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ANALYSIS OF PROPOSED IMPROVEMENTS TO MINIMIZE PIPE LEAKS AND DECREASE IN WATER QUALITY USING TOTAL QUALITY MANAGEMENT METHOD: A CASE STUDY OF PT.XYZ

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ABSTRACT

PT. XYZ is a company engaged in clean water supply management systems in ABC industrial area managed by PT. ABC. PT.XYZ is experienced in the problem of water loss which can be categorized as high in the production process with 15.5% and in the distribution process with 32.6%, in which this value exceeds the standardized rules set by the government. The water loss is caused by pipe leaks, which later will affect to the declining quality of clean water. In this study, the TQM (Total Quality Management) approach was used to overcome these problems. According to research, the company has implemented majority of TQM principles and thus, it has a positive impact on better performance in providing clean water for PT.ABC. The recommendation proposed in this study is by investing additional infrastructure in Water Treatment Plant (WTP).

Keywords: ***Total Quality Management, Quality, Clean Water***

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1. INTRODUCTION

Water is a basic human need. This basic need should be not only unlimited to use in households or individuals but also provided in a large scale such as for the industrial sector. Based on the GE (General Electric) Staff Reports website in August 2017, 70% of water needs are for agriculture, and 20% is needed for industry. Recent research from GE stated that, as the economy improves, industrial demand for water increases by up to 45%.

Based on the USGS (United States Geological Survey), industrial water use includes water operated for various purposes. Industrial activities using water is including the fabrication, processing, washing, dilution, cooling, or transportation of a product; introducing water into the product; or sanitation needs in manufacturing facilities. Some industries that utilize large amounts of water are producing commodities such as food, paper, chemicals, refined petroleum, or primary metals.

ABC Industrial Estate is an industrial area in a big city of Indonesia that is managed by PT. ABC. ABC Industrial Estate requires clean water for the needs of the production process and the daily needs of employee activities supplied by PT.XYZ. The cooperation carried out by ABC Industrial Estate and PT. XYZ is a BOT (Build Operation Transfer) collaboration in managing clean water supply systems in industrial areas since 2012, which is used to serve and meet the needs of industrial companies in the area.

This collaboration is projected to last for 25 years. This partnership initially includes the construction of SPAB (Clean Water Supply System) facilities which consist of intake buildings, raw water transmission pipes, and Clean Water Treatment Plants (IPA), treatment of raw water comes from the S River as well as distribution of clean water from the third XYZ reservoir owned by PT. ABC.

In 2019, there was a change in the alliance between PT. XYZ and PT. ABC where PT. XYZ had additional obligations as the management of SPAB to industrial companies in the ABC Industrial Estate. It made water losses would be the responsibility of PT.XYZ.

Loss of water which is also known as Non-Revenue Water (NRW) is a waste in a drinking water supply company. A study in 2019, stated that on average, XYZ companies have experienced water losses of 15% in the production process and 32% in the distribution process. This water loss certainly causes the company to lose financially and decrease customer confidence (PT.ABC) in the quality of water production produced by PT.XYZ.

There is an inefficiency in the process, though it is potential for PT. XYZ to maximize water production, so PT. XYZ is expected to be able to meet the needs of PT. ABC and ABC Industrial Estate so that customers do not need to look for other water sources to meet their water needs.

Based on these problems, the present study aims to provide an analysis of improvements using the Total Quality Management (TQM) method. Total Quality Management (TQM) is a management principle that is widely applied in most companies and discussed in more detail analysis. However, the majority of organizations and researchers, have a different understanding of this term (Dewhurst, Martínez-Lorente, & Dale, 1999).

TQM reveals that there is an increase number in quality with a decrease in cost. Loss of customers is one of the costs as a consequence of quality discrepancies, which are usually referred to as lost opportunity costs (Dewhurst, Martínez-Lorente, & Dale, 1999).

Dewhurst, Martínez-Lorente, & Dale (1999) in their research, described there are 10 dimensions in TQM, they are support from management, customer relations, relations with suppliers, employee management, employee attitudes, process design for products and/or services, management process flow, data and report quality, the role of the quality division, and comparative studies.

