Global Education Journal
Vol. 3, 1 (January-April, 2025), pp. 409-414
EISSN: 2808-5094, DOI: 10.59525/gej.v3i1.185

Study of the Effectiveness of Rainwater Harvesting in Overcoming Clean Water Scarcity

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Article history Submitted: 2025/09/28; Revised: 2025/11/30; Accepted: 2025/12/05

Abstract

Rainwater becomes refreshing and safe water for use in daily activities such as bathing and even for consumption through a recycling process. The aim of this study is to analyze the need for clean water, water scarcity and rainwater potential as well as analysis of rainwater utilization with rainwater processing technology. The methods used are the Wet Deposition and Wet & Dry Deposition methods with the Automatic Rain Water Sampler (ARWS). The software used for data processing in this research is Minitab version 21.1. The results of field studies based on data from the Mataram Meteorology, Climatology and Geophysics Agency for the NTB region, in the last 3 years, namely 2017, 2018 and 2019, show that the average rainfall in Mataram is 326 mm/year, which means the potential for rainwater to be reuse is huge. Strategic steps are needed to optimize rainwater potential, investment policies in appropriate infrastructure need to be improved, including rainwater collection systems, storage tanks and water treatment technology. Apart from that, the government's role is important in paying attention to legal, regulatory and environmental sustainability aspects in the development and utilization of rainwater resources so that they can be used as a basic ingredient for clean water needs.

Keywords Environmental Sustainability, Rainwater, Water Scarcity, Water Treatment Technology.

1. INTRODUCTION

Rainwater becomes water that is refreshing and safe for use in daily activities such as bathing and even for consumption through a recycling process (Puasa and Jakarta, 2020). Rainwater can be said to be safe to reuse because rainwater is not water that is harmful. Even in the agricultural and plantation industries, water needs for plants are still met by rainwater, especially during the rainy season. So, it can make plants fertile and make the soil loose (Munawir et al., 2022b). The main source of clean water is rain, which is one of the main sources of clean water on earth (Munawir et al., 2022c). Rainwater is collected in lakes, rivers and reservoirs, then processed into drinking water that can be consumed by humans (Sutrisno and Hamdani, 2019). The direct benefit of rainwater is that it helps maintain

ecosystem balance by providing water for various living organisms on land and in water. Small animals also get their drinking water from rainwater.

The main factors of the water cycle include evaporation, condensation, precipitation (rain), and flow back to the sea through rivers and lakes. The presence of rainwater is a groundwater replenishment process where rainwater seeps into the soil and fills groundwater. This is important for maintaining soil moisture and supporting vegetation growth. On the other hand, rainwater helps clean the air from pollutant particles and dust that settle in the atmosphere. This process is known as "acid rain." Rain also helps regulate the temperature at the earth's surface by introducing moisture and reducing hot air temperatures. Rainwater can also be a natural source of irrigation for agricultural plants (Munawir et al., 2019). Plants need water to grow, and rain provides an essential water supply for plant growth. Rainwater can reduce the risk of forest fires, especially in fire-prone areas such as peat areas by increasing humidity and reducing the availability of dry fuel. Thus, rainwater has a very important role in maintaining life on Earth and supporting the sustainability of the ecosystem as a whole.

Long before technology developed, the Al-Quran already contained a divine revelation explaining rainwater. In Surah Ar-Rum, verse 48 reads: "Allah SWT, He is the One who sends the wind, then the wind moves the clouds and Allah spreads them in the sky as He wills, and makes them lumpy; then you saw the rain coming out of the gaps, so when the rain fell on His servants whom He wanted, suddenly they became happy." The description of Ar-rum's letter implies that the hydrological cycle continues perfectly and has been scientifically proven. Rain is a natural process that carries the main content in the form of water vapor or H2O as much as 99.9% (Ministry of Health, 2022). This means that the potential for rainwater to be used as a source of clean water or even a source of drinking water is quite strong, because 0.01% of rainwater is in the form of pollutants. By knowing its characteristics, it can be determined what treatment can be given so that rainwater can be used as water suitable for consumption. The Indonesian Ministry of Health's crisis center states that rainwater may contain: Nitric acid, which comes from factory/industrial contamination or can also come from volcanic eruptions (Ministry of Health, 2022). Nitric acid causes the pH of rainwater to become low (acid); Silica and fly ash; Sulfuric acid, which can be contributed by vehicle exhaust gas, has the potential to cause the pH of rainwater to become low; Salt, usually comes from the evaporation of sea water and generally rainwater in coastal areas which contains salt. For this reason, the implementation of this research focuses on analyzing clean water needs, clean water scarcity and problem solving steps and appropriate technology in overcoming clean water scarcity by using rainwater.

