Efficiency improvement water bottling plant using SOP, 5S and SLP

Pablo M. Reyes-Saldaña[1]; Sebastian G. Alvarado-Portugal[2]; Claudia C. Leon-Chavarri[3]; Rafael Chavez-Ugaz[4]
[1234]Carrera de Ingeniería Industrial, Universidad de Lima, Lima, Perú
[1]20212268@aloe.ulima.edu.pe, [2]20213138@aloe.ulima.edu.pe, [3]cleon@aloe.ulima.edu.pe, [4]rchavezu@aloe.ulima.edu.pe

Abstract*— The bottled water industry performs a crucial role in preventing waterborne diseases and ensuring the overall well-being of people worldwide. Unfortunately, low efficiency remains a significant challenge within the industry, which could jeopardize the ability to meet current demand. Therefore, this study is important as it proposes an improvement in operational efficiency through a conceptual model. This model begins by preventing defective materials from entering the process, then increases the capacity of the bottleneck, and finally reduces defective in-process products during transport. This model includes standard operating procedures, 5S and SLP tools and achieved a significant reduction of 82.14% in unproductive time and a 46.61% reduction in the number of defective bottles. These changes primarily improved efficiency by 8,8%. Initial results were obtained through pilot tests, which were projected to provide a comprehensive solution for the system in Arena simulator. Finally, the economic impact was evaluated using RISK simulator, which confirmed the profitability of the improvements, with a positive Net Present Value ranging from 1.13 US$ to 1.94 US$.

***Keywords*—Operational efficiency, 5S, SLP, process standardization**

I. INTRODUCTION

In Peru, access to clean water remains a major issue, with over 13 million people lacking access to water or sewage systems [1]. Furthermore, 10% of the population in Peru in 2023 did not have access to potable water [2]. The bottled water industry helps the population to have access to clean water, but it faces several problems, including unproductive downtime and defective products, which reduce the capacity to produce and affect water quality [3].

The lack of optimization in production and distribution processes, along with high waste and defects, are the main reasons why the sector doesn't attend to the growing demand [4]. The demand is increasing, and without operational improvements, leading to reduced distribution and potential income loss [5]. Also, without standardized processes or proper control, costs rise, and companies lose competitiveness, which can negatively impact the economy [6]. Therefore, if operational efficiency is not improved by reducing defective products in the bottled water industry, the national and international demand will not be met, exacerbating the current problems of access to potable water [7].

There are studies that have achieved improvements in operational efficiency in bottling plants using Lean tools. Through the organization of work areas with 5S, they achieved a 29% of improvement in efficiency [8]. It has been proven that it's possible to reduce the variability in production times by standardizing processes, and at the same time use SLP to redesign the warehouse, reducing distances from 28.8 meters to 11.7 meters, thus improving operational efficiency [9] [10]. Despite these findings, there is a gap in literature as research uses Lean tools but without specifically integrating 5S SOP and SLP into a model that encompasses various variables/components to improve operational efficiency.

The implementation of an integrated conceptual model, combining tools such as SOPs, 5S, and strategic layout planning through SLP, is essential to overcoming current limitations and improving efficiency in bottling plants. This model must comprehensively address operational inefficiencies, from optimizing material flow to reducing downtime and improving product traceability [11]. A model based on these tools could not only reduce operational costs but also ensure a more reliable and higher-quality supply for the population, thus helping to close the gap in access to potable water in the country [6][7].

II. LITERATURE REVIEW

A. *Low Efficiency in Bottling Plants*

A key issue identified in water bottling plants is low efficiency, which has a direct impact on both productivity and competitiveness within the industry. This problem negatively affects industry efficiency, which has a target value of 75.3% [12]. The main factors contributing to this problem include idle time, process variability, and the presence of defective products. A lack of standardization in production processes leads to significant time differences between shifts, which increases the probability of human error and product defects [13]. Also, plants with low automation levels tend to experience more variations in operational results, which only worsens the efficiency issue. This variability, compounded by a lack of organized workflows, ultimately results in lower overall efficiency [14].

