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RESEARCH ARTICLE

HARVESTING AND USES OF RAIN WATER IN INDONESIA

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ABSTRACT

As a tropical country, Indonesia has quite high rainfall reaching 2000-3000 mm per year in several areas. In general, rainwater utilization in Indonesia is used to support agricultural activities and meet household daily needs, especially drinking water. Methods of utilizing rainwater and processing in Indonesia use a variety of methods ranging from the simplest to the high technology. The manufacture of rainwater storage systems, infiltration wells and biopores are methods used for rainwater utilization and flood control for urban areas. As for the processing of rainwater into drinking water, many have used high technology such as filtration systems.

KEYWORDS

Harvesting, uses, rainwater, Indonesia

1. INTRODUCTION

As a tropical country that is crossed by the equator and is the largest archipelagic country in the world, Indonesia has quite high rainfall. Sumatra and Kalimantan are areas that have high rainfall with an average rainfall ranging from 2000-3000 mm per year and some even reach 4000 mm per year. However, in several areas, such as West Nusa Tenggara and East Nusa Tenggara, the rainfall is quite low. Meanwhile, based on topography, areas that are in the highlands have higher rainfall than areas that have lowlands. The average rainfall in areas with an altitude of 600-1300 m above sea level ranges from 2300-2800 mm per year. The beginning of the rainy season in Indonesia changes every year and varies greatly from region to region. The peak of the rainy season usually occurs in January or February (Aldrian, 2008; Abdulla et al., 2009; Aldrian et al., 2011; BMKG, 2011; Hijauku, 2012; Fadholi, 2013; BMKG, 2014). In Indonesia, the use of rainwater is quite extensive and varied, both for meeting daily needs and for economic activities (Laurentia,2009; Saleh, Chairil. 2011). Utilization of rain water in Indonesia includes:

1.1 Irrigating Rice Fields and Land

High rainfall makes farmers more economical, faster, and easier when irrigating their fields and land. Rain also makes farmers grow corn, rice, and so on. This is because the soil that is exposed to the rain becomes moist and loose, making it easy to cultivate, plow, or hoe.

1.2 Water Reserves During Long Drought

Heavy rain or high rainfall is the most appropriate time to fill water reservoirs that can be used as reserves when the long dry season hits.

1.3 Maintaining the Survival of Living Things on Earth

The absence of rainwater due to long drought has disrupted the survival of some living things. Many animals die from lack of water, plants wither and then dry up. Another result of drought is the reduction of minerals and compounds in the soil. With high rainfall, the levels of these minerals and compounds can return to normal. The survival of living things will be maintained when the high rain water wets the earth.

1.4 One Source of Drinking Water

Rainwater is clean, pure water, without the addition of harmful chemicals. Meanwhile, most of the water used every day comes from Drinking Water Companies (PAM), a chemical disinfectant, namely chlorine. Chlorine is a dangerous substance for the body. Therefore, rainwater becomes a source of drinking water that is healthy and safe for consumption.

1.5 Maintaining forest sustainability

The climate in Indonesia has a very big influence on the sustainability of life on earth. Likewise with the forest which is the lungs of the world. High rainfall can also play a role in maintaining soil and forest fertility. The function of protected forests or other forests, apart from being able to prevent landslides, can also function to prevent soil erosion.

1.6 Agriculture

Rain is very much needed for agricultural activities and it is hoped that farmers can irrigate their fields and water their fields at any time.

1.7 Fertilize the soil

High rainfall can also play a role in maintaining the fertility of an area's soil so that it is suitable for agriculture.

2. RAINWATER UTILIZATION AND TREATMENT METHODS

2.1 Rainwater Utilization Method

Utilization of rain water can be carried out by using a rainwater storage system (PAH), processing it into clean water and ready-to-drink water that can be consumed for daily needs or for commercial purposes. Meanwhile, for the utilization of abundant rainwater and flood prevention in urban areas, infiltration wells (SURES) and biopores can be constructed (Ghisi qt al., 2009; Song et al., 2009; Khoirudin, 2012; Anwar et al., 2013; Hermawan, 2014).

2.2 Rainwater Treatment Method

The principle of rainwater treatment is the same as water treatment in general. The process depends on the content of the type and the concentration of the pollutants. Compared to surface water or river water, rainwater collected from roofs is generally of relatively better quality. By using simple processing technology, good quality water can be produced. Rainwater treatment can be done simply and the application of ready-to-drink water technology. To remove compounds or pollutant elements in rainwater, the processing method can be done as shown in Table 1(Herlambang, and Said, 2005; KELAIR, 2021).

