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TAMPAYANG Innovation as a Seawater Purification Tool in Pulau Ay Village, Banda District, Central Maluku Regency

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Abstract: Pulau Ay is an island located west of the Banda Islands, Central Maluku Regency, Maluku Province. Nearly 85% of the soil structure on Ay Island is filled with coral reefs, so it is very difficult to get clean water and the people of Ay Island only rely on rainwater to get clean water. The purpose of this research is to innovate to purify seawater into drinking water in the village of Pulau Ay and test the quality of the water produced. This research was conducted by designing a seawater purification device called *Tampayang* (Ay Island's drinking water station) consisting of a water storage barrel, a simple filter, a seawater distillation apparatus and a reverse osmosis (RO) membrane machine. The water produced from the purification of seawater is then analyzed in a laboratory according to Indonesian national standard and the regulation of the Minister of Health of 2010 concerning drinking water quality requirements. The results showed that the *Tampayang* tool produces 2 types of water, namely clean water and drinking water. After being tested both types of water meet the water quality requirements for consumption based on physical, chemical and biological parameters. The clean water and drinking water produced can be useful and consumed by the people of Ay Island as a solution to seawater utilization.

Keywords: Sea Water Purification; Desalination; *Tampayang*

Introduction

Indonesia is an archipelagic country where most of its area is ocean. As an archipelagic country, Indonesia has many inhabited islands that still lack clean water, especially during the dry season. One of them is the village of Pulau Ay which is located in the Banda Islands. The Banda Islands are a group of islands in the Maluku Province, which is included in the Banda sub-district, Central Maluku district, with a land administrative area of 55.3 km². Banda District consists of 11 islands surrounded by the sea. Among them are Lontor Island, Banda Island, Banda Api Island, Ay Island, Rhun Island, Pisang Island (Syahrir), Hatta Island and Karaba Island. In addition, there are still a number of coral islands that are not inhabited, such as Suanggi, Naljalaka, and Batukapal. Nearly 85% of the soil structure on the small islands of the Banda sub-district is filled with rocks, making it very difficult to obtain clean water. One of them is Ay Island, which is located west of the Banda Islands (Dinas Kelautan & Perikanan, 2020). The soil structure on Ay Island is composed of coral reefs so that it is very difficult for the people of Ay Island to obtain clean water.

Clean water is needed by humans to ensure their survival. This is because humans not only need water for their body's needs, but for various other needs such as washing, cooking, and others (Harling, 2020). Clean water is a rare and exclusive item in the village of Pulau Ay. So far, to obtain clean water, the people of Ay Island have had to collect rainwater as a supply of clean water. In the dry season, the shortage of clean water requires that the people of Pulau Ay village supply clean water from Banda Neira by using a longboat for 2 hours

The water found in the Banda Islands is in the form of sea water as much as 90%, while the rest is in the form of ground/land water and rain. Seawater is water that has an average salt content of 35‰, meaning that in 1 liter (1000 ml) of seawater there are 35 grams of seawater salt (Dinas Kelautan & Perikanan, 2020). Most of the

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water sources obtained are sea water so to get clean water it is necessary to process or process sea water into fresh water and clean water. Clean water in question is water that is free of impurities, harmful bacteria, and other substances that are detrimental to human health (Ely, 2019).

One of the solutions to get clean water is by desalinating seawater. Desalination is a process of purifying or reducing dissolved salts in seawater which is greater than 1,000 ppm to 40,000 ppm into fresh water with dissolved salt concentrations below 1,000 ppm. The desalination process can be carried out using a distillation system. Distillation is the process of purifying water through distillation. In general, there are various ways that are often used to get clean water, namely: boiling, filtering, desalination and others. The boiling method is done only to kill harmful germs and bacteria, but the dirt in the form of small solids cannot be separated from the water. Filtering is used only to filter out impurities in the form of small solids, but harmful germs and bacteria cannot be separated from the water. The desalination method is an effective method used to produce clean water that is free from germs, bacteria and dirt in the form of small solids (Ely, 2019). In the desalination process with a distillation system there are processes of heat transfer, evaporation and condensation. When seawater is boiled, the salt will dissolve and the water will evaporate. Evaporating water will produce steam which can change phase when the temperature decreases. The phase change that occurs is condensation which can turn steam into water again (Dewantara et al., 2018).