Production is interpreted as an activity to create and increase the usefulness of an item or service by using production factors (Rafdiansyah, 2017). According to Dirjen Cipta Karya (2018), the production of clean water treatment consists of several process units which consist of:

1. Intake of raw water through the intake tapping building
2. Distribution of raw water through the transmission pipeline
3. Coagulation process, that is the process of mixing water purification chemicals added with rapid stirring to agglomerate suspended solids in raw water into flocs.
4. Flocculation process is a slow stirring process usually added with a ballast polymer, this process functions are arranged so that the flocs formed in the coagulation process combines to form larger flocs so that they are able to reach a

specific gravity (SG) value of more than 1.00 Kg/L.

5. Sedimentation process, explained as the process of deposition of the floc which is already heavy so that it can be separated between clean water and residual sludge as process residue.
6. Filtration process, which is the process of filtering the fine floc that is still carried away by the treated water during sedimentation.
7. Disinfection process, that is the process of affixing or adding a substance or disinfectant that functions to kill pathogenic microbes and bacteria in treated water.
8. Distribution process to customers

Many things need to be considered when planning a clean water distribution network, including the number of customers to be distributed, water needs, location (topography) of the area to be distributed, network pattern, clean water distribution equipment system, and leak detection (Habibah, 2020). Water distribution is one aspect of development in a city and depends on the size of the population. The distribution of water should meet the needs of the population. The distribution of water plays a role in improving the standard of living (Kanth, et al. 2019).

According to Arief Wahyudi, Elvira, and Nurhayati (2017), The main function of the distribution network in clean water supply system is to deliver clean water to all customers while still pays attention to quality, quantity, and continuity to water pressure and speed which meets standards. The clean water drainage system in the distribution pipe is divided into two alternative systems, specicifically Sustainable system (continuous system) In this system, water supply and distribution to customers are carried out continuously. This system is applied when there is a real need and the quantity of treated clean water is always available.

1. Rotating System (intermittent)

In this system, water is distributed to customers only at certain times when demand is increasing. This usually occurs in clean water supply systems with limited demand and quantity. Water loss can be defined as a number showing the difference between the volume of water supply (supplied water) and the volume of water consumed (consumed water). The loss of water certainly has an impact on wastewater, technical instability of network components, decreased water quality, inequities in water distribution, increased operating and maintenance costs, and loss of income needed to maintain and expand access to water. The activity of reducing all components of water loss to zero is neither technically nor economically feasible. Losses must be assessed accurately and prioritized for reduction. In simple terms, water loss is the amount of water that is lost and does not become income (AL-Washali et al., 2020).

There are two types of water loss in the clean water supply system (SPAB), expressed by the loss during processing raw water into clean water at the Water Treatment Plant (IPA) which is called plant losses and water loss when water is distributed from IPA to the customer which is called Non-water loss. Revenue Water (NRW) or in other terms called unbanked water (Dirjen Cipta Karya, 2018).

Water Loss Management is a planned and systematic effort to reduce the rate of water loss to a reasonable and controlled limit by taking into account to technical, economic, administrative, and social aspects (Dirjen Cipta Karya, 2018).

2. METHODS

This research focused on the performance of the clean water supply by PT.XYZ to PT.ABC. This study used 2 methods, interviews and observations (data). Interviews were conducted with one of the managers of PT.XYZ. Meanwhile, observations in the form of data collection of water production, water distribution, and water consumption were also carried out to see clean water production throughout 2019 and 2020, and in the first semester (January-June 2021) as a component to be analyzed, which is illustrated in table 1.

Interviews were conducted by indirect communication, using video conference calls with the Zoom platform. The interviews lasted approximately 2 hours. Interviews were conducted to obtain detailed and in-depth information related to conditions in the field.

In addition, a literature study on TQM was also carried out to support the recommendations given.

The limitation of this research is that the

study only focused on the TQM method based on the results of the analysis, and thus appropriate recommendations will be given for PT.XYZ.

3. RESULTS

PT. XYZ has been established in 2011 and started operating in 2013. The initial investment made by PT. XYZ is 85 billion rupiahs, and the estimated payback period is 6 years. However, this is not achieved due to the absorption of clean water that has not been maximized.