B. *5S to reduce defective products*

To improve efficiency in bottling plants, one of the best approaches is adopting the 5S method. This method is all about keeping things organized, clean. The available space is used more effectively using 5S, which naturally boosts productivity [15]. Using 5S to eliminate waste, operations become much smoother [16]. In that line, having a tidy, organized workspace doesn't just improve efficiency, it helps to spot issues before they become bigger problems [17]. Applying 5S isn't just about cutting down on downtime; it helps improve employee morale. More order helps motivation so improve the tasks [18]. This order also makes it easier to solve problems early, which helps streamline quality control and lowers the chances of defects [6]. Experiments were found in the literature that have generated a reduction in defective products by more than 80% [19]. In the same line, its been reported an improvement in efficiency between 30%-40% after reducing defective products by only ordering the plant [20]. Therefore, 5S not only reduces defective products, it improves operational efficiency [21].

C. SOPs to Standardize Processes and Reduce Idle Time

Standard Operating Procedures is important ensuring that every task is done the same way every time. This is especially important when dealing with high employee turnover or staff with poor training programs [22]. It's been point out, SOPs can reduce errors by 80% in industries that are regulated, making them invaluable in the water bottling industry [23]. SOPs also make it easier to solve issues in the process, so fast adjudgments can be done to keep consistent quality [24].

D. SLP to Improve Layout and Reduce Waste from Collisions or Drops

On the layout side, Systematic Layout Planning (SLP) can significantly improve how a plant is organized. By optimizing the layout, SLP helps with the flow of materials. Reference [25] explain that adjusting the layout through SLP reduces the distance materials need to travel, therefore, lowers the risk of bottles being damaged, that leads to fewer defects. Not only does SLP help improve efficiency, but it also ensures safer and more efficient movement of materials throughout the plant, cutting down on internal damages [26].

E. Integrating: 5S, SOP, and SLP

Integrating 5S, SOPs, and SLP, water bottling plants can really improve their efficiency. Using 5S helps to organize the workspace in a way disorder is solved. Meanwhile, SOPs ensure tasks are done the same way every time, which helps cut down on errors and keeps the process smoother reducing variability [12][18]. This consistency in tasks leads to fewer mistakes and better quality. And, SLP helps optimize the plant layout, reducing waste from unnecessary handling and bottle collisions. So, integrating these three techniques should lead the plant to see big improvements in efficiency, cost saving and also put the company in a better position where they can compete being in a stronger position compared with how they were. Therefore, the synergy of SOPs, 5S, and SLP provides an important base for streamlining operations, improving quality and also by ensuring the plant runs sustainably over time [4].

III. METHODOLOGY

A. Conceptual Model

The philosophy considered to build this model focuses on lean manufacturing, searching for an integrative approach to components and techniques is sought. Within the model, the three components aim to improve efficiency. The first component seeks to prevent the entry of defective materials, which results in fewer defective bottles being received in the bottleneck activity later on. Therefore, it favors the increase in bottleneck capacity. Likewise, by preventing the entry of defective bottles, there will be fewer defective bottles passing through the subsequent transfers.

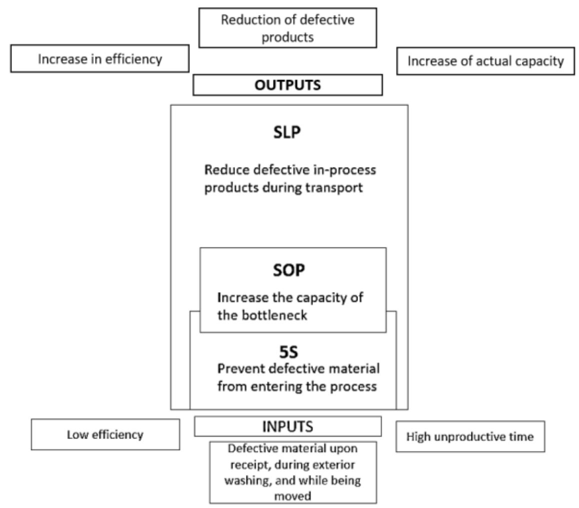

Fig. 1. Conceptual Model.