In addition to desalination, clean water can be obtained by using water treatment technology which has a fairly high performance, namely by using membrane technology. Some of the advantages of separation using membranes are that it does not require the addition of chemicals and does not require large amounts of energy. One of the most widely used membrane technologies today is Reverse Osmosis (RO). A reverse osmosis membrane is defined as a semipermeable membrane capable of separating fresh water from a salt solution at a pressure higher than the osmotic pressure of a salt solution. Separation of dissolved components measuring 0.001 to 0.01 μm and particles of low molecular weight can be carried out by a Reverse Osmosis membrane. If a semipermeable membrane separates fresh water and salt water, the fresh water and salt water will diffuse through the membrane and dilute the salt solution. This event is called an Osmosis Event. If the brine pressure is higher than the osmotic pressure, the water contained in the brine is pushed towards the brine through a semi-permeable membrane, this event is called Reverse Osmosis.

The advantages of this reverse osmosis technology compared to other technologies include the relatively low energy required, minimal problems with equipment corrosion, ease of replacement and installation, and easy integration with existing systems (Sefentry & Masriatini, 2020). The essence of drinking water treatment is the reduction or disappearance of all pollutant substances including physical, chemical, microbiological and radioactive pollutants in the water so that the water is safe and fit for consumption (Emilia & Mutiara, 2019).

The Government of the Republic of Indonesia has determined that the quality requirements for drinking water used daily must be in accordance with the Decree of the Minister of Health of the Republic of Indonesia No. 492/MENKES/PER/VI/2010, in the decision states that the components contained in drinking water must comply with predetermined conditions. The conditions that must be met and examined for water quality in terms of physical parameters are water that does not have an odor, has a taste that is fresh, colorless, and also does not directly impact health, such as the degree of acidity, pH, temperature, turbidity, and the number of solids. dissolved. The standard temperature of clean water is at air temperature, which is ≤ 3° (25°C), for color ≤ 15 TCU, for turbidity ≤ 5 NTU, for total dissolved solids is ≤ 500 mg/l (Permenkes RI, 2010).

In addition to physical parameters, water quality requirements must also include chemical parameters and biological parameters. The chemical requirement in this case is the absence of chemical elements or substances that are harmful to humans. The presence of hazardous chemicals must be kept to a minimum. Meanwhile, certain substances that help create water conditions that are safe from microorganisms must be maintained at certain levels. The parameters in this requirement are divided into two, namely chemicals that have a direct effect on health and cause complaints to consumers. The chemicals included in this parameter are inorganic, organic, and pH. pH stands for pouvoir hydrogene and indicates the concentration of hydrogen ions in water. pH is used to determine the level of alkalinity and acidity of water. pH affects the toxicity of a chemical compound. Many ionizable ammonium compounds are found in waters that have low pH (Emilia & Mutiara, 2019).

Chemically, the clean water quality standard is divided into two parts, namely: drinking water should not contain toxic substances and no substances that may cause health problems. With reference to the requirements above, the presence of chemical substances is still permitted in drinking water as long as the amount does not exceed the limits set by the Drinking Water Quality Standards (Harling, 2020).

Biological parameters include the presence or absence of organic matter or microorganisms such as coli bacteria, viruses, benthos and plankton. Pathogenic bacteria that affect water quality according to the Decree of the Minister of Health are coliform bacteria, such as *Escherichia coli*, *Clostridium perfringens*, and *Salmonella*. *Coliform* bacteria are a group of intestinal bacteria, which live in the human digestive tract. More precisely, fecal *coliform* bacteria are indicator bacteria for contamination by pathogenic bacteria. Determination of faecal *coliform* is an indicator of pollution because the number of colonies definitely correlates positively with the presence of pathogenic bacteria *E. coli* if it enters the digestive tract in large quantities can be harmful to health (Rosita, 2014) According to the Minister of Health Regulation of 2010, the levels of *E. coli* and total *coliform* are 0 MPN/100 ml sample (Permenkes RI, 2010).

