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Evaluation of External Monitoring of Drinking Water in PDAM Tirta Benteng and Tirta Kerta Raharja, Tangerang City

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Abstract
The government and water supply companies, such as Regional Drinking Water Company (PDAM), have the responsibility to ensure the availability of safe and quality drinking water. Regular external monitoring is necessary to ensure that the drinking water provided by PDAM meets established health and safety standards. PDAM Tirta Benteng and PDAM Tirta Kerta Raharja operates in Tangerang City, is responsible for providing safe and quality drinking water to the community. This research went through the stages of sampling, testing the quality of drinking water samples, and analysis using descriptive statistical methods. The evaluation covers aspects such as sampling methods, frequency of testing, and laboratory analyses used. The study also explores the impact of the evaluation results on improving drinking water quality and the improvement measures that can be implemented. This is important not only to ensure that the public gets safe drinking water but also to support transparency and accountability in the provision of drinking water services by public institutions. The comprehensive evaluation is hoped to provide a valuable contribution to efforts to monitor and improve the quality of drinking water in Tangerang City and serve as a basis for developing more effective policies in safeguarding public health through the provision of safe and quality drinking water.
Keywords: *drinking water, water quality, PDAM, external monitoring*

Abstrak
Pemerintah dan perusahaan penyedia air minum, seperti Perusahaan Daerah Air Minum (PDAM), memiliki tanggung jawab untuk memastikan ketersediaan air minum yang aman dan berkualitas. Pemantauan eksternal secara berkala diperlukan untuk memastikan bahwa air minum yang disediakan oleh PDAM memenuhi standar kesehatan dan keselamatan yang telah ditetapkan. PDAM Tirta Benteng dan PDAM Tirta Kerta Raharja yang beroperasi di Kota Tangerang, bertanggung jawab untuk menyediakan air minum yang aman dan berkualitas bagi masyarakat. Penelitian ini melalui tahapan pengambilan sampel, pengujian kualitas sampel air minum, dan analisis menggunakan metode statistik deskriptif. Evaluasi mencakup aspek-aspek seperti metode pengambilan sampel, frekuensi pengujian, dan analisis laboratorium yang digunakan. Penelitian ini juga mengeksplorasi dampak dari hasil evaluasi terhadap peningkatan kualitas air minum dan langkah-langkah perbaikan yang dapat dilakukan. Hal ini penting dilakukan tidak hanya untuk memastikan masyarakat mendapatkan air minum yang aman, namun juga untuk mendukung transparansi dan akuntabilitas penyediaan layanan air minum oleh institusi publik. Evaluasi komprehensif ini diharapkan dapat memberikan sumbangan yang berharga bagi upaya pengawasan dan peningkatan kualitas air minum di Kota Tangerang dan menjadi dasar bagi pengembangan kebijakan yang lebih efektif dalam menjaga kesehatan masyarakat melalui penyediaan air minum yang aman dan berkualitas.
Kata Kunci: *air minum, kualitas air, PDAM, pengawasan eksternal*

1. Introduction

Safe water and sanitation are essential for human health and well-being. Effective regulation of drinking water and sanitation services plays a critical role in ensuring the delivery of safe, inclusive and sustainable services that protect public health [1]. Healthy water, sanitation and hygiene are essential for human health and well-being. However, millions of people around the world do not have adequate WASH services and consequently suffer or are exposed to many preventable diseases [2].

Access to safe and quality drinking water is a fundamental necessity for human health. The responsibility of ensuring the availability of safe and quality drinking water lies with the government and

water supply agencies, such as the Regional Water Company (PDAM) [3]. In the effort to ensure that the water provided by PDAM meets health and safety standards, periodic external monitoring is essential [1].

According to World Health Organization (WHO), the volume of clean water demand for the average population in the world is different. In developed countries, the water required is approximately 500 litres/day while in Indonesia (big cities) it is 400 litres/day. The need for water also changes. The clean water crisis is a phenomenon caused by uncontrolled handling of the environment and natural assets. Uncontrolled management of clean water sources causes a decrease in the quality and availability of clean water sources [4].