B. Components

The first component of the solution is to prevent the entry of defective materials into the production process. This first component is the foundation for the model, as it prevents future defective work-in-processes that could impact other areas down the road, such as the bottleneck. The 5S technique is proposed within this component.

Second, there is the component of increasing the bottle neck. When seeking efficiency improvements, this component directly influences a company's actual capacity. Increasing the bottleneck's capacity allows for more production with the same activity as the bottleneck, or in other cases, the bottleneck will be moved to another activity. The most important tool in this second component is SOP. However, the pursuit of increasing the bottleneck by standardizing the bottleneck activity goes hand in hand with 5S. The last S allows for control through the discipline of control habits, and the fourth S directly facilitates standardization.

Third, after increasing the bottleneck's capacity, defective work-in-processes are reduced during shipments. The first component aims to prevent defective materials from entering the process. However, defective work-in-process is generated during task execution and manual transfer through the aisles. The third component reduces defective work-in-process by focusing on the SLP technique. Therefore, the warehouse will be redesigned to reduce the generation of defective work-in-process by reducing distances. It is important to highlight that reducing distances through SLP will have an impact on transfer times, and consequently, the redesign of the entire plant will also have an impact. The previous components will synergize with this third component, ultimately complementing a general and holistic modification.

C. Methodology of validation

For the first two components, pilot tests were conducted to reduce defective drums in the warehouse and a SOP pilot to reduce processing time per drum in the bottleneck activity. Third, the comprehensive proposal was simulated in Arena Simulator, including the new distances that would result from the proposed redesign.

IV. RESULTS

A. As is Scenario

In the bottling plant, it was found that the two most impactful reasons for the low efficiency were unproductive times and high defective bottles.

TABLE I. DEFECTIVE PRODUCTS IN PROCESS

Defective products in the bottle reception activity	**Defective products during the movement of bottles**	**Defective products in the external washing process**
Monthly	Monthly	Monthly
1838.93	1305.29	364.43
52.39%	37.18%	10.38%

As seen in Table I, washing activity at the bottling plant is the largest source of defectives. This adds up to a total of 3511 monthly waste, which represents 13.74% of the total production. Therefore, if we reduce the defective products in the entry then we will have less defective bottles in the movement of bottles and external washing.

In the bottleneck activity, after the time study was conducted, the variability obtained is shown in Table II. The time study data showed that the duration of the external washing activity was 75.28 seconds, with an unproductive time percentage of 30%

TABLE II. VARIABILITY IN EXTERNAL WASHING

Tasks	**Visual inspec tion**	**Remova l of the cover**	**Manual external brushin g**	**Rinsing with pressurize d water**	**Dryin g**	**Final inspec tion**
Standard deviation	1.11	0.80	6.48	6.25	2.47	0.90
Coefficie nt of variation	17%	19%	25%	29%	31%	12%
Sample mean (average)	6.44	4.06	28.03	21.30	7.99	7.46
High variability ?CV>20 %	No	No	Yes	Yes	Yes	No

To obtain the defects per segment, the statistical sample consisted of 27 trips, with a standard deviation of 7.9597. However, the sample provided by the company is larger than the one given by the following formula for samples in finite populations.

The high variability presented in Table III for each task is due to three main reasons identified in the time study: Unnecessary brushing, the drum falling during handling, and Unnecessary rinsing. These reasons generate a substantial increase in the time used to carry out the regular washing process, causing the washing coefficient to increase compared to the standard average. This was evaluated for each task and explained in table V.

TABLE III. DEFECTIVES IN MOVEMENT

Movement	**Average**	**Distance**
Sterilization to Filling	2.30	5
Labeling to Finished good warehouse	22.53	12
Filling to Labeling	15.43	11
Bidon reception to Laundry	3.50	5.78
Laundry to Sterilization	5.63	6.8
Total defective average	**49.40**	**40.58**

Table III shows how the average number of defective drums is significantly higher when they travel longer distances. Specifically, the section from Labeling to Finished Product Warehouse and Filling to Labeling present the highest average number of defective drums and also the highest coefficient of variability, as shown in Table II. This point was also validated using the correlation coefficient (R2) and a regression model to see the degree of correlation between both variables. It was found that the R2 between the distance variable and the average number of defective units was 0.991, which indicates a high degree of correlation between the variables when modeled with quadratic regression, as seen in Figure 2.