Table 1: Methods of Processing and Removing Rainwater Pollutants (KELAIR, 2021)

No	Quality of Raw Water	Treatment Methods
1	Turbidity (TSS)	Filtration with silica sand media, filter or slow sand filter, coagulation-flocculation process and rapid sand filtration, filtration with ultrafiltration membrane.
2	Micro Pollutant	Filtration with activated carbon.
3	Carbon dioxide free / CO2 aggressive	Aeration, treatment with alkaline substances.
4	PH adjustment	Treatment with alkaline substances.
5	Iron	Prechlorination, aeration, pH control, with ferrous bacteria, ion exchange, w / MnO2 catalyst, oxidation w / KMnO4 or ozone etc.
6	Manganese	1) [Oxidation] + [Flocculation] + Sand Filter, Pre-Chlorination, Oxidation with Potassium Per-manganate, Oxidation with Ozone. 2) Filtration of contact filter media containing MnO2, Double Flitration. 3) Process with iron bacteria with slow sand filter.
7	Plankton	With the use of chemicals: copper sulfate, chlorine, copper chloride; double phytation; micro filter.
8	Odor	Odor Aeration Process, remove micro-organisms, Process with activated carbon, chlorination, ozone treatment.
9	Detergents and phenols	Treatment with activated carbon, Process biological pretreatment, oxidation

2.4 Water Quality Analysis

The temperature of the solar still be recorded by using thermometer given (placed at thermometer port inside the solar still). The collected desalinated water sample was transferred into the measuring cylinder and the volume of each sample be recorded. The reading was repeated at least three times in order to obtain an average data at optimum condition. Then, followed by the pH by using pH meter, TDS by using TDS meter and electrical conductivity measurement by using conductivity meter.

As for the Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), all the desalinated water samples taken does not required any dilution as it was originally clean. Therefore, the measurement of BOD of each sample has been taken directly by filling up 300 ml full of the BOD bottle. Meanwhile, for COD measurement, a low range COD vials which has maximum limit of 150 mg O_2/l has been used by adding 2.0 ml desalinated water sample into the digestion vial (Herlambang, and Said, 2005; KELAIR, 2021).

The AAS was used to identify the concentration of the Na, K, Mg and Ca presence in the water sample. The stock solution and the standard solution have been prepared for each chemical which for the Na, the 0.245 g of sodium chloride, NaCl being used and diluted into 0.25 ppm, 0.5 ppm and 0.75 ppm. Meanwhile, for the K, the 0.2 g of potassium chloride, KCl being used and diluted into 1 ppm, 3 ppm and 5 ppm. 2.5 ml of magnesium solution has been used for Mg determination by the dilution into 0.15 ppm, 0.3 ppm and 0.45 ppm. As for Ca, the 2.5 ml of Calcium solution has been used with dilution into 2 ppm, 4 ppm and 6 ppm (Herlambang, and Said, 2005; KELAIR, 2021)

3. Results and Discussion

3.1 Rainwater Quality

The quality of rainwater depends on weather conditions or air quality and is influenced by the material or storage material and the time it is stored in the storage tank. Rainwater that has just fallen generally has a slightly low pH (acidic). This is because the rainwater that has just fallen dissolves a lot of CO2 gas or SO2 gas that is in the atmosphere. The acidity of rain water depends on the level of concentration of these gases. If it has been stored for a long period of time, the pH of the water will usually rise to near normal because the dissolved CO2 gas will escape or evaporate again until equilibrium occurs.

Pollutants that are often present in rainwater include CO2 which causes the pH of the newly stored water to be slightly acidic, then SO2, NH3, NOx, suspended solid particles due to dust impurities, metal Fe, Mn, Zn, Ca, Mg which depend on the roofing material. the shelter used, the possibility of coli bacteria or other pathogenic microorganisms depending on the level of cleanliness of the roof and the storage tub.

The average pH value of rainwater is 5.6 which is a value that is considered normal or natural rain as agreed internationally by the world body WMO (World Meteorological Organization). If the pH of the rainwater is lower than 5.6, the rain is acidic, or it is often called acid rain and if the pH of the rainwater is greater than 5.6, the rain is alkaline. The impact of acidic rain can erode buildings / buildings or are corrosive to building materials, damaging the life of biota in lakes and rivers. The slightly acidic nature of rain is caused by the dissolution of carbonic acid (H_2CO_3) which is formed from CO2 gas in rainwater. Carbonic acid is weakly acidic so that the pH of rainwater is not low. If rainwater is polluted by strong acids, the pH of rainwater drops below 5.6 rain, this is called acid rain. The term acid rain is actually less precise, it is actually acid deposition.

There are two types of acid deposition, namely dry deposition and wet deposition. Dry deposition is an event where objects and living things are exposed to the acids in the air. This can occur in urban areas due to air pollution from heavy traffic and in areas directly exposed to polluted air from factories. It can also occur that the hills are exposed to the wind which contains acid. Dry deposition usually takes place near the source of the contamination. Wet deposition is the dropping of acids in the form of rain. This happens when the acid in the air dissolves in the water droplets in the cloud. If it rains from that cloud, the rainwater is acidic. The acid rained or rained. Wet deposition can also occur because rain falls through acidic air so that the acid dissolves into rainwater and falls to the earth. The acid is washed or wash-out. Wet deposition can occur in areas far from sources of pollution.