The purpose of this study was to produce a seawater purification device for drinking water in the village of Pulau Ay (*Tampayang*) and to test the quality of the water produced according to the drinking water quality requirements set by the Minister of Health.

Method

This research uses experimental research by designing a *Tampayang* tool (Ay Island Drinking Water Place) as a seawater purification tool along with testing the quality of clean water that can be used for daily needs and drinking water that is fit for consumption. This research will be carried out in Pulau Ay Village and water testing will be carried out at the Maluku Province Health Laboratory Center. This research consists of 2 stages namely:

Tampayang trial as a seawater purification tool

The *Tampayang* equipment series consists of solar panels as a source of electricity, water barrels as water reservoirs, *Tampayang* as seawater purification equipment, and RO filter machines. The initial stage of the trial was carried out by designing the *Tampayang* tool and carrying out physical tests in the form of color, smell, taste, TDS (Total Disolve Solid), Temperature, pH and Salinity in seawater. The process of purifying seawater in the Tampayang tool is carried out by desalination using a distillation system. Desalination is a process of purifying or reducing dissolved salts in seawater greater than 1,000 ppm to 40,000 ppm into fresh water with dissolved salt concentrations below 1,000 ppm (Ely, 2019) using a distillation system.

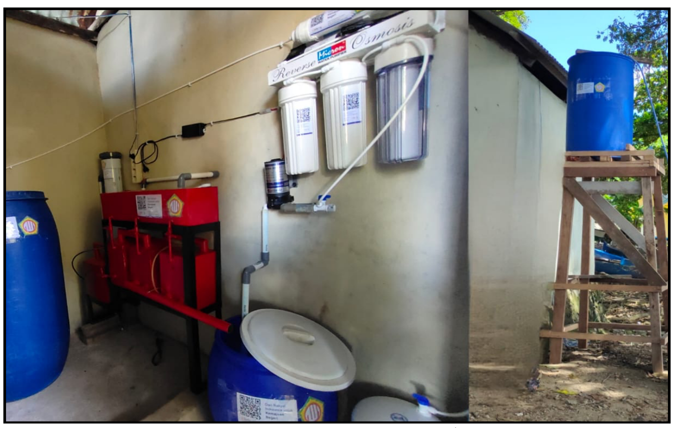
Water quality analysis

The water obtained from the results of seawater purification using the Tampayang apparatus was then tested with physical parameters in the form of smell, color, taste, TDS (total dissolve solid), turbidity, temperature and salt content; chemical parameters in the form of inorganic chemical parameters (fluoride, total metal Cr, metal Cd, nitrite, nitrate, Fe, hardness, chloride, manganese, pH, Zn, sulfate and Pb) and organic parameters (in the form of organic substances contained in water); as well as biological parameters in the form of total *coliform* and *E. Coli* in accordance with SNI 01-3554-2006 (BSN, 2006) concerning methods for testing bottled drinking water and the Minister of Health Regulation of 2010 concerning drinking water quality requirements (Permenkes RI, 2010).

Result and Discussion

Tampayang (Ay Island Drinking Water Place) as a Seawater Purification Tool

Tampayang is a series of seawater purification equipment implemented in the village of Pulau Ay. The source of the heat energy used in the *Tampayang* tool comes from utilizing solar energy through solar panels with the help of an inverter so that electricity can be used in the seawater purification process. Harnessing solar energy is one of the main goals in recent years to achieve many innovative applications in seawater purification so as to meet future fresh water needs (Arunkumar et al., 2021). Seawater that has been collected is flowed into the filter tube and forwarded to the *Tampayang* or distillation equipment. The working principle of the *Tampayang* tool is desalination using a distillation system. Desalination with a distillation system is a process of purifying or reducing dissolved salts in seawater and brackish water through a distillation process (Aende et al., 2020). In the distillation process there are processes of heat transfer, evaporation and condensation (Ely, 2019). Ay Island became the target of the *Tampayang* tool trial due to its soil structure which is difficult to obtain clean water in accordance with the statement Saavedra et al. (2021) which states that the desalination process is intended to increase water availability in areas that are structurally short of water and experience repeated periods of drought. The *Tampayang* series of tools can be seen in Figure 1.