Currently, the quality of drinking water in major cities in Indonesia is still a concern. Population density, wrong spatial planning and high exploitation of water resources greatly affect water quality. Clean fresh water for drinking is increasingly scarce in cities [5]. The rivers that serve as its source have been polluted by various kinds of waste, ranging from organic waste disposal, households to toxic waste from industrial companies [6]. Groundwater is no longer safe for drinking water because it has been contaminated by seepage from septic tanks and surface water. One of the health impacts of drinking water quality is diarrheal disease [7].

The management and distribution of clean water in Indonesia is managed by the state. Regional Drinking Water Company (PDAM) is a company authorized by the state to manage water resources and its utilization for consumption by the general public [8].

The Minister of Health Regulation No. 2 Year 2023 also explains that drinking water providers must ensure that the drinking water they produce is safe for health. Drinking water providers include State-Owned Enterprises (BUMN)/Region-Owned Enterprises (BUMD), cooperatives, private business entities, individual businesses, community groups, and/or individuals who organize the provision of drinking water. Water that is insufficient in terms of quantity and unqualified in terms of quality will cause various diseases and can increase the incidence of disease. The quality of drinking water, especially from PDAMs, must be monitored externally and internally. External supervision is in accordance with Minister of Health Regulation No. 2 Year 2023 that external supervision is supervision conducted by the District/City Health Office [9].

According to Minister of Health Regulation No. 2 of 2023, which pertains to the Implementation Regulation of Government Regulation No. 66 of 2014 on Environmental Health, drinking water is defined as water that has undergone either a treated or untreated process and meets specific conditions that render it suitable for direct consumption. Ensuring the healthiness of drinking water is vital, as it must adhere to essential factors such as physical, microbiological, chemical, and radioactive requirements, in addition to any supplementary parameters. All drinking water providers are required to comply with mandatory parameters regarding the quality of their water.[10] On the other hand, local governments set additional parameters based on the unique circumstances and environmental quality of each region, utilizing the guidelines established by Minister of Health Regulation No. 2 Year 2023 [9].

PDAM Tirta Benteng, operating in Tangerang City, holds the responsibility of providing safe and quality drinking water to the community. However, to guarantee the quality of the water produced by PDAM, an external evaluation that provides an objective overview of water quality monitoring is necessary.

This research aims to evaluate the effectiveness and efficiency of the external water monitoring system conducted by PDAM Tirta Benteng. The evaluation encompasses aspects such as sampling methods, testing frequency, and laboratory analysis. Furthermore, the study will explore the impact of the evaluation results on improving drinking water quality and the corrective measures that can be implemented.

By identifying strengths and weaknesses in the external monitoring system, this research is expected to offer constructive recommendations for enhancing the effectiveness of water quality supervision by PDAM Tirta Benteng. This is crucial not only to ensure that the community receives safe drinking water but also to support transparency and accountability in public institutions' provision of water services.

Through this comprehensive evaluation, it is anticipated that valuable contributions will be made to the monitoring and improvement of drinking water quality in Tangerang City. Additionally, it will serve as a foundation for the formulation of more effective policies in safeguarding public health through the provision of safe and quality drinking water.

The aims of this study are to assess the drinking water quality in Tangerang City, evaluate the findings of environmental health inspections conducted on piped water supply facilities, and report on the external monitoring of PDAM drinking water by the Tangerang City Health Office. This study offers several advantages. Firstly, it can serve as a comprehensive policy framework for effectively managing the quality of drinking water in Tangerang city. Secondly, it provides an evaluation of the drinking water

quality management practices implemented by PDAM at the city level. Lastly, it serves as a valuable reference for readers seeking information on the measurement results of PDAM's drinking water quality.

2. Material and Methods

This research was conducted in Tangerang city from September to November 2023. This research went through the stages of sampling, testing the quality of drinking water samples, and analysis using descriptive statistical methods. The descriptive statistical method starts from collecting data to obtaining information by presenting the data that has been collected. Data is presented to illustrate the quality of drinking water at the Municipal Level which includes PDAM Tirta Benteng and Tirta Kerta Raharja based on the Minister of Health Regulation No.2 Year 2023.