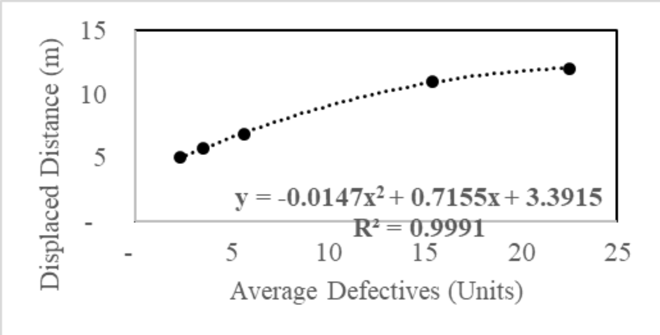

Fig. 2. Correlation between Distance vs Defective Drums.

B. Model Application

To prevent defective material entering to the process, we used 5S, the audits done followed the criteria outlined in Table IV.

TABLE IV. 5S AUDIT CRITERIA

S	Points	Criteria
1	0	Unnecessary items have not been eliminated
	1	Some unnecessary items have been eliminated
	2	Most unnecessary items have been eliminated, but there is room for improvement
	3	All unnecessary items have been eliminated, and the work area is optimized
2	0	Materials are not organized or identified
	1	Some materials are organized, but not optimally
	2	Most materials are properly located and identified
	3	All materials are well organized and labeled, allowing for immediate access
3	0	No cleaning is performed in the work area
	1	Occasional cleaning is performed, but it is insufficient
	2	Cleaning is good in most cases, with some areas for improvement
	3	The area is consistently kept clean, following an appropriate cleaning plan
4	0	No standards or signage exist in the area
	1	Partial signage or inconsistent standards exist
	2	Most standards are implemented, but not completely
	3	All standards are implemented, and signage is clear and consistent
5	0	There is no discipline in maintaining 5S
	1	Discipline is irregular, and some procedures are not followed
	2	Most procedures are followed, but there are areas where they are can improve
	3	The team consistently follows the 5S, demonstrating discipline and commitment

Then, within the second component, to increase the production capacity of the bottleneck, the activity of the bottleneck was studied.

However, the result was 60 samples for a standard deviation of 4.076%. The time study performed consisted of 150 cycles for each operator involved in the exterior bottle washing process. Each operator was trained to follow the steps outlined in Table V.

TABLE V. NEW EXTERNAL WASHING PROCESS

External Brushing	Brush quickly and vigorously in the dirtiest areas
	Brush the edges where dirt accumulates
Drying	Dry the producto using a clean, dry cloth
	Dry the internal surfaces first
	Dry external areas
Pressure wáter rinse	Adjust the preassure according to the type of dirt
	Do a deeper rinse in the hardest areas
	Check if residues have been completely removed

Third, the validation methodology for the third component of the conceptual model to reduce the distances of movement between areas. A study was conducted to quantify the number of drums impacted within the current layout. For the statistical sample, media population formula was again used, with a standard deviation of 7.95%, derived from a preliminary pilot sample, suggesting that the sample should consist of 111 data points. Despite this, the study consisted of 150 data points divided into each transfer at the plant.

After the study, the Poisson distribution was used to relate the new distances to impacts. In equation (1), λ is the average hit rate, $P(X = k)$ is the probability that k hit rates occur, k is the number of hits observed, and e is the Euler's number.

$$P(X = k) = \frac{\lambda k e^{-\lambda}}{k!}. \quad (1)$$

The distribution is useful to obtain the probability of occurrence of defective products. The table below summarizes the data obtained from the hit study using the average hit rate. The prediction of time was calculated considering a proportional relation between time and distance.