Gambar 1. *Tampayang* Tool Set

The distillation tool or *Tampayang* consists of 3 tubes that function as heaters and 1 tube that functions as a condenser. Sea water heated in the first tube will evaporate and go to the condenser tube then the steam will turn into a water point and flow into the water reservoir. The process of purifying seawater using a *Tampayang* apparatus produces 2 types of water, namely clean water obtained directly from distillation and drinking water obtained from clean water filtered using Reverse Osmosis (RO) membrane technology. Seawater desalination technology with RO has developed rapidly in recent years. Due to the advantages of high efficiency, simple equipment and convenient maintenance, it has been widely used in industrial seawater treatment and other industries (Huang et al., 2020; Lim et al., 2021). Thus, the incorporation of renewable energy such as solar into the desalination process and integrated RO processes has received attention as an alternative to desalination to reduce energy costs by 50–75% of operational costs (Saavedra et al., 2021).

The amount of water produced from the distillation process is ± 2 to 3 liters from 3 heating tubes with a capacity of 2 liters for each tube. While the amount of water produced from the RO membrane process is ± 1.5 liters. The water obtained is then taken to the laboratory for further analysis.

Analisis Kualitas Air

Water is a basic need for living things. By humans, water is used for life purposes such as drinking, bathing, cooking, washing and other needs (Faisal & Atmaja, 2019; Permana, 2019). Chemically, the standard for the quality of clean water is that there should not be toxic substances in drinking water and no substances that may cause health problems. With reference to the requirements above, the presence of chemical substances is still permitted in drinking water as long as the amount does not exceed the limits set by the Drinking Water Quality Standards (Harling, 2020).

According to Minister of Health Regulation No. 492 of 2010, Drinking water is water that has gone through a processing process or without a processing process that meets health requirements and can be drunk directly. The water produced from the seawater purification process using the *Tampayang* apparatus was analyzed at the Maluku Province Health Laboratory in the form of three parameters, namely: physical parameters, chemical parameters and biological parameters.

Parameter Fisika

Standar suhu dari air bersih adalah ≤ 3°C, untuk warna ≤ 15 TCU, untuk kekeruhan ≤ 5 NTU, untuk total zat padat terlarut adalah ≤500 mg/l Hasil analisis laboratorium pada parameter fisika air bersih dan air minum dapat dilihat pada Tabel 1 dan Tabel 2.

Mandatory requirements that must be met for water quality in terms of physical parameters are water that has no odor, has a fresh taste, is colorless, and also does not directly impact health such as the degree of acidity, pH, temperature, turbidity, and the amount of dissolved solids. The standard temperature of clean water is ≤ 3 °C, for color ≤ 15 TCU, for turbidity ≤ 5 NTU, for total dissolved solids is ≤ 500 mg/l. Laboratory analysis results on the physical parameters of clean water and drinking water can be seen in Table 1 and Table 2.

Table 1. Results of Analysis of Clean Water Physics Parameters

Physics Parameters	Unit	Clean Water	
		Result	Max Limit
Odor	-	Odorless	Odorless
TDS	mg/l	37.5	1000
Turbidity	NTU	0.0	25
Taste	-	Tasteless	Tasteless
Temperature	°C	27.4	Air temperature ± 3
Color	TCU	1	50
salinity	%	0	0

Table 2. Results of Analysis of Drinking Water Physics Parameters

Physics Parameters	Unit	Drinking Water	
		Result	Max Limit
Odor	-	Odorless	Odorless
TDS	mg/l	18.92	500
Turbidity	NTU	0.44	5
Taste	-	Tasteless	Tasteless
Temperature	°C	27.5	Air temperature ± 3
Color	TCU	1	15
salinity	%	0	0

Based on the results of laboratory analysis in Table 1 and Table 2, it can be stated that the distilled water is clean water and the RO membrane filtered water is drinking water suitable for consumption because it is still at the standard that is tolerated according to the Minister of Health. According to (Permenkes RI, 2010), drinking water is safe for health if it meets the physical, microbiological, chemical and radioactive requirements contained in the mandatory parameters and additional parameters. This indicates that the water is clean and not contaminated by substances that may endanger health.