2. METHODS

The research method used in this study uses quantitative descriptive research. The quantitative descriptive method is a research method used to explain what is happening now or in the past, with the aim of describing the problems that arose when the research was conducted (Munawir et al, 2022a), in this case the data sources are analyzed in numerical or combined form quantitative data. The location of this research was carried out in West Nusa Tenggara, as well as several regions in Indonesia and the time used in this research was 3 months, starting from September until the end of this research. The data used in this paper is secondary data in the form of maximum rainfall. The time interval used in the data is the annual rainfall period from 2017 to 2019. The data was obtained from the West Nusa Tenggara Climatology Station of the Meteorology, Climatology and Geophysics Agency (BMKG). The variable used in this research is the maximum rainfall in Mataram City in three periods from 2017 to 2019 and then pH measurements were carried out, rainwater in Indonesia which was monitored at 52 stations using the Wet Deposition and Wet & Dry Deposition methods with the Automatic Rain tool. Water Sampler (ARWS). The software used for data processing in this research is Minitab version 21.1.

FINDINGS AND DISCUSSION

Rustan et al. (2019) stated that water need is the amount of water which is a basic human need. The Ministry of Public Works provides an overview of the standards for clean water requirements as follows:

Table 1. Department of Public Works Water Requirements Standards

Necessity	Consumption (Liter/Person/Day)
Bath, wash, toilet	12,0
Drink	2,0
Wash clothes	10,7
House cleanliness	31,4
Park	11,8
Wash the vehicle	21,1
Wudhu	16,2
Etc	21,7
Total	126,9

Source: Slamet, 1994 in Rustan, et al. (2019)

In table 1 shows that the need for bathing, washing and toileting is around 12.0 liters/person/per day, which includes water use for bathing, washing the body, cleaning the toilet and other activities in the bathroom. The need for drinking water is around 2.0 liters/person/per day, with the basic need to drink water every day. It is important to maintain body hydration. Wash clothes 10.7 liters/person/per day, water used to wash clothes, both manually and with a washing machine. House cleanliness is 31.4 liters/person/per day, including the use of water to clean floors, furniture and other surfaces in the house. Water use in the park is around 11.8 liters/person/per day, water used to water plants in the park or yard. Wash vehicles 21.1 liters/person/per day, water used to wash cars, motorbikes or other vehicles. Wudhu water is around 16.2 liters/person/per day, water used in the ablution ritual, or cleansing before performing prayers in Islam. Others range from 21.7 liters/person/per day, this includes water use for various other purposes that are not included in the above categories, such as cooking, cleaning eating utensils, and so on. The total water requirement per person per day is 126.9 liters, which includes all the above activities. These are average estimates and actual figures may vary depending on individual habits, household type, and other factors. It is important to use water wisely and look for ways to reduce water consumption where possible, especially considering limited water resources in some areas.

Water Scarcity and Rainwater Potential

The 2020-2024 RPJMN released by the Office of the Ministry of National Development Planning/Bappenas states that by 2030 for the Java, Bali and Nusa Tenggara regions, it is predicted that there will be an increase in water scarcity and a decline in water quality (Rustan et al., 2019). One effort that can be used as an alternative to overcome the problem of water scarcity is to create technology that can recycle water (Presidential Decree 18, 2020). Rainwater can be recycled and processed into clean water or water suitable for consumption.

Data released by the Mataram Meteorology, Climatology and Geophysics Agency for the NTB region, in the last 3 years, namely 2017, 2018 and 2019, shows that the average rainfall in Mataram is 326 mm/year. If we refer to the rainfall category based on BMKG, this means that the potential for rainwater in Mataram is large enough to be used as a source of clean water (Helmi, 2021; NTB in Figures, 2022). Average rainfall data can be presented in Table 2 below:

Table 2. Average rainfall data for research locations in 2022

Rainfall	ANNUAL AVERAGE			AVERAGE
(mm)	2017	2018	2019	(mm)
Mataram	139.00	139.00	144.00	326
Sumbawa Besar	86.00	86.00	128.00	100
Bima	95.00	95.00	82.00	90,67

Quoted from NTB in Figures 2022
Source : Badan Meteorologi, Klimatologi dan Geofisika Mataram
Source Url: https://ntb.bps.go.id/indicator/151/48/3/curah-hujan.html
Access Time: March 8, 2022, 10:59 am

The potential of rainwater in Mataram can be a very valuable resource if used properly. According to Munawir et al (2022c), the main source of clean water is rainwater which can be collected and filtered to become a source of clean water. This can reduce reliance on wells or other surface water sources, especially in areas that may experience drought. Amos et al (2018) explains that collected rainwater can be used to irrigate plants in farms, parks or gardens, helping local agriculture and maintaining environmental sustainability. Collecting and channeling rainwater can help reduce the risk of flooding by channeling excess rainwater into an appropriate drainage system (Munawir et al., 2023). Rainwater can be stored in tanks or reservoirs to be used for daily purposes such as washing, bathing and cooking. On the other hand, based on the opinion of Sulandari et al. (2021) channeling rainwater into a water capture or soil infiltration system can help reduce soil erosion and maintain soil fertility. Apart from that, on a larger scale, rainwater collected in reservoirs can be used for hydroelectric power plants, providing a renewable energy source. Properly treated rainwater can be used as a source of safe and clean drinking water, especially in areas where access to safe drinking water is limited.