TABLE VI. RATE OF KNOCK BY DISTANCE TRASLATED

Original Distance (m)	**Average Time (s)**	**New Distance (m)**	**Projected Time (s)**	**New (λ)**	**New probability**
5	14.92	5	14.92	2.8	0.27%
12	31.34	6.5	16.98	4.35	0.42%
11	27.12	5.3	13.07	3.06	0.29%
5.78	6.01	5.78	6.01	3.52	0.34%
6.8	15.15	6.8	15.15	4.76	0.46%

This information is important because will be entered to simulate the new scenarios changing the probabilities of defective products and also the time of movement between areas.

Similarly, the proximity analysis carried out is presented:

TABLE VII. PROXIMITY ANALYSIS

Area/Area	**R**	**Exterior Wash**	**A**	**LL**	**E**	**Packaging**
Reception	X	A	E	O	U	U
Exterior washing	A	X	I	O	U	U
Storage	E	I	X	E	O	U
Filling	O	O	E	X	A	E
Labeling	U	U	O	A	X	A
Packaging	U	U	U	E	A	X

Finally, the new layout is simulated in arena simulator with the new distances and probabilities. First, the probability of waste generation decreases in the drum reception, drum washing, and drum transfer activities. Furthermore, downtime is reduced in the external washing activity, allowing us to simulate the activity with the new time.

C. *To be, results*

Once the variables mentioned in the validation were adjusted, the number of defective drums was significantly reduced, as shown in Table VIII with the efficiency indicator, increasing from 62.1 to 67.6, resulting in a 8.8% change.

For the first component the result of the polit of the 5S can be appreciated in this image.

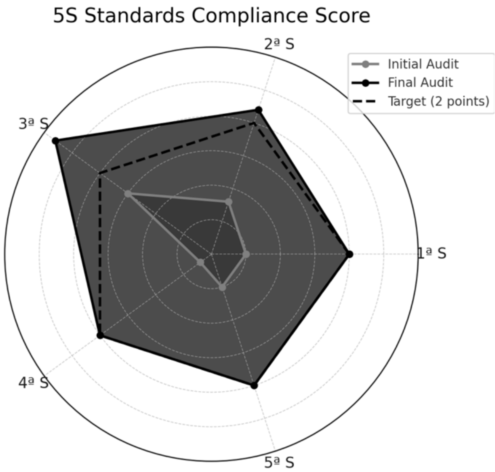

Fig. 3. 5S audit result

This improvement led to a reduction of defective products in the incoming warehouse by more than 35%, which was the goal, as shown in the graph. Initially, there was an average of 64.98 defective bottles, and eventually, 30.81 defective bottles. On average, since the implementation of the pilot test, there is an average of 49.77 defective bottles.

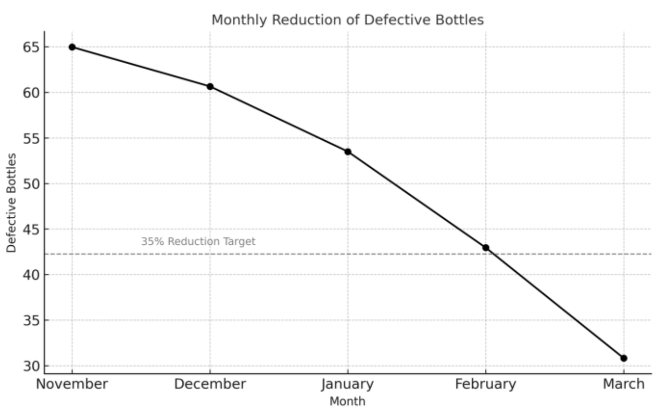

Fig. 4. Monthly Reduction of Defective Bombs

For the second component, to increase the capacity of the bottleneck, after standardizing the tasks in the external washing activity, as shown in Table V, we were able to reduce the variability of the times to less than 20% for all tasks.

