



## CLEAN WATER FOR SMALL ISLANDS IN INDONESIA: CASE STUDY OF CHILD DIARRHEA IN KELAPA AND KELAPA DUA ISLANDS, KEPULAUAN SERIBU

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### Abstract

Clean water quality/water sources are critical factors in preventing diarrhea, especially in island areas that often face challenges of limited access and infrastructure to provide adequate clean water. This study aimed to see the descriptive relationship between the physical and microbiological quality of dug well water and the incidence of diarrhea in children on Kelapa Island and Kelapa Dua Island, Kepulauan Seribu. The results of the analysis showed that the physical quality of water in both locations met the criteria of the Minister of Health Regulation number 2 of 2023, namely, the temperature was in the range of 24°C-30°C, turbidity <1 NTU, and water that was odorless and colorless. Microbiological analysis revealed significant contamination, with total Coliform Bacteria and *Escherichia coli* levels exceeding the maximum allowable limit (> 0 CFU/100 ml ). Factors such as shallow well depths of less than 3 meters and well distances of less than 10 meters from pollution sources contribute to water pollution indicates fecal contamination that increases the risk of diarrhea, especially in children under five. Given the island region's limited access to water quality, these findings emphasize the need for improved water quality monitoring and environmental quality improvements to reduce public health impacts.

**Keywords:** *Water Quality; Escherichia Coli; Diarrhea; Islands*

### 1. Introduction

According to the Regulation of the Minister of Health of the Republic of Indonesia Number 21 of 2020 concerning the Strategic Plan of the Ministry of Health for 2020-2024, diarrhea and other gastrointestinal infections are the fourth leading cause of infant mortality with a percentage of (7%). Meanwhile, according to the World Health Organization (2024) there are several important facts related to diarrhea which is the third leading cause of death in children aged 1-59 months (toddlers). Every year this disease causes the death of around 443,832 children under 5 (five) years and 50,851 children aged 5 (five) to 9 (nine) years. Most diarrhea diseases can be prevented through safe drinking water and adequate sanitation and hygiene. Diarrhea is also a major cause of malnutrition in children under 5 years (World Health Organization, 2024)).

Bacterial sepsis is a life-threatening condition that occurs when the body's response to infection injures its tissues and organs. Sepsis is caused by conditions that threaten the functional integrity of the host, such as microbial invasion (Bullock & Benham, 2019). According to the Decree of the Minister of Health of the Republic of Indonesia Number HK.01.07 / MENKES / 342/2017 concerning National Guidelines for Medical Services for the Management of Sepsis, the biggest cause of sepsis is Gram-negative bacteria (60-70% of cases). The Regulation of the Minister of Health Number 2406 / MENKES / PER / XII / 2011

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concerning General Guidelines for the Use of Antibiotics states that one of the gram-negative

bacteria or microorganisms is *Escherichia coli*. *Escherichia coli* is also a sepsis-causing bacteria that is capsule-shaped (Minasyan, 2019).

According to the World Health Organization (2024), diarrhea is defined as 3 or more loose or liquid bowel movements per day (or more frequent bowel movements than usual in a person). Diarrhea is a symptom of infection in the intestinal tract caused by various bacterial, viral, and parasitic organisms. This disease is spread through contaminated food or drinking water. Diarrhea begins with symptoms of infection caused by various bacteria, viruses, and fungi, most of which are spread in water contaminated with feces. Infection is more common when there is a lack of adequate sanitation and hygiene and safe water for drinking, cooking, and cleaning. In children under 5 years of age, the most common pathogens are Rotavirus and *Escherichia coli* (World Health Organization, 2024). Water contaminated with human waste, such as sewage, septic tanks, and latrines, is a serious concern. The proportion of morbidity and mortality from diarrhea is uneven among children under five in developing countries where access to health services, clean water, and sanitation is limited. Poor water and sanitation are the leading causes of diarrhea, which are responsible for 72.1% and 56.4% of diarrhea deaths in children under five years of age, respectively (Merid et al., 2023).