In 2019, PT.XYZ has an average production volume of 83,258 m^3 per month and in 2020 it is 174,254 m^3 per month. While the production capacity of PT.XYZ is estimated to reach 259,000 m^3/month, with a deviation of about +30%, it is estimated that the maximum production capacity of PT.XYZ is 280,000 m^3/month. This means, in 2019 and 2020, PT. XYZ only produces around 29.7%-62% of the total maximum production capacity. With 2 problems experienced by PT. XYZ, namely pipe leakage and decreasing water quality, PT. XYZ is projected to have more turnover if it makes improvements to these 2 problems, and can also increase customer confidence (PT.ABC) in the performance of PT. XYZ in the supply of clean water.

Table 1 describes water production, water distribution, and water consumption by PT. XYZ for the period 2019-2020, and January-June 2021. Based on the table, in 2019, it can be seen that the water loss that occurred in the clean water distribution process was greater with a minimum value of 28.1% and a maximum value of 38.1% compared to the water loss in the production process with a minimum value of 11.9% and a maximum of 18.3%.

From the table, especially on the rate of water loss in the distribution process, the figure has exceeded the limit set by Peraturan Menteri Pekerjaan Umum No 20/PRT/M/2006, namely the loss of water suitable for a clean water distribution system or drinking water is 20%. PT.XYZ. The principles of TQM that can be proposed to overcome these problems are as follows:

A. Top Management Support

Top management reviewed the problems and made amendments to the agreement with consumers (PT.ABC) related to infrastructure, investment, and re-set the selling price. Replacing the pipe and closing the reservoir are 2 steps that PT.XYZ can take to improve water quality and increase water production to consumers (PT.ABC). This pipe replacement requires an investment of up to IDR 14 billion based on the result of negotiations with top management such as the director of the engineering department, the director of the finance department, and the deputy. PT. XYZ is committed to completing this pipe replacement to minimize leakage and is targeted to be completed in August 2021.

The initiation to close the reservoir (3 reservoirs) was carried out. The closed reservoir is owned by consumers (PT.ABC), currently replaced by a reservoir owned by PT.XYZ, thus, the monitoring process will be easier to do because it is a reservoir network owned by the producers themselves. These two initiatives are carried out with the hope that PT. XYZ can improve services to consumers. Replacement of sand as water filtration media is also carried out periodically as an action to improve water quality.

Table 1 Water Production, Distribution and Consumption in 2019-2020 and January-June 2021

Period	Description	Water Volume/Month			Water Loss/Month			
		Production	Distribution	Consumption	Production to Distribution		Distribution to Consumption	
		m^3	m^3	m^3	m^3	%	m^3	%
2019	Total	1,760,888	1,486,786	999,101	274,102	15.6	487,685	32.8
	Min	117,027	96,714	69,114	16,108	11.9	27,600	28.1
	Max	178,751	148,212	101,331	32,737	18.3	55,697	38.1
	Average	146,741	123,899	83,258	22,842	15.5	75,028	32.6
2020	Total	2,737,187	2,468,682	2,091,047	268,505	9.8	377,635	15.3
	Min	176,713	147,460	92,876	10,043	4.0	10,855	4.5
	Max	306,814	286,492	237,943	34,730	16.7	64,311	37.0
	Average	228,099	205,724	174,254	22,375	10.3	31,470	16.5
Jan-Jun 2021	Total	1,625,823	1,541,480	1,467,959	84,343	5.2	73,521	4.8
	Min	227,334	218,168	202,656	9,166	3.4	5,841	2.3
	Max	291,832	275,471	262,680	19,803	7.3	16,386	7.1
	Average	270,971	256,913	244,660	14,057	5.2	12,254	4.8

B. Relationship with Customers

PT.XYZ improves relationships with customers by taking advantage of technological advances. Previously, complaints from customers were compiled and later submitted to PT. XYZ. It was difficult for PT. XYZ to detect when and how long a problem had occurred. However, the growing technology such as short messages and discussion groups on WhatsApp, customers, and PT.XYZ creates a discussion group to monitor complaints and problems that occur in customers (PT.ABC). If a problem occurs, PT.XYZ can immediately review and make some improvements.

C. Relationship with Suppliers

With communication and coordination with suppliers, especially regarding with the implementation of TQM in the company environment, will certainly affect the company's performance. However, PT. XYZ does not have a permanent supplier, it means no engagement. It happens because of PT.XYZ's internal considerations, so that it enables to choose materials from suppliers according to their needs and prices.