TABLE VIII. VARIABILITY IN EXTERNAL WASHING

Tasks	**Visual inspec tion**	**Remova l of the cover**	**Manual external brushin g**	**Rinsing with pressurize d water**	**Dryin g**	**Final inspec tion**
Standard deviation	1.11	0.81	1.99	1.07	1.64	0.91
Coefficie nt of variation	6%	18%	19%	10%	8%	12%
Sample mean (average)	6.36	4.1	19.04	12.67	7.38	7.52
High variability ?CV>20 %	No	No	No	No	No	No

This reduction in variability also causes a decrease in the total time of the activity of external washing from 75.03 to 57.07 seconds, this is a reduction of 17.96%. Also, the defective bottles dropped by 25% in this activity.

The new layout with the new distances and after the proximity analysis done have the same area of 921.43m^2 but the changes are in an area of 295m^2.

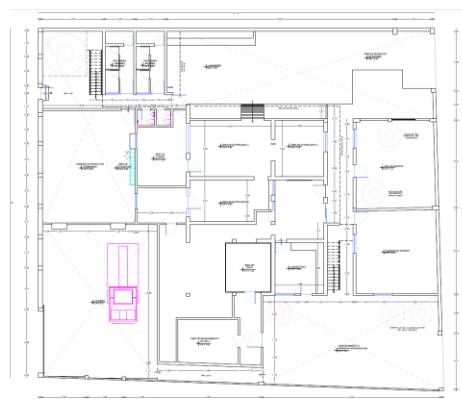

Fig. 5. New Layout

Then, after the simulation in Arena Simulator, the results shown in Table VIII were obtained, where the improvement in most of the indicators is evident.

TABLE IX. RESULTS OF NEW LAYOUT SIMULATION

Indicator	As-Is	To-Be	Variation (%)
NC defective units in transit to storage	21.13	4.02	-81%
NC defective units in transit to washing	2.32	2.35	1%
NC defective units in transit to sealing	14.86	3.04	-80%
NC defective units in transit to filling	5.41	3.18	-41%
NC defective drums at reception	80.18	57.40	-28%
NC defective drums after exterior washing	10.03	12.55	25%
NC defective units in transit to sterilizing	3.09	3.99	29%
Efficiency	62.1	67.6	8.8%

a. Results obtained from simulation. With an Confidence Interval at 95%, As-Is: Baseline, To-Be: After Simulation.

It is worth mentioning that the percentage increases for the external washing activities and the movement to sterilization and the washing area are due to the increased production. For this reason, the objective of reducing defective bottles in the external washing activity by 30% could not be met. However, for the transfers where distances were reduced, there was a significant reduction in defects, which allows the objective shown in Table IX to be achieved. As shown in Table IX, the solution model shows a considerable improvement in the proportion of defective drums, from 13.74% to 7.4%, while also reducing the unproductive time from 29.40% to 5.25%.

TABLE X. MOST IMPROTANT INDICATORS

Indicator	As-Is	To-Be	Goal	Variation (%)
% of defective drums	13.74%	7,4%	8.85%	46,61%
% of downtime	29.40%	5.25%	21%	82.14%

b. Results obtained from simulation. As-Is: Baseline, To-Be: After pilot, Impr: Improvement, CO: Changeover and Var: Variability

Analyzing the results obtained, the presented problem should be considered as a subject of change in the model inspired by continuous improvement. Thus, adjustments in the working method should be applied so that the increase in defective bottles during transit to sterilization 29%, washing 1%, and 25% during the external washing activity can be reduced.

Finally, the economic impact of the proposed improvement was evaluated using a risk simulator. The variables used were the COK and annual production. The data for COK were requested by the company, with a minimum of 8%, an average of 9%, and an optimal value of 10%. The production, used as a variable, came from the results of the Arena simulation with a minimum value of 340,200, an average of 340,500, and a maximum value of 341,400, with a 90% confidence level

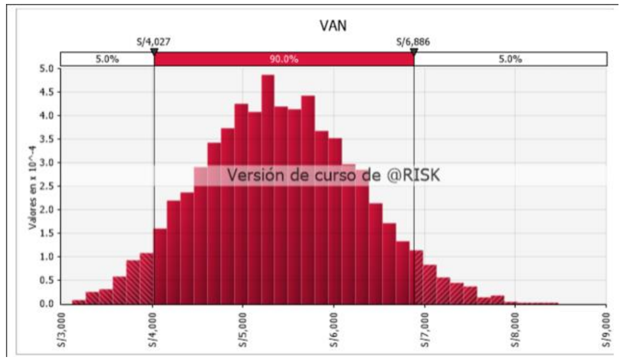

Fig. 6. RISK Economic Impact Anlaysis

In summary, the functional aspects of the proposed solution include an improvement in operational efficiency by optimizing the workspace, reducing defective materials, and enhancing task organization, along with an optimized layout. This resulted in a reduction of variability in the bottleneck activity, an increase in plant production, and a decrease in unnecessary movements, preventing product spills during the process.