Indonesia is one of the developing countries with the largest archipelago in the world. There are around 17,508 (Seventeen thousand five hundred and eight) islands included in the sovereign territory of the Unitary State of the Republic of Indonesia, of which 16,056 islands have been standardized in the UN until July 2017 (Deputy for Maritime Sovereignty of the Coordinating Ministry for Maritime Affairs, 2017). One of the archipelagos with a cluster of small islands scattered around Jakarta Bay is the Kepulauan Seribu. Kepulauan Seribu Island is one of the administrative districts in the Special Capital Region of Jakarta. It has 111 islands and a total area of 10.18 km<sup>2</sup> and one of the Kepulauan Seribu Administrative Regency islands with the largest population is Kelapa island Sub-district. Kelapa island is also the center of the capital city, Kepulauan Seribu District administration, with a population of 7,678 consisting of 3,816 male and 3,862 female residents (Kepulauan Seribu District Annual Report, 2024). Kelapa Island is also the second most densely populated island after Panggang Island with a density of 26,644 people/km<sup>2</sup> (Central Statistics Agency, 2017). This results in the distance between residents' houses being very close. This density poses challenges in terms of environmental management such as the provision of clean water that meets the standards of the Regulation of the Minister of Health of the Republic of Indonesia Number 2 of 2023 concerning Environmental Health. In carrying out daily household activities, residents on Kelapa Island use 4 water sources, namely refilled water or bottled water which is used as a source of drinking water, processing sea water into fresh water with *reverse osmosis* (RO) and communal dug well water which is used as water for household hygiene and sanitation needs and the third water source is the use of rainwater as reserve water for hygiene and sanitation needs during the dry season.

Data from the Kepulauan Seribu Health Center located in the Kelapa Island area in 2024, semester 1, January, March, May and June, it is known that diarrhea is recorded as one of the top 10 diseases in the area (secondary data from the Kepulauan Seribu Islands Health Center, 2024). This report on the top 10 diseases aims to determine the number of diseases in the Health Center (Hosizah & Maryati, 2018). Cases of diarrhea in toddlers found and reported by the Kepulauan Seribu Health Center from January to June 2024 were 29 toddlers with the highest cases in May 2024, amounting to 13 (thirteen) cases (secondary data from the Kepulauan Seribu Utara Health Center 2024). According to Dangiran and Dharmawan (2020), factors that can facilitate or accelerate the occurrence of diarrhea are caused by germs, nutritional status, hygiene & sanitation, socio-culture, population density and socio-economics. Providing clean water sources through communal dug wells for household hygiene and sanitation purposes, Kelapa Island has four dug wells that residents share. The wells are located on Kelapa Island as many as 3 (three) wells, and on Kelapa Dua Island, as many as one.

Based on this information, this study also examine the depth of the well and the distance of the well from the source of water pollution. The following results and discussions will describe the findings from water sample measurements carried out at both locations, sample measurement carried out from directly measurement by researcher for one sample communal well (primary) and two sample measurement of communal well as secondary data from Kepulauan Seribu Utara Health Center and this study focused on

the archipelago. Although previous studies have examined water quality in relation to diarrhea, studies that focus on archipelagos are still relatively limited. This study is expected to provide an overview of water quality and diarrhea in archipelagos, especially in Indonesia.

## 2. Method

This research was conducted in Kelapa Island Village, Kepulauan Seribu Utara District, Seribu Islands Administrative Regency, DKI Jakarta. The location of this research was chosen because Pulau Kelapa is one of the islands with a high population density in the Kepulauan Seribu Utara which can affect access and quality of clean water and the prevalence of diarrhea. The research focused on the location of communal dug wells in Kelapa island and Kelapa Dua. This type of research is descriptive research with a quantitative approach. In this case, descriptive research is used to describe the condition of water quality from communal dug wells on Kelapa island. This study does not attempt to determine a causal relationship, but aims to describe existing conditions based on the data collected. A quantitative approach is used because this study involves numerical measurements of physical and microbiological parameters of water, as well as the number of diarrhea cases by age group.

The population in this study were all communal dug wells used for hygiene and sanitation purposes by residents on Kelapa Island. Kelapa Island owns four communal dug wells, with three wells on Kelapa Island and one on Kelapa Dua Island. Meanwhile, the total sample in this study was three communal dug wells from four communal dug wells, namely two samples from Kelapa Island (Sample two dug wells in RW IV) and one sample from Kelapa Dua Island (Sample RW V). The sampling criteria were relevant; for example, samples were selected from communal dug wells that residents actively used for hygiene and sanitation purposes, and samples were also taken from locations representing the two research areas, namely Kelapa Island and Kelapa Dua.