Monitoring of rainwater acidity (pH) in Indonesia is carried out at 35 (thirty five) stations. Sampling using the Wet Deposition and Wet & Dry Deposition methods with an Automatic Rain Water Sampler (ARWS). Rainwater sample analysis was carried out in the BMKG air quality laboratory using an ion chromatograph. In February 2012, the number of rainwater samples received at the Air Quality Laboratory came from 24 (twenty four) rain observation stations in Indonesia. The analysis showed that the acidity (pH) of rainwater in 22 (twenty two) cities: Angkasa Pura - Jayapura, Bandung - West Java, Bawil -1 - Medan, Citeko - Cisarua, Darmaga - Bogor, Juanda - Surabaya, Karang Ploso - Malang, Kemayoran - Jakarta, Kenten - Palembang, Kototabang - Padang, Panakukang - Maros, Patimura - Ambon, Baai Island - Bengkulu, Samratulangi - Manado, Selaparang - Mataram, Semarang - Central Java, Siantan - Pontianak, St. Thaha - Jambi , Tangerang - Banten, Temindung - Samarinda, Tjilik Riwut - Palangkaraya, Yogyakarta - Central Java is below the Threshold Value (TLV) of normal rainwater pH of 5.6. This condition indicates that the rain that falls in the 2 (twenty two) cities is acidic. The acidity level of rainwater in the city of Banjar Baru - Banjarbaru, Branti - Lampung shows that the pH value of rainwater is above the Threshold Value (pH = 5.6). In more detail, the results of the analysis of the pH of rainwater in February 2012 can be seen in Figure 1 and Figure 2. Some examples of rainwater quality in Indonesia can be seen in Table 2 (BMKG, 2011; Hijauku, 2012; Fadholi, 2013; BMKG, 2014; KELAIR, 2021)

3.2 Benefits of Rainwater Utilization System (RUS) and Infiltration Wells (IW)

3.2.1 Application of Rainwater Storage Systems (RUS) and Infiltration Wells (IW)

Rainwater Storage System (RSS) is a rainwater storage system that is prepared to process rainwater for daily use. The basic principle of RSS is to drain rainwater that falls to the roof surface through a pipe, then it is collected into a storage tank that has been prepared. Then the filtered water from the reservoir is channeled into an infiltration well. The RSS system works as follows:

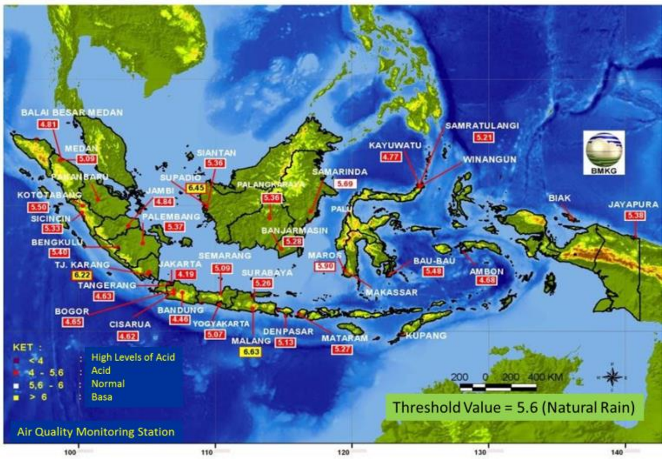

Figure 1: Map of the acidity (pH) of Rainwater in Indonesia Februari 2012 (BMKG, 2011; Hijauku, 2012; Fadholi, 2013; BMKG, 2014; KELAIR, 2021))

Figure 2: Graph of the acidity (pH) of rainwater in Indonesia, February 2012 (BMKG, 2011; Hijauku, 2012; Fadholi, 2013; BMKG, 2014; KELAIR, 2021))

Source: BMKG-http: //staklim-bengkulu.net/index.php/ air quality/ rainwater quality

Rainwater that falls on the roof is ready to be flowed through a pipe to a rainwater reservoir. The existing dirt will be filtered in the reservoir, then the filtered water will enter a larger reservoir with a volume of about 10 m³ of water. If the rain lasts for a long time and the water reservoir is full, the water will come out through the output pipe and enter the infiltration well with a well hole depth of about 3 meters (Mulyana, 1998; UNEP, 2021; Pergub DKI Jakarta, 2008; Permen LH Nomor 12. 2005; Rianawati, and Sagala. 2014; Suprayogi, 2015; KELAIR, 2021).