D. Employee Management

PT.XYZ conducts training and socialization to employees, particularly if there are new policies or procedures. This is intended so that all employees have the same understanding and competence to achieve common goals. Moreover, employees recruitment and additional divisions were also executed to monitor the action to prevent pipe leakage. Currently, PT. XYZ has a pipe maintenance team in an effort to achieve better PT. XYZ performance.

E. Employee Attitude

With the change in management and new resources, PT. XYZ's employees are welcomed this positively. Weekly briefings for each division are also implemented to provide clear directions to employees if there are new procedures.

F. Design Process for Products and / or Services

PT.XYZ management can deploy the technical department, quality department, and human resources department to make improvements. The technical department plays a role in making estimates related to investment considerations for pipe repairs which reach 14 billion rupiahs. This is further strengthened by the existence of a maintenance division that will monitor the technical condition of the pipeline. In addition, PT.XYZ also oversees the quality of water distribution with the existence of a quality department. This movement is also extended by the role of the human resources department by increasing the number of employees and holding regular weekly briefings to provide understanding and direction for employees at PT.XYZ

G. Design Process for Products and/or Services

PT.XYZ management circulates the technical department, quality department, and human resources department to make improvements. The technical department plays a role in making estimates related to investment considerations for pipe repairs which reach 14 billion rupiahs. This is further boosted by the existence of a maintenance division that will monitor the technical condition of the pipeline.

H. Process Flow Management

PT.XYZ does not implement 5S/5R, but PT.XYZ has periodic check activities. This periodic check is in the form of water quality control activities in the pipeline network. Sampling in the pipeline with a frequency of 3 times a day at certain points. Quality control at the Water Treatment Plant (WTP) is also carried out by referring to several main parameters, using tools such as quality sensors, which will be monitored by the operator. The results are later outlined in the quality data form.

I. Quality of Data and Reports

PT.XYZ has a periodic quality check program which is stated in the quality data entry form report. This is intended to review the quality of the water produced so that if there are things that are outside the control limits, repairs can be fulfilled immediately. Role of Quality Division

PT.XYZ has a quality division whose role is to control the quality distributed to customers. The quality division now has a change of work due to additional area of responsibility. Therefore, the quality division has control authority down to the customer's pipeline and water meter (PT.ABC).

J. Comparative Study (Benchmarking)

PT. XYZ has some competitors, one of them is a regional company providing drinking water. Comparative studies have never been conducted by PT. XYZ to competitors. After the management improvement process was carried out, in 2020, PT.XYZ's water production increased and the percentage of water loss decreased. The percentage of water loss for distribution to consumers has declines to 15.3% and has been included in the threshold category of the Peraturan Menteri Pekerjaan Umum 20/PRT/M/2006, about the loss of proper water for a clean water distribution system or drinking water is 20%.

By implementing TQM, PT. XYZ can increase water production, reduce pipe leakage rates, and improve water quality for consumption. However, although pipe repairs have been carried out gradually, PT. XYZ is still experiencing water loss. In the period January- June 2021, it can be seen in table 2, that PT.XYZ still experiences water loss but with a reduced percentage. Therefore, the author calculated the estimated financial loss encountered by PT. XYZ in the 6 months with the estimated selling price of water is Rp. 10,000.00/m^3. Based on table 2, we can conclude that, although it has experienced an increase in product performance and water quality, PT. XYZ still has a potential turnover of 14.6 billion rupiahs. However, because it is still dealing water loss, PT. XYZ has lost opportunity costs of 10% (about 1.5 billion rupiahs) of the total measured turnover that would be obtained if all of the water could be used for sales.

With the pipeline repair action is scheduled to be completed in August 2021, it is hoped that water production can increase due to reduced pipe leakage and

improved clean water quality. With an increase in water production, PT. XYZ well, PT. XYZ will be able to serve the needs of customers (PT. ABC) better than before. Seeing this opportunity, PT. XYZ projects seek to carry out an amendment to the work agreement. with the amendment, PT. XYZ is projected to increase the selling price of water per $m^3$3 to consumers. PT. XYZ targets to increase the selling price of water to PT. ABC by 12.5% or Rp. 12,500.00/m^3 from the previous selling price of Rp. 10,000.00/m^3.