Data collection in this study used secondary data and primary data. Secondary data includes information obtained from the Kepulauan Seribu Utara Health Center report regarding the distribution of population age groups, diarrhea cases and the results of communal well water quality examinations. This data provides an overview of diarrhea cases on Kelapa Island and water quality based on the results of the analysis that has been carried out by the Health Center previously, while primary and secondary data in this research was measurements of three communal well in research area. Water samples were taken using sterile bottles, and then was analyzed in the laboratory to see the physical and microbiological parameters using Most Probable Number (MPN). Researchers also observed the physical condition of the well, such as depth, construction, and distance from sources of pollution such as septic tanks.

## 3. Results and Discussion

### *Population Distribution Data of Kelapa Island Based on Age Group*

According to the Minister of Health Regulation No. 25 of 2016 concerning the National Action Plan for Elderly Health for 2016-2019, it is known that the grouping of children's health ages is divided into infants and toddlers (0 to 5 years), preschoolers (5 to 6 years); children (6 to 10 years) and adolescents (10 to 19 years). Based on the Annual Report Data of the Kepulauan Seribu Utara Health Center, it is known that the number of residents according to the age group can be seen in the table below:

**Table 1.** Distribution of Population by Child Age Group and Gender in 2024

Age (Years)	Man	Woman	Total Population	Percentage (%)
0 to 4	784	796	1580	43.25
5 to 9	386	422	808	22.12
10 to 19	625	640	1265	34.63
Total	1795	1858	3653	100.00

Based on the table above, it can be explained that the largest population is in the infant and toddler age group (0 to 4 years), namely 1,580 residents (43.25%) compared to other age groups. The second

position is occupied by the adolescent age group (10 years to 19 years) with a total of 1265 residents (34.63%). Meanwhile, the third position is occupied by the children's age group (5 years to 9 years) with a population of 808 people (22.12%).

#### *Number of Diarrhea Cases by Age Group Semester I of 2024*

**Table 2.** Number of Diarrhea Cases Based on Child Age Group in Semester I of 2024

No	Age group	Number of Cases from January to June 2024	Percentage (%)
1	0 to 4 years	29	51.79
2	5th to 9th	15	26.79
3	10 years to 19 years	12	21.43
	Total	56	100.00

Based on the table above, it can be explained as follows the age group of infants and toddlers (0 to 4 years) experienced the highest number of diarrhea cases compared to other age groups with a total of 29 cases (51.79%). This shows that toddlers are the group most susceptible to diarrhea. In many cases, infants and toddlers are more susceptible to bacteria, viruses, or parasites that can cause diarrhea because their immune systems are not yet fully developed. The children's age group (5 to 9 years) is in second place with 15 cases (26.79%) and has a lower number of diarrhea cases compared to the 0 to 5 years age group. This is likely due to more mature and stronger immunity compared to the infant and toddler age group. The adolescent age group (10 to 19 years) has the least number of diarrhea cases compared to the other two age groups, which is 12 cases (21.43%). This percentage reflects that adolescents and young adults have less frequent diarrhea cases compared to younger age groups.

#### *Results of Measurement of Physical and Microbiological Water Quality Parameters*

The results of the study were obtained through secondary data from the Kepulauan Seribu Utara Health Center regarding the examination of the physical and microbiological quality of communal dug well water located in RW IV Kelapa island and RW V Kelapa island Dua which was carried out by the Kepulauan Seribu Utara Health Center through the Regional Health Laboratory of the DKI Jakarta Provincial Government in April 2024 as well as primary data collection through direct measurement of 1 sample of communal dug well water located in RW IV Kelapa island (behind SD 01, with the following results:

**Table 3.** Results of clean water sample measurements from communal dug wells on Kelapa Island and Kelapa Dua

No	Parameter	Unit	Maximum permissible levels (Minister of Health Regulation No. 2 of 2023)	Measurement result		
				Sample I (RW IV Kelapa Island)	Sample II (RW V Kelapa Dua Island)	Sample III (RW IV Kelapa Island/ Behind SD 01)
A	Physique					
1	Temperature	°C	± 3°C (24°C -30°C)	25.2	26.3	29.3
2	Turbidity	NTU Scale	<3	0.46	1.01	0.67
3	Color	TCU Scale	10	<0.86	<0.86	2
4	Smell	-	Odorless	Odorless	Odorless	Odorless
B	Microbiology					
1	Total Coliform	Colony/10 0 ml	0	>1000*	>1000*	50*
2	Escherichia Coli	Colony/10 0 ml	0	410*	12.7*	40*

\*: Indicates that the parameter value exceeds the maximum allowed limit.