According to the Regulation of the Ministry of Health of the Republic of Indonesia No. 2 of 2023, drinking water is water that goes through a treatment process or without a treatment process that meets health requirements and can be drunk directly. Drinking water is safe for health if it meets physical, microbiological and chemical requirements. The following is a table of mandatory drinking water quality parameters: [9]

Table 1. Mandatory Drinking Water Quality Parameters

No.	Type of Parameter	Maximum Allowable Level	Unit
1.	**Microbiology**		
	Escherichia coli	0	CFU/100 ml
2.	Total Coliform	0	CFU/100 ml
3.	**Physic**		
	Temperature	Temperature ± 3	^{0}C
4.	Total Dissolved Solid	< 300	mg/L
5.	Turbidity	< 3	NTU
6.	Colour	< 10	TCU
7.	Odour	No Odour	-
8.	**Chemical**		
	Ph	6.5 – 8.5	-
9.	Nitrate (As NO^3) (dissolved)	20	mg/L
10.	Nitrite (As NO^2) (dissolved)	3	mg/L
11.	Chromium Valence 6 (Cr^{6+}) (dissolved)	0,01	mg/L
12.	Iron (Fe) (dissolved)	0,2	mg/L
13.	Manganese (Mn) (dissolved)	0,1	mg/L
14.	Residual Chlorine (dissolved)	0,2-0,5 with contacted time 30 minutes	mg/L
15.	Arsenic (As) (dissolved)	0,01	mg/L
16.	Cadmium (Cd) (dissolved)	0,003	mg/L
17.	Lead (Pb) (dissolved)	0,01	mg/L
18.	Flouride (F) (dissolved)	1,5	mg/L
19.	Aluminium (Al) (dissolved)	0,2	mg/L

3. Results and Discussion

Commencing in 2022, the Tangerang City Health Office has undertaken measures to meticulously oversee the external quality of PDAM water by assigning a dedicated budget for supervision. Previously, the Puskesmas Health Operational Assistance fund, which was still limited in size, conducted internal quality monitoring.

In 2021, PDAM Tirta Kerta Benteng sent a formal letter to the Health Office, requesting their assistance in conducting external monitoring. Subsequently, in 2022, a follow-up meeting between the Health Office and PDAM took place. In 2022, a total of 202 samples were successfully collected and supervised using Binkes money. The sampling process was carried out, and the supervision of the samples continued in 2023 with an additional 202 samples. In 2023, the Tangerang City Health Office is now carrying out external monitoring of the Tirta Bentang and Tirta Kerta Raharja PDAMs. The allocation of the available number of samples is divided between the two PDAMs, ensuring that the sampling is done proportionally.

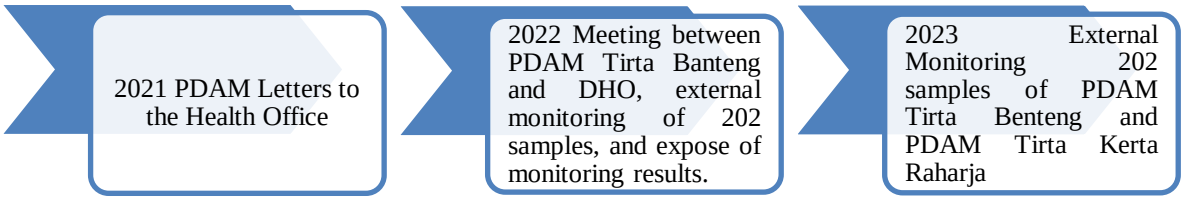

Figure 1. PDAM Water Quality External Monitoring Process

External Monitoring Process

The external water quality monitoring process of PDAM Tangerang City is preceded by the calculation of monitoring samples. In 2022, the supervision carried out can only accommodate the external supervision of PDAM Tirta Benteng and the existing sample allocation is only 202 samples. In 2023 the sample allocation for external supervision has the same number of 202 samples but in 2023 the supervision carried out has been carried out to PDAM Tirta Benteng and Tirta Kerta Raharja.

Table 2. Comparison of Sample Size of PDAM Tirta Benteng

PDAM Tirta Benteng	2022	2023
Number of Household Drains	91,491 (2021 End Data)	105,000 (2022 End Data)
Minimum Sample Size	466	526
Number of Samples Supervised	202	145

Table 3. Comparison of Sample Size of PDAM Tirta Kerta Raharja

PDAM Tirta Kerta Raharja	2022	2023
Number of SRs	70.300 (2021 End Data)	52.960 (2022 End Data)
Minimum Sample Size	397	314
Number of Samples Supervised	0	57

The external monitoring method commences by computing the quantity of samples. Once the number of samples to be monitored is determined, proportional sampling is computed based on the number of residential drains in each location. The current number of samples for external monitoring falls short of the desired target. However, the Tangerang City Health Office is actively striving to optimize external monitoring as a means of ensuring the quality of water for the community. The subsequent data represents the sample size determined by the Public Health Centre working area.