V. CONCLUSIONS

The proposed conceptual model, along with the application of engineering tools, will achieve a 8.8% efficiency improvement, which was the main objective. This improvement is in line with previous applications of these components in the sector, which report improvements between 5% and 10% [7].

Unlike most models found in the literature, which operate separately, this model consolidates and generates synergy between the three components. It achieved very high results for the sector in relevant KPIs, such as downtime, which was reduced by 82.14%, and the proportion of defective drums, which was reduced by 46.6% with a 95% confidence level.

Future research could explore the automation of key processes, such as drum washing, which is the bottleneck and most time-consuming activity in the process. With automation, the implementation of technologies such as robotics or artificial intelligence would be necessary, which could further improve operational efficiency and reduce downtime and defects. A cost-effectiveness analysis would be necessary to determine if it would ultimately be profitable for the plant.

REFERENCES

[1] Instituto Peruano de Economía, "Más de 13 millones de personas carecen de agua o desagüe en el país," Instituto Peruano de Economía, 2023. [En línea]. Disponible en: https://www.ipe.org.pe/portal/mas-de-13-millones-de-personas-carecen-de-agua-o-desagueen-el-pais/

[2] Gobierno del Perú. (2024). *El 10% de la población peruana no tiene acceso a agua potable, y el 23% no cuenta con servicios de alcantarillado. Actualmente, 3.3 millones de peruanos carecen*

de acceso a agua potable, lo que representa un desafío significativo para la salud pública y el bienestar social en el país. Recuperado de https://www.gob.pe/institucion/sunass/noticias/781301-el-10-la-poblacion-peruana-no-tiene-agua-potable-y-23-no-accede-al-alcantarillado

[3] Sociedad Nacional de Industrias, "Producción de agua embotellada en el Perú 2012–2016," SlideShare, ene. 2018. [En línea]. Disponible en: https://es.slideshare.net/slideshow/2019matppiu16102tpdf/254508572

[4] D. Alvarado y J. Sánchez, "SOP Standardization in Water Bottling Processes," *Water Bottling & Distribution Journal*, vol. 8, no. 2, pp. 100–115, 2024. doi: 10.1234/wbdj.2024.0821.

[5] López, M. (2022). Desafíos y oportunidades en la industria embotelladora de agua en Perú. *Revista de Tecnología y Producción*, *18*(2), 33-45.

[6] A. Campos, R. Fernández y J. Mendoza, "Water bottling industry in Latin America: Trends and sustainability challenges," *Environmental Science & Policy*, vol. 128, pp. 160–175, 2023. doi: 10.1007/s11267-023-1458-9.

[7] C. Mendoza y B. Aguirre, "Reducing Inefficiencies in Bottling Plant Warehousing," *Lean Manufacturing Journal*, vol. 28, no. 3, pp. 170–185, 2024. doi: 10.1016/j.tifs.2021.06.009.

[8] Chilón, X., Esquivel, L., & Tamay, W. (2017). Implementación de las 5S para incrementar la eficiencia en una planta embotelladora de agua. *INGnosis Revista de Investigación Científica*, 3(1), 130-139. https://doi.org/10.18050/ingnosis.v3i1.2028

[9] Campos, F., Fernández, L., & Mendoza, P. (2023). Implementación de 5S en una planta embotelladora: Impacto en la reducción de tiempos improductivos. *Ingeniería Industrial, 42*(2), 35–50. https://doi.org/10.1016/j.ri.2022.04.002

[10] Choirun, A., Brilliantina, A., & Triardianto, D. (2024). *Facility layout design improvement in bottled drinking water at teaching factory*. IOP Conference Series: Earth and Environmental Science, 1338(1), 012070. https://doi.org/10.1088/1755-1315/1338/1/012070

[11] R. Kumar, A. Gupta y P. Sharma, "Impact of standard operating procedures in reducing process variability in manufacturing industries," *Journal of Industrial Engineering and Management*, vol. 11, no. 1, pp. 45–58, 2018. doi: 10.1016/j.jiem.2018.03.005.