The table above shows the results of the examination of the physical parameters of water, such as temperature, turbidity, color, and odor, all water samples are below the maximum threshold allowed according to Permenkes No. 2 of 2023 concerning Environmental Health. However, the results of the microbiological examination showed a significant problem. The Total Coliform count in the three samples above exceeded the maximum limit allowed, which was >1000 colonies/100 ml. In addition, the levels of *Escherichia Coli* in all samples also exceeded the maximum limit allowed. In addition, related to the results of physical observations of communal dug wells, including the depth of the well in each sample has well depth < 3 meters from the ground surface. This can be explained as follows:

#### *Physical Quality Analysis of Communal Dug Wells*

Based on the results of the study of the physical quality of water from communal dug wells in RW IV Kelapa island and RW V Kelapa Dua island, it shows that the physical parameters expressed such as temperature, turbidity, color, and odor are still at a safe level according to the established quality standards. As seen in the measurement of water temperature from both locations (Kelapa and Kelapa Dua island) are within safe limits according to water quality standards. There is no indication that the water temperature causes problems or negatively affects water quality and is in the range of 24°C - 30°C. This is in accordance with the standard for drinking water source temperature according to the Regulation of the Minister of Health of the Republic of Indonesia No. 492 / MenKes / Per / IV / 2010, namely 24°C -30°C. This is also in line with the results of research conducted by Aramana (2013) who obtained the results of the examination of the quality of dug well water temperature in Bitung Karangria Village showing that the well water temperature meets 100% of the requirements, where all well water sample temperatures are approximately  $\pm 3^\circ\text{C}$ . Air temperature, namely 27°C to 29°C at an air temperature of 30°C.

The results of the measurement of the turbidity of the communal dug well water in RW IV Kelapa island were 0.46 NTU (Nephelometric Turbidity Unit) and 0.67 NTU, while the results of the measurement of the turbidity of the communal dug well water in RW V Kelapa Dua island were 1.01 NTU so that overall, the turbidity of the water from the communal dug well meets the water quality standards set. The low turbidity in Kelapa and Kelapa Dua island indicates the water was clear but it does not mean free of microbacteriological contaminants and it shown by the measurement result of microbacteriological parameter there have total coliform and *Eschericia Colli*. results of another study conducted by Alhamda et al. (2021) entitled Analysis of the Physical and Bacteriological Quality (E-coli) of Communal Dug Well Water in Jorong Koto Kaciak Kanagrian Magek, Magek District, with the results that overall the community's dug well water samples looked clear and not turbid.

The results of measurements on the physical parameters of color show that the color value of communal dug well water in RW IV Kelapa and RW V Kelapa Dua island is good and clear because there is no pollution from environment that source from industrial waste or mining. This shows that the water is very clear and not contaminated by dyes that can affect its appearance or quality. The results of the study on the odor and taste parameters also show that the communal dug well water is odorless. The results of this study are in line with the results of other studies conducted by Alhamda et al. (2021) entitled Analysis of the Physical and Bacteriological Quality (E-coli) of Communal Dug Well Water in Jorong Koto Kaciak Kanagrian Magek, Magek District. The results showed that in general the physical quality of dug well water samples based on smell and taste had met the health standard requirements, namely odorless and tasteless water where the water did not emit an odor and tasted fresh.