Table 4. Sample Size by Public Health Centre Working Area

Public Health Centre	Number of Samples in 2022	Number of Samples in 2023
Batu Ceper	15	9
Benda	7	5
Bugel	1	2
Cibodasari	1	16
Cikokol	8	4
Ciledug	1	1
Cipondoh	22	14
Jubar	12	6
Karawaci Baru	1	1
Kedaung Wetan	9	6
Ketapang	15	10
Kunciran	7	5
Kunciran Baru	5	2
Neglasari	13	7
Pabuaran Tumpeng	1	2
Panunggangan	5	3
Pasar Baru	2	2

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Public Health Centre	Number of Samples in 2022	Number of Samples in 2023
Petir	3	3
Pondok Bahar	2	1
Poris Gaga	18	10
Poris Plawad	23	13
Priuk	3	2
Sukasari	15	9
Tanah Tinggi	13	7
Sample IPA DINKES	0	7
Sample TKR	0	Kec. Jatiuwung 14 Kec. Karawaci 23 Kec. Periuk 18
Grand Total	**202**	**202**

Figure 2. Sampling Process

External Monitoring Results

In 2023, the Health Office has undertaken an external monitoring process to assess the quality of PDAM. This approach involves collecting and analyzing 202 samples of PDAM water quality. Additionally, the Health Office will undertake IKL (Environmental Health Inspection) operations at piped facilities using a specific form. PT Kerta Benteng Kota Tangerang and PT Tirta Kerta Raharja Kabupaten Tangerang administered the collection of 202 samples using proportionate sampling in the residential channel coverage area. The outcomes of the external monitoring are as stated:

A. Results of Environmental Health Inspection of Piped Facilities

In the environmental health inspection of house connection piping facilities, there are 10 aspects that are assessed.