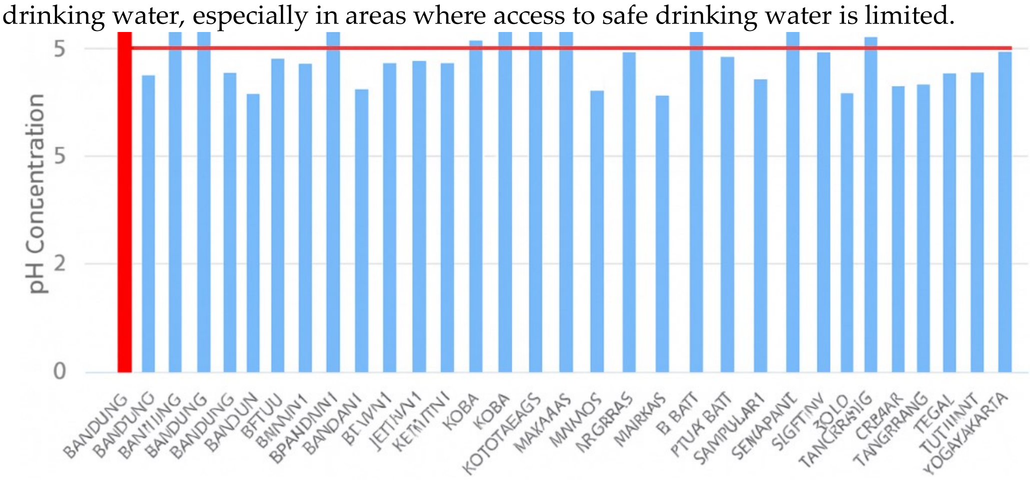

Figure 1. Chemical Quality Data for Rainwater December, 2021

Based on Figure 1, this data can determine a treatment model to overcome the pH problem of rainwater, namely by using limestone. Using limestone is safer than using other chemicals, besides using limestone it can be time released and easy to obtain. Limestone is a material that comes from white sedimentary rock and contains the minerals calcium (CaCO3), dolomite CaMg (CO3)2 and aragonite (CaCO3) (https://www.bmkg.go.id). Limestone, which contains the main element calcium, apart from being able to correct the pH of water, can also function as a coagulant and is able to purify water. After lime treatment, rainwater can be processed using a filter with zeolite media and silica sand and activated carbon.

Filters with zeolite media, as shown in Figure 2, are very effective for removing various inorganic elements in water. Zeolites can function as absorbents, ion exchangers, molecular filters. Many studies have been carried out regarding the use of zeolite as a water filter media material, one of which is research conducted by Sai Hevi (2015), almost all parameters that require clean water have been proven that zeolite is able to reduce levels of Sulfate (SO4), Nitrate (NOj) and Nitrite (NO2) to meet clean water quality standards (Sai Hevi, 2015; https://www.geologinesia.com).

Meanwhile, the sand filter functions to filter suspended solids and the active carbon filter functions to improve the taste, color and odor of rainwater. To improve the quality of the processed water, so that the water is free from pathogenic microorganisms, sterilization can be carried out using ultraviolet.

Figure 2. Rainwater Treatment Process Flow

According to Helmi (2021), efforts need to be made to provide water reservoirs such as reservoirs, dams and embungs in order to maintain the existence of water to meet the need for clean water, as well as creating alternative technology that can be used to recycle water so that it can overcome the problem of water scarcity. This processing method is quite simple and the ingredients used can be obtained in many areas in Indonesia. Thus, looking at the potential for quite large rainfall in the Mataram area and its surroundings and by looking at the availability of materials for the rainwater processing process, in fact the potential for rainwater to be used as a source of clean water and a source of water suitable for consumption can be used as an alternative. Harvesting rainwater can be a necessity for the continued availability of clean water as an answer to concerns about water scarcity in the future.

3. CONCLUSION

The threat of clean water scarcity in the eastern region, especially until 2030 for the Java, Bali and Nusa Tenggara regions, is predicted to decrease both the quantity and quality of clean water. Data released by the Mataram Meteorology, Climatology and Geophysics Agency for the NTB region, in the last 3 years, namely 2017, 2018 and 2019, shows that the average rainfall in Mataram is 326 mm/year, which means the potential for rainwater to be utilized very big return. Strategic steps are needed to optimize rainwater potential, investment policies in appropriate infrastructure need to be improved, including rainwater collection systems, storage tanks and water treatment technology. Apart from that, the government's role is important to pay attention to legal, regulatory and environmental sustainability aspects in the development and utilization of rainwater resources so that they can be used as a basic ingredient for clean water needs.

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