#### *Bacteriological Quality Analysis of Communal Dug Wells*

Based on the results of research conducted on clean water from communal dug wells on Kelapa Island and Kelapa Dua, it is known that the three samples showed potential contamination by pathogenic microorganisms and did not meet the established health standards. At all three locations, the results of microbiological measurements showed that the number of Total Coliform exceeded the maximum limit allowed and the results of the measurements also showed that there was *Escherichia Coli* contamination

in communal dug wells on Kelapa Island and Kelapa Dua Island. This is not in accordance with the Minister of Health Regulation No. 2 of 2023 which states that the maximum level allowed for coliform and *Escherichia coli* bacteria is 0 CFU/100 ml or no coliform or *Escherichia coli* bacteria were found. *Escherichia coli* is a fecal coliform bacteria found in the human intestine. *Escherichia coli* in water can be caused by contamination of animal and human feces, causing a bowel movement disorder called diarrhea. The most common cause of diarrhea is believed to be water contaminated by bacteria, while water is one of the components closest to humans and is also a constant need for the quality and continuation of human life (Ety, Susianti, & Soleha, 2019). WHO also emphasizes that water contaminated with human waste, for example from waste, septic tanks, and latrines can cause diarrhea (World Health Organization, 2024).

*Escherichia coli* Alone is the most commonly known biological indicator of environmental pollution by feces. *Escherichia coli* is very easy to culture in the laboratory, but to identify its pathogenic genotype requires a virulence gene detection method such as PCR (*Polymerase Chain Reaction*) using feces samples which are now starting to be widely developed (Setianingsih, I., Andiarsa, D., & Hariyati, E. (2019)). In a preliminary survey, researchers found that fecal examination to detect Diarrhoeogenic *E. coli* (DEC) on Kelapa Island and Kelapa Dua Island had never been carried out by the Kepulauan Seribu Utara Health Center or the Kepulauan Seribu Utara Health Service. In fact, according to the World Health Organization (2024) *E. coli* is transmitted to humans through fecal contamination of water and food. *E. coli* strains are often found in water bodies such as ponds and rivers, wells and water tanks, and can survive for a long time in livestock waste and water tank sediments. Similar studies in Sub-Saharan Africa have shown that households with unimproved drinking water sources and unimproved toilet facilities are more likely to report diarrhea in children under five years of age ((Amadu et al., 2023).

The presence of total coliform and *Escherichia coli* content in communal well water on Kelapa Island and Kelapa Dua is related to the physical condition of the communal well. Researchers conducted observations on the physical condition of the communal well visually and obtained results that the distance between the septic tank and the communal well was <10 meters due to the distance of densely populated houses and the depth of the communal well was found to be only <3 meters from the ground surface. The results of the study are in line with the study conducted by Rizza (2013) entitled Physical conditions and pollution of dug wells, case studies in urban and rural areas explaining that floor conditions that do not meet requirements are also related to the occurrence of pollution of dug wells. The condition of the well floor that does not meet requirements varies, both in the form of a length of less than 1 (one) meter from the edge of the well, a cracked floor and some do not have a well floor (directly soil). (Radjak, 2013) also explained that the physical condition of dug wells that do not meet health standards can be a source of pollution because water that has been mixed with bacteria or other sources of pollution can seep or enter through the pores of the walls, lips and parts of dug wells that are not watertight, causing pollution. In this research study, the physical condition of communal dug wells on Kelapa Island and Kelapa Dua did not meet health requirements. This is due to limited land, especially on small islands, where land space is very limited. As a result, the construction of septic tanks is often installed close to houses to maximize the use of available land.

#### 4. Conclusion and suggestions

The results of the study showed that the physical quality of communal dug well water on Kelapa Island and Kelapa Dua has met the standards set by the Minister of Health Regulation in terms of temperature, turbidity, color, and odor. However, the microbiological quality of the water showed significant contamination by pathogenic bacteria, with the total number of coliforms and *Escherichia coli* exceeding the maximum allowable limit and the results of observations showed that the physical condition of the communal dug well with a shallow well depth and a well distance from the septic tank of less than 10 m, these conditions contributed to water contamination and increased health risks. This indicates contamination of human or animal feces, especially for children under five years of age who are most susceptible to diarrhea. Based on these findings, it is recommended that the Kepulauan Seribu Utara Health Center conduct fecal examinations on diarrhea sufferers, especially toddlers on Kelapa Island and

Kelapa Dua to identify the pathogens that cause diarrhea more specifically and direct appropriate medical treatment and it is recommended that researchers conduct further research to analyze the extent to which environmental quality affects the prevalence of diarrhea, the quality of human resources and its impact on public health.

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