1) Results of Environmental Health Inspection of Piped Facilities

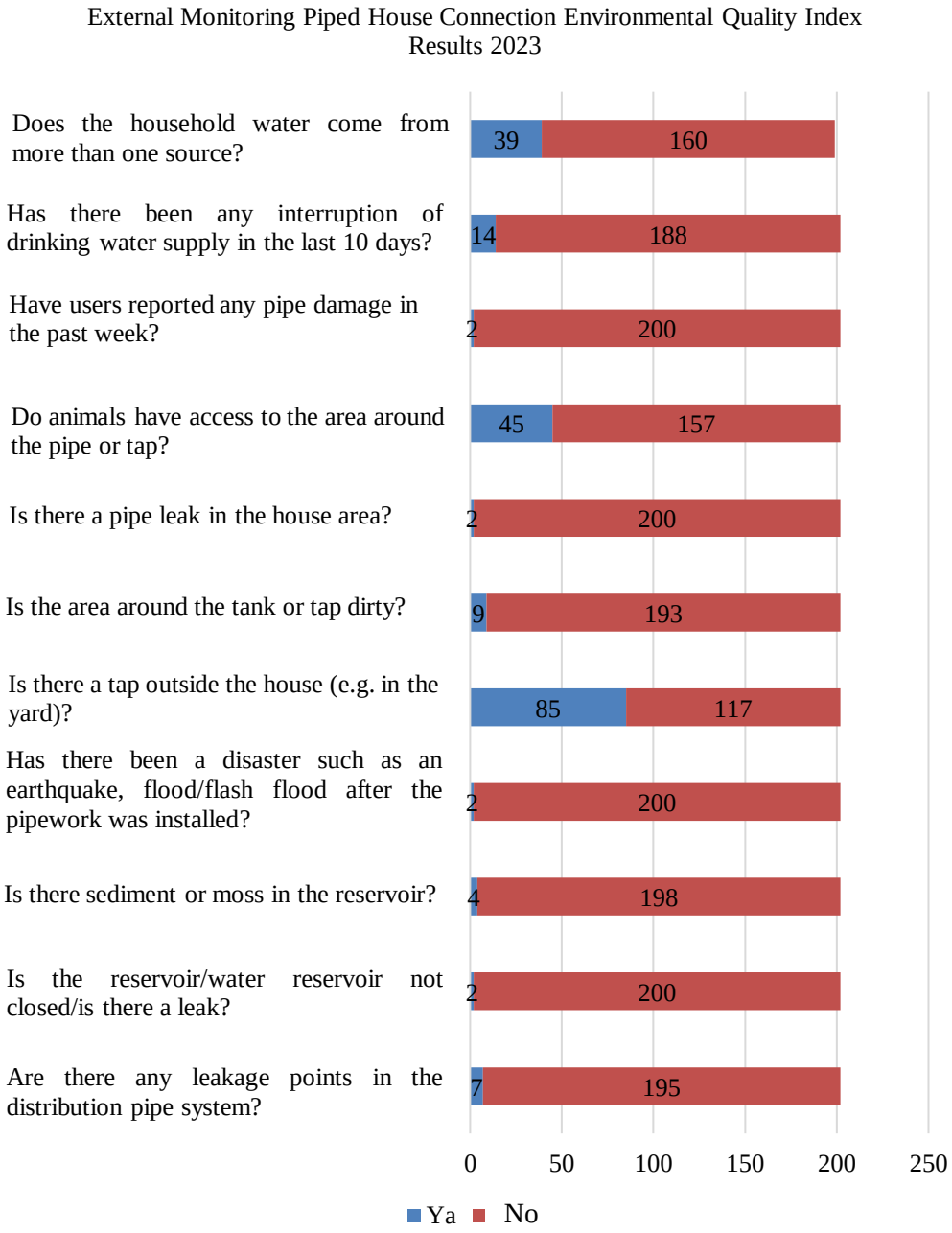

Figure 3. Environmental Health Inspection Results of Piped Facilities

2) Contamination Risk Assessment Categories

From the results of the environmental health inspection of plumbing facilities connected to the house based on special risk assessment data, the risk category of the results of the environmental health inspection of plumbing facilities in Tangerang City in 2023 is as follows:

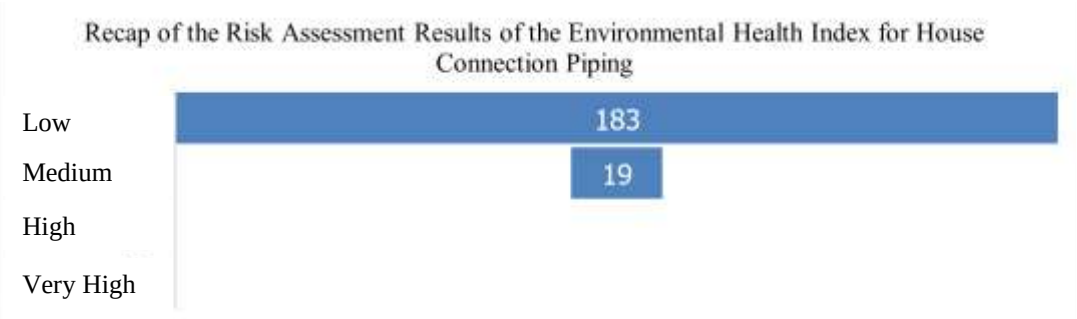

Figure 4. Recapitulation of Risk Assessment Results for House Connection Piping

The graph indicates that in 2023, PDAM Tangerang City pipeline facilities are distributed among several risk categories as follows: 183 facilities in the low risk category, 19 facilities in the medium risk category, and no facilities in the high or very high risk categories. The calculation results are derived from the weight assigned to determine the risk category in the following manner:

Amant High Risk (AT), if the number of "Yes" answers in the special risk assessment data is 10 - 11; High Risk (T) if the answer "yes" in the special risk assessment data is 6-9; Medium Risk (S) if the number of "Yes" answers is 3-5; Low Risk (R) if the answer "Yes" in the special risk assessment data is 0-2.