One of the determining factors for good water quality is temperature, and in this study the temperature of clean water and drinking water was still within normal limits. In accordance with (Koniyo, 2020) temperature is a very important physical factor in water, because together with the substances/elements contained therein it will determine the density of water, and together with pressure it can be used to determine the density of water. Furthermore, the density of water can be used to determine the saturation of water.

In testing the physical parameters, it was added by measuring the salt content in the distilled water and filtering it with an RO membrane. The salt content obtained from the two types of water is 0 so that it can be proven that the desalination process with the distillation system in seawater purification was successful.

Parameter Kimia

Chemical parameters are mandatory parameters that must be possessed by water as a condition for water quality that is suitable for use and consumption. Based on the Minister of Health Regulation of 2010 concerning the quality of drinking water, chemical parameters are divided into two, namely inorganic chemical parameters in the form of metal content in water, hardness, nitrite, nitrate pH and organic parameters in the form of water-dissolved organic matter levels.

The tolerance limit for chemical parameters in the analysis of clean water is different from that in the analysis of drinking water, so the results obtained are also different. The results of chemical parameter analysis for clean water and drinking water can be seen in Table 3 and Table 4.

The maximum limit value of chemical parameter indicators in drinking water analysis is smaller than the maximum limit value in clean water analysis. This is because the amount of substance accumulated in the body must be less so it does not cause health problems, one example is cadmium metal. Cadmium is a heavy metal that can be fatal if it accumulates in the body a lot. The maximum cadmium allowed in drinking water is 0.003 mg/ml while in clean water it is 0.005. The results of the analysis show that cadmium metal is not found in clean water or drinking water so that both of these waters are suitable for consumption.

Table 3. Results of Analysis of Clean Water Chemical Parameters

Chemical Parameters	Unit	Clean water	
		Result	Max limit
Fluoride	mg/l	0.0	1.5
Total Chromium	mg/l	0.0	0.05
Cadmium	mg/l	0.0	0.005
Nitrite (as NO_2)	mg/l	0.01	1
Nitrates (as NO_3)	mg/l	0.01	10
Iron	mg/l	0.0	1
Hardness	mg/l	7.2	500
Chloride	mg/l	15.2	250
Manganese	mg/l	0.0	0.5
pH	mg/l	7.23	6.5-8.5
Zinc	mg/l	0.0	15
Sulfate	mg/l	5.38	400
Plumbum	mg/l	0.0	0.0
Organic Substances	mg/l	1.4	10

Table 4. Results of Analysis of Drinking Water Chemical Parameters

Chemical Parameters	Unit	Drinking Water	
		Result	Max limit
Fluoride	mg/l	0.0	1.5
Total Chromium	mg/l	0.0	0.05
Cadmium	mg/l	0.0	0.003
Nitrite (as NO_2)	mg/l	0.01	3
Nitrates (as NO_3)	mg/l	0.01	50
Iron	mg/l	0.0	0.3
Hardness	mg/l	7.2	500
Chloride	mg/l	15.2	250
Manganese	mg/l	0.0	0.4
pH	mg/l	7.23	6.5-8.5
Zinc	mg/l	0.0	3
Sulfate	mg/l	5.38	250
Copper	mg/l	0.0	2
Ammonia	mg/l	0.0	1.5
Organic Substances	mg/l	0.6	10

Iron (Fe) is considered an indispensable element for human nutrition. It is essential for hemoglobin to transport oxygen from the lungs to the cells. However, Fe in high levels is considered a dangerous poison (Dopp et al., 2019). In this study, no Fe content was found in clean water or drinking water. This is in accordance with recommendations from WHO which does not set a range of Fe content in water for drinking purposes (Kormoker et al., 2022).