Water that has entered the infiltration well will seep into the ground through the infiltration zone of the infiltration well and become a source of groundwater. The infiltration area is at the bottom filled with gravel as a filter. The water that has been collected in infiltration wells is then pumped and filtered with the ARSINUM system to be processed into clean, ready-to-use water. An example of a design drawing of a rainwater storage system (RSS) and infiltration well (IW) can be seen in Figure 3 with a volume of 10 ~ 12 m³ (Said, 2006 and 2008; Putra, 2015; KELAIR, 2021).

Table 2: Rainwater Quality in Several Areas (KELAIR, 2021)

No.	Parameters	Unit	Quality Standard	Location: Depok	Semarang Tengah	Semarang Timur	Pandeglang	Description
A.	PHYSICS							
1	Smell	-	No smell	No smell	No smell	No smell	No smell	SNI 01-3554-2006 (2.2)
2	Flavors	-	Normal	Tasteless	Tasteless	Tasteless	Tasteless	SNI 01-3554-2006 (2.2)
3	Color	Pt-Co	5	7	2,4	3	-	SNI 01-3554-2006 (2.2)
4	Turbidity	NTU	1,5	14	1	0	0,65	SNI 01-3554-2006 (2.4)
5	Dissolved Solids (TDS)	mg/l	500	38	310	820	77	SNI 01-3554-2006 (2.5)
B.	CHEMICAL							
1	pH (26 ºC)	-	6,5-8,5	7,3	7	7	8	SNI 01-3554-2006 (2.3)
2	Organic Substances ($KmnO_4$)	mg/l	1,0	11,0	-	-	8,2	SNI 01-3554-2006 (2.6)
3	Nitrate (NO3-N)	mg/l	10	2	0,0295	0,2219	0,25	SNI 01-3554-2006 (2.8)
4	Nitrite (NO2-N)	mg/l	0,005	0,091	< 0,005	< 0,005	0,42	SNI 01-3554-2006 (2.8)
5	Ammonia (NH4)	mg/l	0,15	1,39	-	-	1,08	SNI 01-3554-2006 (2.9)
6	Sulfate (SO4)	mg/l	200	1,0	1,1	7,9	3,85	SNI 01-3554-2006 (2.10)
7	Chloride (Cl-)	mg/l	250	2,9	1,6	4,9	0,98	SNI 01-3554-2006 (2.12)
8	Fluoride (F)	mg/l	1,0	0,18	< 0,02	< 0,02	0,23	SNI 01-3554-2006 (2.13)
9	Cyanide (CN)	mg/l	0,05	< 0,005	< 0,01	< 0,01	-	SNI 01-3554-2006 (2.14)
10	Iron (Fe)	mg/l	0,1	0,11	< 0,03	< 0,03	0,04	SNI 01-3554-2006 (2.15)
11	Manganese (Mn)	mg/l	0,05	< 0,02	< 0,01	< 0,01	0,004	SNI 01-3554-2006 (2.16)
12	Cl2 free	mg/l	0,1	< 0,01	-	-	-	SNI 01-3554-2006 (2.17)
13	Chromium (Cr)	mg/l	0,05	< 0,02	< 0,0001	0,00013	< 0,02	SNI 06-6989.17-2004
14	Barium (Ba)	mg/l	0,7	< 0,1	-	-	-	SNI 06-6989.39-2005
15	Boron (B)	mg/l	0,3	< 0,01	-	-	-	SNI 01-3554-2006 (2.20)
16	Selenium (Se)	mg/l	0,01	< 0,002	< 0,005	< 0,005	-	Std Method (ed.21) 3500 Se
17	Lead (Pb)	mg/l	0,005	< 0,005	< 0,04	< 0,04	< 0,05	SNI 06-6989.8-2004 3)
18	Copper (Cu)	mg/l	0,5	< 0,02	-	-	< 0,006	18-5A/K-Cu
19	Cadmium (Cd)	mg/l	0,003	< 0,003	< 0,001	< 0,001		SNI 06-6989.16-2004 3)
20	Mercury (Hg)	mg/l	0,001	< 0,0005	< 0,001	< 0,001	< 0,0001	SNI 06-6989.2-2003
21	Arsenic (As)	mg/l	0,01	< 0,005	< 0,002	< 0,002	-	SNI 06-6989.33-2005
C.	MICROBIOLOGY							
1	Initial Total Plate Number 1)	Koloni/ m l	100	90	-	-	-	SNI 01-2897-1992
2	Final Total Plate Figures 2)	Koloni/ m l	100.000		-	-	-	SNI 01-2897-1992
3	Kabteri Coli (Coliform)	MPN/ 100ml	< 2	0	-	-	-	SNI 06-3957-1996
4	Salmonella	-	Negative/ 100ml		-		-	SNI 01-3554-2006 (2.24)

Information: SNI 01-3553-2006 Bottled Water Quality Standard

1) = Di Parik 2) = On the Market 3) = Heavy metals are dissolved metals <= smaller Raw water = well water