B. Laboratory Quality Control Results

1) Physical Quality

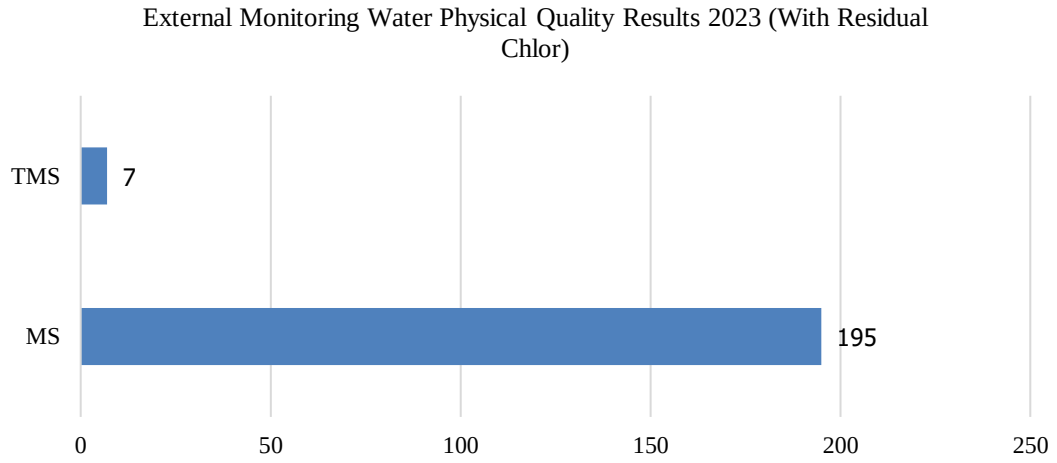

Figure 5. Physical Water Quality Results

According to the graph provided, it indicates that the physical quality of PDAM water, as a result of PDAM supervision, is 94% out of 202 samples that meet the physical quality criteria. This includes parameters such as turbidity and TDS (Total Dissolved Solid). On the other hand, 6% or 7 samples do not meet the physical quality criteria, specifically in the TDS and turbidity parameters. The subsequent data presents the top three measurements of TDS and turbidity levels obtained from the external monitoring findings of 2023.

Table 5. Physical Quality Measurement Results of PDAM Water

	Turbidity	**Total Dissolved Solids**
Highest 1	17,2	805
Highest 2	10,77	353
Highest 3	7,49	313
Lowest	0,130	20,00

Based on the presented table, the relevant physical quality attributes to consider are turbidity and total dissolved solids (TDS) measurements. The places exhibiting TMS turbidity are Alam Jaya, Manis Jaya, Jurumudi Baru, Jurumudi, Sukasari, Cipondoh Makmur, and Babakan. The wards equipped with TMS TDS include Batuceper, Sudimara Barat, Cimone, Periuk Jaya, Kunciran Indah, and Sudimara Baru.

Drinking water with a high concentration of Total Dissolved Solids (TDS) can cause various health problems such as nausea, respiratory irritation, skin rashes, and vomiting. Despite extended usage, the water retains a multitude of hazardous substances and pollutants that can have negative impacts on the neurological system, weaken the immune system, and potentially result in problems in newborns. Cipondoh Makmur is characterized by the highest turbidity level in the water quality of PDAM, whereas Periuk Jaya has the highest amount of total dissolved solids (TDS).

2) Chemical Quality

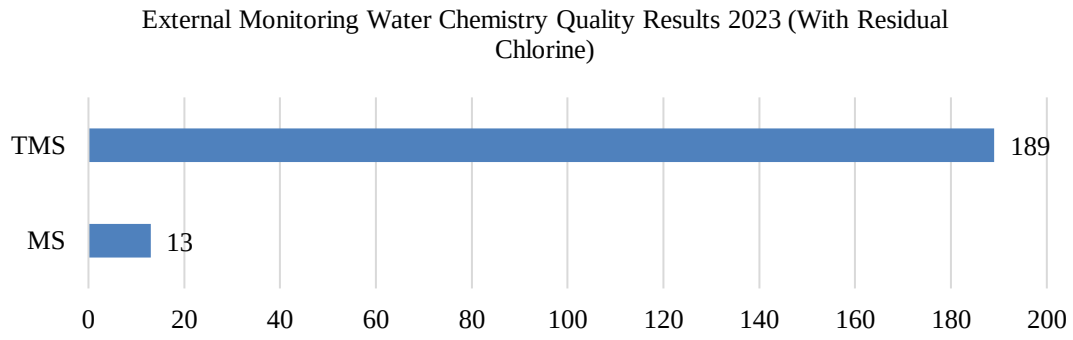

Figure 6. Water Chemical Quality Results with Residual Chlorine

Based on the graph above, it shows that the percentage of PDAM water chemical quality from external monitoring is 13 samples that meet the chemical quality requirements, while 189 do not meet the chemical quality requirements. The chemical parameters checked include (Dissolved Iron, Nitrate, Nitrite, pH, Manganese, Flouride, Ammonia, Hexavalent Chromium, Chlorine Residual and Sewage). However, the data is complemented by the remaining Chlor results.