Based on previous data, in 2019, the average clean water production of PT. XYZ was 83,258 m^3/month and in 2020, the average production of clean water of PT.XYZ increased to 174,254 m^3/month or (109% increase). Currently (January-June 2021), the average clean water production from PT. XYZ is 244,660 m^3 per month. This shows a positive development related to the improvement efforts made by PT. XYZ. One of the reasons for this is the management's commitment to making projects that this will be in line with an increase in performance. If this repair goes improvements in clean water production. With the commitment from the top management, the entire process and business activities at PT. XYZ then becomes directed towards improving the existing system. This then has an impact on the more positive performance of PT. XYZ.

The total production capacity of PT.XYZ is 280,000 m^3/month, this means, although the average production of clean water of PT.XYZ per month has increased, the production in the last 6 months of PT.XYZ has only used about 87% of the total production capacity PT.XYZ. Seeing the development of increasing production of clean water PT.XYZ, it can be estimated that PT.XYZ will need additional infrastructure, especially in serving customers as supplying clean water needs in industrial areas.

Table 2 Estimated Financial Losses Due to Water Loss of PT.XYZ for the period January-June 2021

Period	Month	Water Volume per Month			Water Loss per Month				Water Loss Calculation			
		Production	Distribution	Consumption	Production to Distribution		Distribution to Consumption					
		m^3	m^3	m^3	m^3	%	m^3	%	Total loss (%)	Total Loss (m^3)	Price / m^3	*Lost Opportunity Costs* (Rp)
January - June 2021	January	227,334	218,168	202,656	9,166	**4.0**	15,512	**7.1**	10.9	24,678	10000	246,780,000
	February	270,811	251,008	235,144	19,803	**7.3**	15,864	**6.3**	13.2	35,667	10000	356,670,000
	March	291,832	275,471	259,085	16,361	**5.6**	16,386	**5.9**	11.2	32,747	10000	327,470,000
	April	269,963	256,270	250,429	13,693	**5.1**	5,841	**2.3**	7.2	19,534	10000	195,340,000
	May	283,355	267,675	257,965	15,680	**5.5**	9,710	**3.6**	9.0	25,390	10000	253,900,000
	June	282,528	272,888	262,680	9,640	**3.4**	10,208	**3.7**	7.0	19,848	10000	198,480,000
	Average	270,971	256,913	244,660	14,057	**5.2**	12,254	**4.8**	**9.7**	**26,311**	10000	**263,106,667**
	Financial Amount (Rp)			14,679,590,000								**1,578,640,000**

4. CONCLUSIONS

PT.XYZ is a drinking water treatment company designated for the ABC Industrial Estate which is managed by PT.ABC. Previously, PT. XYZ perceived two main problems, the first is pipe leaks which caused loss of water to be distributed to customers and the second is the decreased quality of water for consumption. The application of TQM was proposed and PT. XYZ began to minimize these two problems so that the performance of PT. XYZ increased. By using the TQM method, improvement and change enthusiasms are accomplished starting from top management, to the division that handles technical matters. Improvements have been carried out in stages by PT. XYZ, one of which is the repair of a 29 km pipeline which is currently 98% completed. This is

also supported by periodic briefings, an additional number of employees, a water quality monitoring system, and pipe maintenance management carried out by PT.XYZ. The increase in clean water production is achieved slowly. However, even though these improvements have been made, based on data, PT. XYZ still underwent lost opportunity costs of 10% of the potential turnover which is expected to be obtained by PT. XYZ if all of the water can be used for sales, in the period January-June 2021.

The suggestion recommended by the author for PT. XYZ is to maintain the quality of the distributed water. With the better process of quality control and monitoring by PT. XYZ internally affects customer trust and customer loyalty on PT. XYZ's performance.

In addition, another proposal for PT.XYZ is to increase water production capacity. This can be done by investing in infrastructure. The addition of WTP is one of the proposals that can be considered. The investment for this additional WTP is estimated to cost 15 billion rupiahs. With the addition of infrastructure, PT. XYZ is expected to be able to meet the demands of PT. ABC as a customer so that PT. ABC does not need to look for other water sources. If PT. XYZ can maximize its production capacity, it will have an impact on widening profits and advancing the coverage of PT. XYZ's service area is a clean water supply agency in an industrial area.

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