Based on the results of water analysis at the Health Laboratory in Maluku province, distilled water (clean water) and RO filtered water (drinking water) are below the maximum limit set by the Regulation of the Minister of Health of 2010 for both inorganic and organic chemical parameters so that it can be said that purified water by using Tampa tools that are suitable for consumption. Yuniarti and Biyatmoko (2019) explains that many organic substances containing phosphate levels are carried by currents into the waters causing high phosphate levels in the waters, it is suspected that land has a major influence on phosphate concentrations. In addition, the number of chemicals dissolved in water will indicate that the water temperature will exceed the normal limits of ordinary water. The decomposition of organic matter in the water will cause the water temperature to be higher than usual (Permana et al., 2020).

In addition to inorganic and organic chemical parameters, pH also affects water quality. The water to be consumed should be neither acidic nor alkaline (neutral) to prevent heavy metal dissolution and corrosion of the water distribution network (Rohmawati & Kustomo, 2020). The recommended pH for clean water and drinking water is a maximum of 6.5–8.5 according to WHO (Kormoker et al., 2022; Permenkes RI, 2010). The effect of pH on water is very large, if the pH of the water is too low then the water will taste bitter/sour, for human consumption and is corrosive.

Acidic water can release metals from pipes such as copper (Cu), lead (Pb), and zinc (Zn) so that water will contain these three metals. A high pH value indicates that the water is alkaline for human consumption. Alkaline drinking water does not directly cause health problems but causes aesthetic problems such as an alkaline taste, makes coffee taste bitter, and reduces the efficiency of the water heater (Marhamah et al., 2020).

Biological Parameters

Biological parameters include the presence or absence of microorganisms such as coli bacteria, viruses, benthos and plankton. Kormoker et al. (2022); Hamakonda et al., 2019) reported three groups of coliform bacteria (total coliform (TC), fecal coliform (FC), and Escherichia coli) that can be found in water. Each species can act as an indicator of drinking water quality and each has a different level of risk. Pathogenic bacteria that affect water quality according to the Decree of the Minister of Health are coliform bacteria, such as *Escherichia coli*. The results of the analysis of biological parameters for clean water and drinking water can be seen in Table 5.

Table 5. Results of Biological Parameter Analysis

Biological Parameter	Result (MPN/100 ml)		Maximum limit
	Clean water	Drinking water	
Coliform	0.0	0.0	0 MPN/100 ml
E. coli	0.0	0.0	

Tests for biological parameters included tests for coliform bacteria and *E. coli* bacteria which had been carried out on 2 samples showing negative results or 0 counts per 100 mL sample. Based on the results of water testing on biological parameters, the two types of water purified by the *Tampayang* tool are suitable for consumption in accordance with the Regulation of the Minister of Health of 2010 concerning drinking water quality requirements.

Coliform bacteria are indicator organisms because they indicate the possibility of bacteria that have the potential to cause disease through water. Appearance of *coliform* bacteria in water does not indicate that the water consumed is causing infection; however, their presence means contamination of water by sources containing disease-causing bacteria, which can lead to serious health implications (Kormoker et al., 2022). *Coliform* bacteria are a group of intestinal bacteria, which live in the human digestive tract. Determination of fecal *coliform* is an indicator of pollution because the number of colonies definitely correlates positively with the presence of pathogenic bacteria *E. coli* if it enters the digestive tract in large quantities can endanger health (Rosita, 2014).

Conclusion

Based on the results of research that has been done, the Tampayang apparatus is a series of seawater purification equipment that uses the principle of desalination with a distillation system. The results of water purification are clean water that comes from distillation and drinking water that comes from distilled water that has gone through an RO membrane filter. Both types of water were analyzed at the Maluku provincial health laboratory and declared fit for consumption in accordance with drinking water quality requirements by the Regulation of the Minister of Health in 2010 in the form of physical, chemical and microbiological requirements.

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