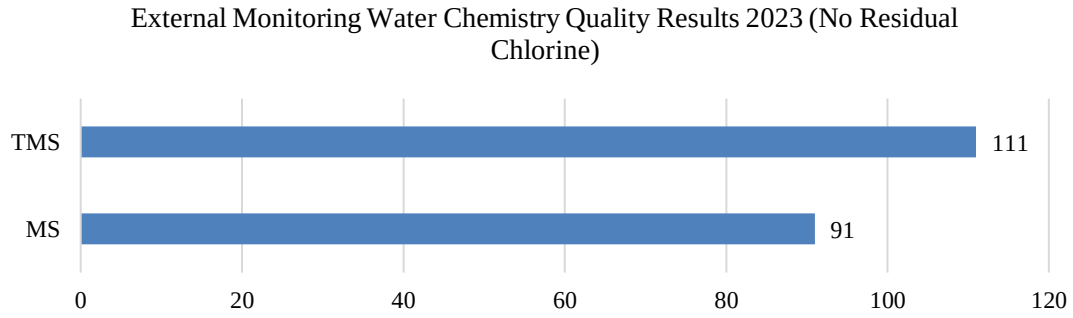

Figure 7. Water Chemical Quality Results not with Residual Chlorine

According to the graph provided, it indicates that 91 samples of PDAM water chemical quality meet the standards, while 111 samples do not match the requirements. The chemical parameters analyzed consist of Dissolved Iron, Nitrate, Nitrite, pH, Manganese, Fluoride, Ammonia, Hexavalent Chromium, Residual Chlorine, and Lead. However, the data for residual Chlorine is incomplete due to concerns about potential bias in the inspection results because the standard chlorine test is an examination at one time. The following is data on the results of water chemical quality measurements based on the results of the highest level of inspection results.

Table 5. Chemical Quality Measurement Results Based on the Highest Level Results

Level	Dissolved Iron (Fe)	pH	Dissolved Manganese (Mn)	Fluoride (F)	Ammonia	Hexavalent Chromium	Residual Chlorine (Dissolved)	Lead (Tb)
Highest 1	0,345	8,12	6,82	0,72	1,3	0,263	0,45	0,001
Highest 2	0,058	8,05	0,909	0,64	1,09	0,142	0,44	0,001
Highest 3	0,035	7,24	0,797	0,57	0,58	0,14	0,43	0,001
Maximum Level	0,2	6,5-8,5	0,1	1,5	1,5	0,01		0,01

Based on the **Table 5**, it shows that from the results of chemical quality that requires special attention, namely the iron parameter in Bugel Village, while for the Nitrate parameter, the results exceed the quality standards in Kunciran Indah Village. For the dissolved manganese parameter, the villages that have the highest unqualified results are in Jurmudi Baru, Periuk Jaya, Bugel. 3 Village locations that have Hexavalent Chromium are in the Batuceper, Kebon Besar, Cipondoh Makmur villages.

It is important to note that a significant number of samples were discovered to contain Chromium-6. Starting in 2023, the Tangerang City Health Office will exclusively utilize the Chromium-6 measurement as a standard testing parameter for external monitoring.

Chromium-6 is a substance that causes cancer and is harmful to the reproductive systems of both males and females.[11] Exposure to levels of chromium-6 that exceed the maximum contamination limit (MCL) established by the EPA, whether it is for a short or long period of time, can potentially lead to the following health consequences: The potential health risks associated with exposure to some substances include skin irritation, asthma exacerbation, nausea, seizures, disorientation, cancer, reproductive harm, kidney impairment or failure, as well as liver impairment or failure [7], [12], [13].