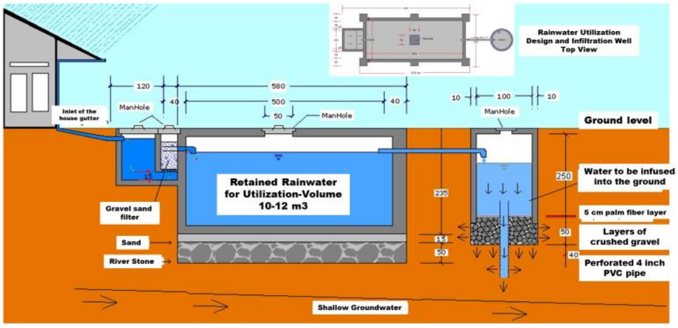

Figure 3: Rainwater Utilization System (RUS) and Infiltration Well (IW) (Said, 2008; KELAIR, 2021)

The functions and benefits of this rainwater utilization system and ready-to-drink water treatment are:

1) Save on the use of groundwater,
2) Holds 10 cubic meters of water when it rains,
3) Reducing run off & river load during heavy rain,
4) Increase the amount of water that enters the ground,
5) Maintaining the ground water level,
6) Reducing the concentration of groundwater pollution,
7) Improve the quality of shallow groundwater,
8) Reducing the rate of erosion and sedimentation,
9) Reducing the dimensions of the drainage network,
10) Maintain the balance of groundwater hydrology so as to prevent seawater intrusion,
11) Prevent land subsidence,
12) Water stock during the dry season (plus rain harvesting).

3.2.2 infiltration wells (IW) Construction

Rainwater that falls in large volumes can be used for storage and use at any time, such as during the long dry season which makes it difficult to get water and so on. One of the uses of rainwater in buildings is to apply infiltration wells. The infiltration well building is an engineering water conservation technique that is made to resemble a dug well with a certain depth that is used to collect rainwater and is ready to use at any time. The benefits of these infiltration wells include reducing flooding, standing water that causes the ground to fall down, reducing erosion and of course the collected rainwater can be channeled as a source of water that can be used for washing or for watering plants (Kuesnaidi, 2000; Pungut, 2009). The form of infiltration wells that is often made is a rectangular or cylindrical well with a certain depth (according to regulations) as shown in Figure 4.

Figure 4: Construction of rainwater storage systems (RSS) and infiltration wells (IW) (Said, 2008; KELAIR, 2021)

Benefits of infiltration wells:

1) Reducing runoff water, so that the drainage network will be minimized.
2) Prevent standing water and flooding.
3) Maintaining groundwater level which is decreasing day by day, due to deficit in water use.
4) Reducing / restraining sea water intrusion in areas adjacent to coastal areas.
5) Prevent land subsidence, due to excessive groundwater extraction.
6) Reducing groundwater pollution.
7) Provide water reserves for farming for the surrounding land.

The components of the infiltration well consist of:

1) Irrigation canals as a source of water that will be inserted into the well.
2) Control tub which functions to filter water before it enters the infiltration well.
3) Intake pipe
4) Infiltration wells
5) A drain pipe that functions as a drain when the water in the infiltration well is full.

Infiltration Well Technical Scheme and Infiltration Well Construction Conditions:

1) It is better if the location is above or in the upstream direction of the dug wells which will be maintained / increased the ground water level.
2) To maintain water pollution in the aquifer, the depth of the infiltration well above the groundwater level is not depressed (unconfined aquifer).
3) In limestone / karst hilly areas with shallow soil depths, the groundwater depth is generally very deep, so making infiltration wells is not recommended. Likewise, in tidal agricultural land, the water is very shallow.
4) To get an adequate amount of water, infiltration wells must have rainwater catchment in the form of a landscape either agricultural land or house roofs.
5) Application of the Biopore System.

The biopore system is the making of a hole in a plot of land with a certain depth which aims to increase water absorption in the soil (Figure 5). In addition, this biopore hole can be used to produce compost with organic waste material that can be used to fertilize plants. Another benefit of this biopore system is one of the ways to prevent flooding, preserve underground water resources, free from standing water and of course avoid mosquitoes that carry dengue fever (Brata and Nelistya, 2009; Dinolefty. 2010).

Benefits of Biopores for the Environment and Everyday Life

1) Overcoming Floods
2) Organic Waste Disposal Place
3) Plant Fertilizer
4) Increase Water Absorption Power in the Home Environment
5) Soil Healer Due to Soil Biota Activities
6) Enhancing Green Areas.

3.3 Rain Water Treatment Technology

3.3.1 Simple Rainwater Treatment Technology

One of the simple rainwater processing equipment is a drinking water processing tool which is a package consisting of a barrel (tank), stirrer, aeration pump and filter made of sand or abbreviated as TP2AS Model. This tool is designed for household purposes in such a way that the manufacturing method and how to operate it are easy and the cost is low. This TP2AS model of drinking water processing equipment is very suitable for processing rainwater, both collected from the roof and rainwater captured by reservoirs, as well as other raw water containing iron and manganese and organic substances, at a very low cost.