[12] Y. Zhang, J. Huang, X. Sun y Y. Wang, "Advanced oxidation processes for removing antibiotic resistance genes from water and wastewater: A review," *Environmental Science and Pollution Research*, vol. 27, no. 30, pp. 37583–37596, 2020. doi: 10.1007/s11356-020-09850-6.

[13] K. Chang, J. Lee y T. Adi, "Standardization strategies for quality assurance in food and beverage operations," *Asian Journal of Quality*, vol. 22, no. 3, pp. 144–160, 2021.

[14] R. M. Aadil, A. Khan y A. Gani, "Quality Control in Beverage Production: An Overview," en *Food Science and Technology*, vol. 39, no. 4, Academic Press, 2019, pp. 895–910. doi: 10.1016/b978-0-12-816681-9.00001-1.

[15] J. Rodríguez y S. Díaz, "Implementación de 5S para la mejora en la manipulación de productos en plantas de embotellado," *Revista Latinoamericana de Ingeniería*, vol. 12, no. 3, pp. 150–165, 2022. doi: 10.29057/escs.v7i14.5642.

[16] Granillo-Macías, J., García-Pérez, A., & González, M. (2020). Impacto de la metodología 5S en la productividad en la industria embotelladora. *Journal of Industrial Engineering, 35*(4), 455–470.

[17] J. Granillo-Macías, L. García-Pérez y A. González, "Aplicación de la metodología 5S para la reducción de tiempos improductivos en la industria alimentaria," *Revista de Ingeniería Industrial*, vol. 38, no. 2, pp. 55–70, 2020.

[18] D. Campos, M. Fernández y R. Mendoza, "Lean tools for operational improvement in SMEs," *Ingeniería Industrial*, vol. 45, no. 2, pp. 34–47, 2023.

[19] Palacios, J., & Rojas, M. (2021). Aplicación de la metodología 5S en la planta embotelladora de agua: Un estudio de caso. *Revista de Ingeniería y Tecnología, 32*(1), 101–115. https://doi.org/10.4067/S0718-192X2021000100101

[20] Rodríguez, M., Díaz, J., & Suárez, L. (2022). Mejora de la eficiencia operativa en el sector embotellador utilizando la metodología 5S. *Revista Latinoamericana de Ingeniería, 15*(1), 10–25.

[21] Martínez, C., García, S., & Silva, L. (2020). Mejora continua en plantas embotelladoras mediante la metodología 5S: Un enfoque práctico. *Revista de Ciencias Industriales, 38*(2), 221–235.

[22] F. Palacios y M. Rojas, "Efectos de la organización visual sobre el desempeño de operarios en líneas de embotellado," *Revista Peruana de Ingeniería Industrial*, vol. 17, no. 1, pp. 66–78, 2023.

[23] R. Kumar, P. Gupta y M. Sharma, "Implementation of standard operating procedures in bottling plants: A performance assessment," *Operations Management Research*, vol. 11, nos. 3–4, pp. 157–166, 2018.

[24] J. Hernández Asian, A. Martínez y C. Villanueva, "Diagnóstico y mejora operativa en planta embotelladora," *Revista de Ingeniería de Producción*, vol. 29, no. 1, pp. 22–34, 2023.

[25] J. Bessant, *Continuous Improvement in the Digital Age*. Londres: Routledge, 2022.

[26] C. Prahalad, R. Rajan y M. Tanvir, "Integrating Lean Manufacturing and Six Sigma for Continuous Improvement in Production Systems," *GSC Advanced Research and Reviews*, vol. 4, 2023.