3) Microbiology Quality

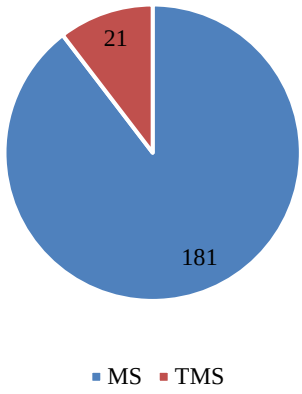

Figure 8. Percentage of Microbiological Quality of External Surveillance 2023

Based on the **Figure 8,** it shows that as many as 21 PDAM water quality samples taken do not meet microbiological quality while as many as 181 samples meet microbiological quality. These results indicate that the PDAM water quality is polluted with E. coli and Coliform. The results of the highest levels of sample examination results are as follows.

Table 6. Highest Level Results of Sample Examination

Microbiology Quality	Highest 1	Highest 2	Highest 3
E. coli	980	291	195
Total Coliform	2420	1986	1300

The results of the highest level of sample examination found that the highest level of E. coli from the samples examined was 980 and total coliform 2420. The details of the microbiological quality inspection results that do not meet the requirements are in the villages of Sudimara Barat, Petir, Poris Plawad Indah, Bugel, Koang Jaya, Bojonng Jaya, Nusa Jaya, Cimone, Selapajang, Periuk Jaya, Cipete, Cikokol, Kelapa indah, Cipondoh Makmur, Mekarsari.

Escherichia coli, generally known as E.coli, is a bacterial species that is frequently present in the intestinal tract of healthy individuals [1]. There exist multiple variations of this bacterium, the most of which are innocuous. Nevertheless, several strains have the potential to induce foodborne illness and severe infections [2], [14].

Certain types of E. coli bacteria have the ability to generate toxins that are highly hazardous and can lead to severe medical disorders. An example of a harmful bacterial strain is E.coli, which can cause symptoms such as bloody diarrhea, abdominal pains, and vomiting [1]. It is crucial to give careful consideration to the presence of E.coli and total Coliform in the water quality of PDAM [15]. This requires thorough examination of the treatment and piping channels to determine the exact source of the E.coli contamination.[16]–[18]

Evaluation of PDAM External Monitoring

The anticipated results of the assessment of PDAM Tirta Benteng's external monitoring system for drinking water encompass:[1], [4], [10], [15], [19]

a. Water Quality Identification: The evaluation seeks to assess the water quality supplied by PDAM Tirta Benteng and PDAM Tirta Kerta Raharja, verifying its compliance with prescribed health and safety criteria.
b. The review: aims to appraise the efficacy and productivity of the external monitoring system, encompassing factors such as sampling techniques, testing frequency, and laboratory analyses employed.
c. Effect on Enhancing Water Quality: The objective is to investigate the influence of the evaluation outcomes on enhancing the quality of drinking water and the potential strategies that may be put into practice for improvement.
d. Practical Suggestions: The research aims to offer valuable suggestions to enhance the efficiency of PDAM Tirta Benteng's water quality monitoring.
e. Evaluation plays a crucial role in promoting openness and accountability in the delivery of drinking water services by public entities.

The assessment aims to support the monitoring and enhancement of drinking water quality in Tangerang City. It also serves as a foundation for the development of more efficient policies to protect public health by ensuring the provision of safe and high-quality drinking water.

4. Conclusion

The Health Office conducted external monitoring of PDAM quality and found that of the 202 samples tested, 14 were physically unqualified, 189 were chemically unqualified (considering chlorine parameters) or 111 were chemically unqualified (not considering chlorine parameters), and 35 were microbiologically unqualified. In addition, of the 202 facilities that underwent Environmental Health Checks, 183 facilities were categorised as low pollution risk and 19 facilities were categorized as medium pollution risk. Nonetheless, the Health Office conducted external monitoring of the PDAM's water quality and provided advice to improve it, particularly in terms of physical parameters such as Total Dissolved Solids (TDS) and turbidity. It is particularly important to focus on the Hexavalent Chrome parameter as many samples fail to meet the standard. Periodic pipeline inspections should be conducted to ensure compliance with the Indonesian National Standard (SNI) and Minister of Health Regulation 3, year 2022. In addition, internal surveillance should be implemented to monitor residual chlorine levels, thus preventing potential health issues associated with public water consumption in the future.

5. Abbreviations

PDAM	Regional Drinking Water Company
IKL	Environmental Health Inspection
%	Percentage
MS	Eligible
TMS	Not Eligible
STBM	Community-based Total Sanitation
SR	Household Drains

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