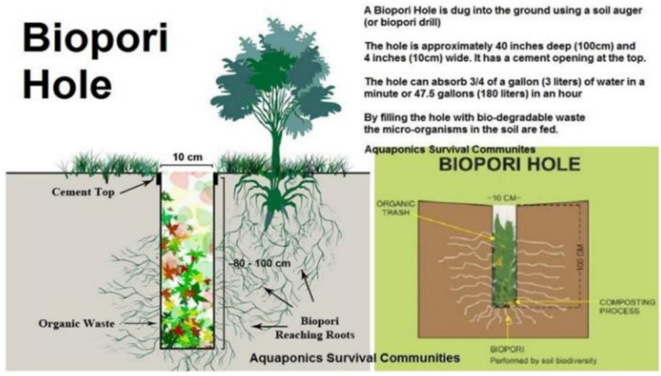

Figure 5: Biopori System (Rianawati and Sagala, 2014).

3.3.1.1 Process Stages

The processing stage consists of several stages (Figure 6) namely:

1) Neutralization by applying lime / limestone.
2) Aeration by pumping air.
3) Coagulation - Flocculation with alum.
4) Precipitation.
5) Filtering.

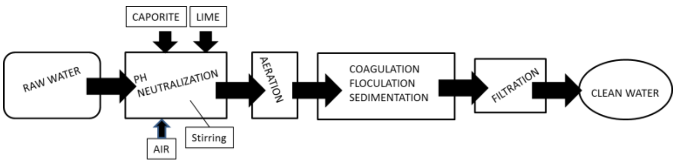

Figure 6: Schematic of the process stages (Said, 2006 and 2008; KELAIR, 2021)

1) Neutralization

What is meant by neutralization is to adjust the acidity of water to become neutral (pH 7 - 8). For acidic water such as peat water, the cheapest and easiest way is to apply lime / limestone. The function of giving lime, in addition to neutralizing acidic raw water, is also to help the effectiveness of the next process.

2) Aeration

What is meant by aeration is contacting the air with raw water so that the iron and manganese content in the raw water reacts with the oxygen in the air to form iron compounds and manganese compounds that can be deposited. Besides that, the aeration process also functions to remove unwanted gases such as H2S, Methane, Carbon Dioxide (CO_2) and other poison gases. The reaction of the oxidation of Iron and Manganese by air can be written as follows:

$$4\ Fe^{2+} + O_2 + 10\ H_2O \rightarrow 4\ Fe(OH)_3 + 8\ H+$$

Insoluble

$$Mn^{2+} + O + H\ O \rightarrow MnO + 2\ H^+$$

insoluble

From the equation for the reaction between iron and oxygen, it can theoretically be calculated that 1 ppm of oxygen can oxidize 6.98 ppm of iron ions. This oxidation reaction can be influenced, among others: the amount of oxygen that reacts, in this case it is influenced by the amount of air that is contacted with water and the area of contact between the air bubbles and the water surface. So the more evenly and the smaller the air bubbles are blown into the raw water, the bigger the oxygen that reacts. Another factor that greatly affects the reaction of iron oxidation with oxygen from the air is the pH of the water. This oxidation reaction is very effective at a water pH greater than 7 (seven). Therefore, before aeration is carried out, the pH of the raw water must be increased until it reaches pH 8. This is so that the pH of the water does not deviate from the standard pH for drinking water, namely pH 6.5 - pH 8.5. Manganese oxidation with oxygen from the air is not as effective as for iron, but if the Manganese content is not too high then some of the manganese can also be oxidized and precipitated.

3) Coagulation

This process is used when rainwater contains a lot of suspended or cloudy solids. If rainwater is collected from the roof this process is usually unnecessary because the rainwater is clear enough. If rainwater is collected in the reservoir, it usually still has quite high turbidity. Coagulation is the process of placing chemicals into water so that impurities in the water in the form of suspended solids such as organic dyes, bacterial fine sludge and others can clot and settle quickly. The easiest and cheapest way is to add alum / alum or the chemical formula $Al_2\ (SO4)_3.18\ H_2O$. (in the form of white crystals).

Coagulation reactions with alum can simply be written as follows:

$Al_2(SO_4)_3.18H_2O + 3\ Ca(HCO_3)_2 ==> 2\ Al(OH)_3 + 3\ Ca(SO_4) + 6\ CO_2 + 18\ H_2O$
Alkalinity

$Al_2(SO_4)_3.18\ H_2O + 3\ Ca(OH) ==> 2\ Al(OH)_3 + 3\ Ca(SO_4) + 3\ CO_2 + 18\ H_2O$
settles

Dirt deposition can occur due to the formation of aluminum hydroxide, $Al\ (OH)_3$ which is a solid particle which will attract dirt particles so that they clump together, become large and heavy and can immediately settle. The method of adding alum can be done as follows: a number of alum / alum is dissolved in water then put into raw water and then stirred quickly until evenly distributed for about 2 minutes. After that the stirring speed is reduced in such a way that dirt clumps are formed due to the joining of suspended impurities in the raw water. After that, it is allowed for a while so that the lumps of dirt or so-called flocks grow big and heavy and settle quickly.

