	Quality	Volume	Quality
Cooling				
Boilers				
Restrooms				
Kitchen				
Landscape				

9.2. Integrate water efficiency into every lean practice

A variety of lean tools including standard work, visual controls, 5S, and total productive maintenance help workers identify and eliminate waste in their daily activities. Along with other waters, these lean tools can reinforce and promote strategies to reduce unnecessary water use.

9.2.1. Waste elimination culture

Lean is built around the framework of eliminating waste and striving for perfection.one can integrate water efficiency into the "culture of lean" at the industries, developing the capacity of the employees to identify the water waste in their normal work practices and find solutions that help to meet industries' lean and water goals. When the workers are passionate about improving the way the industry uses the water, the gains you achieve can become self-sustaining into the future. In a long run, developing people to be effective problem solvers is more important than implementing specific tools. It is critical, to train employees on how to identify water waste and to encourage and motivate them to work towards organization's water efficiency goals. The use of goals combined with incentives and support resources can be a powerful way to drive change and performance improvement.

9.2.2. Visual controls

Often used as part of standard work, visual controls support standardized procedures and display the status of an activity, so every employee can see it and take appropriate action. Visual controls make it easier to perform actions in a correct way and notice when there are problems. These are essential for supporting behavior-based water efficiency strategies which includes signs to encourage employees to use less water, placards on water-using equipment showing proper operation, water meters or sub-meters on high water using processes, display of facility water use and reduction goals on production controls boards, along with other performance metrics.

9.2.3. 5S

Another way to incorporate water efficiency into lean is through 5S which is a systematic, five-step process used to create and maintain a clean, orderly work environment. Many organizations add a sixth "S" for safety, creating 6S.The figure shows the framework of six pillars of lean concepts [14]:

Fig.5 Framework of 6S pillars

One key step that is relevant to reducing water use is "Shine", since water is often used in cleaning and rinsing. Many industrial and manufacturing businesses use large amount of water to flush lines, rinse parts and tanks, and clean equipment, floors, and other areas. These cleaning and rinsing practices often are large sources of wasteful water use and, therefore, opportunities for water savings. Educating employees on how to do the "Shine" step using less water, considering some of the water-efficient cleaning strategies. Since employees work alternatively to maintain a clean and neat work environment in 5S, it presents a good opportunity to spot water waste. Water considerations are also relevant to "Safety". Preventing water from being on the shop floor and walkways can eliminate slipping hazards.

9.2.4. Total productive maintenance

As a key strategy for finding and preventing water losses, as well as other equipment failures, total productive maintenance (TPM) is also relevant to water efficiency.TPM is ale an method that focuses on optimizing the effectiveness of manufacturing equipment.TPM focuses on team-based maintenance that involves employees at every level and function. A key practice in TPM is to maintain equipment in a manner that enables workers to quickly identify and correct problems that may result in leaks or spills. Since many facility operations use water, not just production processes, it's important to extend the preventative maintenance practices of TPM to non-production areas example restrooms and irrigation when looking for water issues [6]. The proactive maintenance tips to reduce water use are: adopt a user friendly system for reporting water leaks and fix leaks immediately. Inspect hot and cold water lines, steam lines and traps, water-using equipment, and plumbing fixtures routinely to identify potential problems and keep them operating properly. When performing maintenance on water-using equipment, replace worn parts and check to make sure that water-saving features are operating properly. Shut off water supply to equipment in areas that are not in use.

9.3 Lean and Water applications for facility operations and support processes

The most water consuming aspects of your facility may not be production processes but the other water uses include cooling towers, boilers, restrooms, kitchens, irrigation etc. The questions to identify water savings opportunities in facility operations and support processes are [6]:

1. Cleaning- Can process cleaning or facility cleaning be accomplished without using water i.e., using pressurized air to clean products or containers, sweeping debris off the floor? Have steps been taken to reduce the water used by steam sterilizers, such as jacket and chamber condensate cooling modification? Are we using detergents that clean easily be removed with little water?
2. Processes equipment- Can process equipment reuse (closed loop) or use reclaimed water from other parts of the facility? Are signs posted near equipment encouraging employee awareness of water use, and discouraging tampering with equipment flow rate?
3. Cooling and Heating- Has a facility replaced once-through cooling systems with multi-pass cooling tower or closed systems? Can one can optimize the blow down/bleed off controls on boilers and cooling towers? Have you considered switching to air-cooled equipment instead of water-cooled equipment? Does the facility reuse condensate water?
4. Restrooms and Kitchens-Do restrooms have water-efficient fixtures like water sense labeled toilets, faucet aerators and showerheads? Do kitchens use new water-and-energy efficient dish washers like energy star qualified models? Have to adjust plumbing to use minimum amount of water that is functional?
5. Landscaping and Irrigation- Has your facility designed its landscape to consider the local climate and grouped plans by similar watering needs? Does the facility use drip irrigation, low-flow sprinklers and optimized watering schedules to minimize water use?
6. Leaks- How to identify and repair leaks, holes, etc. throughout the facility? Is there a user-friendly method to report leaks? Are the employees and custodial crews are educated and empowered to identify leaks and point them out for repair? Are we conducting regular leak inspections like monthly basis, quarterly basis or annual basis?

X. CONCLUSION

Lean methodologies are highly positive in their findings, resulting in strong evidence that lean has infact a positive contribution in the improvement of the environmental performance. Furthermore, the strong focus on continuous improvement in the Lean concept needs employee involvement and training. Another feature of the lean concept is not only to solve any problem that occurs in facility, but to avoid occurrence in the future. We focused how lean principles are addressed in using water in various facilities in industries.Water is being scarcity in this generation, we tried to show in what ways does the water is wasted and used within the location by various industires.By applying some of the best lean strategies, the water efficiency can be improved practically and the facilities using water are minimizing their water usage in unnecessary activities and can be improved for the optimum utilization of water resource.

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