4) Precipitation

After the coagulation process, the water is allowed to stand until the lumps of dirt have settled (± 45 - 60 minutes). After the dirt settles, the water will appear clearer. Sediment that has collected at the bottom of the tank can be cleaned by opening the drain valve located at the bottom of the tank.

5) Filtering

In the deposition process, not all lumps of dirt can be all deposited. The large and heavy lumps of dirt will settle, while the small and light ones will still float in the water. To get water that is truly clear, a filtering process must be carried out. Filtering is done by flowing water that has been deposited with dirt into a filter tub consisting of a sand filter.

3.3.1.2. Equipment

The equipment used consists of barrels, stirrer, aeration pump and sand filter. A simple rainwater treatment diagram can be seen in Figure 7.

1) Tong / Storage Tank

Consists of a plastic drum with a volume of 200 liters. The drum is equipped with two taps, namely to drain water into the filter tub and to drain the drain. At the bottom of the drum, the inside is plastered with cement so that it is shaped like a cone for easy draining. In addition, you can also use a 550 liter volume fiber or PE tank equipped with a mud discharge valve. Tongs or storage tanks can also be made from other materials, for example from used oil vats with a volume of 200 liters or from pottery. The function of the drum is to hold raw water, for aeration or blowing with air, for coagulation and flocculation processes and for deposition.

2) Aeration Pump

The aeration pump consists of a pressure pump (bicycle pump) with a cross section of 5 cm and a tube height of 50 cm. The function of the pump is to blow air into the raw water so that iron or manganese dissolved in the raw water reacts with oxygen in the air to form iron oxide or manganese oxide which can be precipitated. The pump is connected to an aerator pipe to spread the air blown by the pump into the raw water. The aerator pipe is made of plastic hose with a cross section of 0.8 cm, which is shaped like a spiral and the surface is made of holes, the distance of each hole is + 2 cm. Besides that, the aeration process also functions to remove unwanted gases such as H2S, Methane, Carbon Dioxide (CO_2) and other poison gases.

3) Filter Tub

The filter tub consists of a box-shaped plastic tub with a height of 40 cm and a cross-sectional area of 25 X 25 cm and is equipped with a tap on the bottom. Sand is used for filter media. gravel, charcoal and palm fiber. The arrangement of the filter media filter media from the most basic to the top is as follows:

- 1st layer: gravel or coral 1-3 cm in diameter, 5 cm thick.
- Layer 2: fibers with a thickness of 5 cm.
- 3rd layer: wood charcoal, thickness 5-10 cm.
- 4th layer: small pebbles + 5 mm diameter, + 5 cm thickness.
- Layer 5: silica sand, diameter + 0.5 mm, thickness 10-15 cm.
- Layer 6: gravel, 3 cm in diameter, 3-6 cm thick.

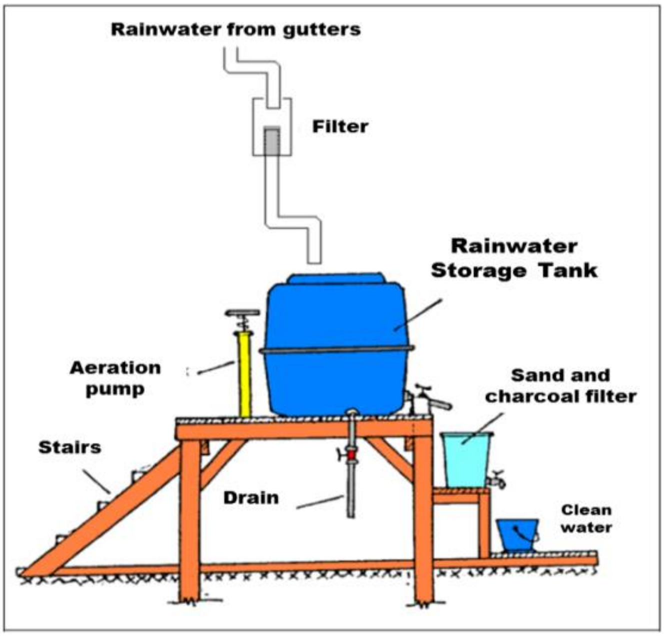

Figure 7: Simple Rainwater Treatment (Said, 2006 and 2008; Said and Widayat, 2010; KELAIR, 2021)

3.2 Processing of Rainwater Into Ready-to-Drink Water

3.2.1 Processing Process

One example of a rainwater processing installation into ready-to-drink water has been built at the Mandalawangi Islamic Boarding School, Pandeglang. The raw water used to treat water comes from rainwater from the roof which is collected in rainwater collection tanks (RCT). The diagram of the rainwater processing process into ready-to-drink water can be seen in Figure 8 Said, 2006 and 2008; Said and Widayat, 2010; KELAIR, 2021).

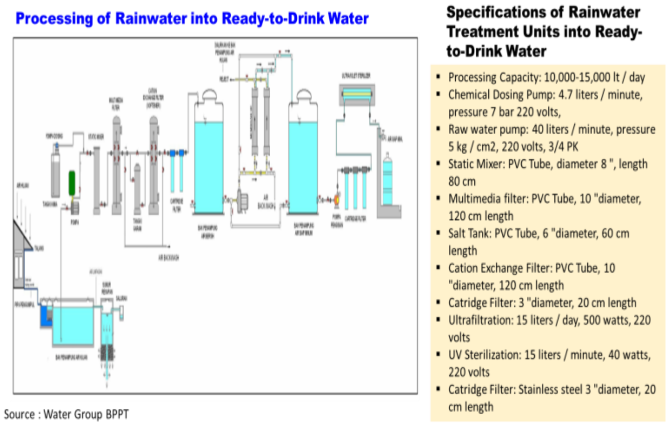

Figure 8: Process Diagram of Rainwater Processing Into Ready-to-Drink Water (Said, 2006 and 2008; Said and Widayat, 2010; KELAIR, 2021)

To process rainwater into water that is ready to drink, the processing process is as follows: Water from the rainwater collection basin is flowed by a pump while being injected with a chlorine solution through a static mixer (mixer) to a multimedia filter.

The multimedia filter functions to filter out iron or manganese oxides which are formed after the chemical application of chlorine is completely mixed in the static mixer. This multimedia filter contains sand, manganese zeolite and activated carbon. After filtering with a sand filter, there is still a possibility that the iron and manganese content has not been oxidized and deposited.

This content is then removed with manganese zeolite. Activated carbon functions to remove micro-pollutants such as organic substances, detergents, odors, phenol compounds, heavy metals and others. After going through the multimedia filter, the water is flowed into the cation exchange filter (cation exchange resin). From the ion exchange filter then it is flowed through the ultra filtration membrane then it is accommodated in a stainless steel storage tank. For packaging into gallon bottles, water from the reservoir is flowed into gallon bottles by a pump, which first goes through an ultra violet disinfection system and a cartridge filter (Said, 2006 and 2008; Said and Widayat, 2010; KELAIR, 2021).

3.2.2. Specifications of Rainwater Treatment Unit into Ready-to-Drink Water

Following is the specification of processing rain water into ready to drink water:

- Processing capacity: 10,000 - 15,000 liters per day
- Chemical Dosing Pump: 4.7 l / m, pressure 7 bar, 220 volts
- Raw water pump: 40 liters / minute, pressure 5kg / cm2,
- 220 volts, ¾ PK
- Static Mixer: PVC tube, ⍰ 8 ", 80 cm long
- Multimedia Filter: PVC tube, ⍰ 10, length 120 cm
- Salt Tank: PVC tube, ⍰ 6 ", 60 cm
- Cation Exhange Filter: PVC tube, ⍰ 10 ", 120 cm
- Catridge Filter: ⍰ 3 ", 20" long
- Ultrafiltration: 15 m3 / day, 500 watts, 220 volts
- Ultraviolet Sterilization: 15 liters / minute, 40 watts, 220 volts
- Catridge Filter: Stainless steel, ⍰ 3 ", 10" long

4. Conclusions

High rainfall, especially in urban areas, can be controlled to prevent flooding by developing various methods of utilizing rainwater and absorption wells, including the development of biopores. Apart from being used to support various agricultural activities, rainwater has also been widely used to meet the daily needs of households and even industries. Utilization of rain water for daily needs, in addition to gardening, also to meet drinking water needs. For the utilization of rainwater, various methods have been used and developed, ranging from the simplest to the high technology. For flood control in urban areas, rainwater utilization systems and infiltration wells have been developed in various shapes and sizes, including biopores. Meanwhile, for drinking water treatment, filtration systems are widely used using various membrane sizes and rainwater treatment systems to clean pollutants, neutralize and sterilize rainwater so that it can be drunk for the production of ready-to-drink water.

Author Statement

Suhendar I Sachoemar: contributed the Conceptualization, Methodology, Formal analysis, Investigation, Writing - review & editing, Collecting Data and Information, Formal analysis, Investigation and Writing the Manuscript of this paper. Ratu Siti Aliah, Haryanti and Joko Prayitno Susanto: also contributed to the, Collecting Data and Information and Writing Manuscript of this paper.

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