The technology of rob water treatment becomes clean water by using the combination of electrolysis, filtration, and ozonation methods

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Abstract. Coastal residents have difficulty in fulfilling the needs of clean water due to tidal water and tidal water intrusion. Meanwhile, clean water is a crucial component in carrying out activities of daily life. This initiative aims to provide an alternative solution in the form of technology to treat water polluted by saline water into clean water. This initiative used the method of electrolysis, filtration, and ozonation. Electrolysis has functions to remove salt contained and reduce levels of heavy metals while filtration functions to filter out the impurities in the form of solid particles, and ozonation takes a role to kill bacteria. Moreover, the target output of this work is the creation of a prototype by using this technology as a technology that can treat water polluted by saline water into clean water. The parameters assessed from this initiative are physical, chemical, and biological parameters of clean water. The results of the total test of dissolved solids of water before processing were 7130 ppm while it was 2490 ppm after getting treatment. The decreasing total value of dissolved solids is 65.077%, which indicates that the test was successful. The result of an electrical conductivity test of water before processing is 310 mA while after processing is 88.6 mA. The decrease in the current value of 71.419% indicates that the test was successful. The results of the turbidity test of water before processing are 0 FAU while after getting treatment is 0 FAU. The turbidity value remains 0, which indicates the test was successful. The results of the pH test of water before processing were 5.7 while the result after treatment got 6.1. The increase in pH value towards pH 7 (neutral) indicates that the test was successful. The test results of salt and heavy metals (Fe, Cu, Cl, Na, and Pb) of water before processing were 0.073 ppm, 0.07 ppm, 0.17 ppm, 0.04 ppm, and 4.24 ppm while after processing was 0 ppm, 0 ppm, 0.07 ppm, 0.03 ppm, and 1.36 ppm. There was a decrease in Fe 100%, Cu 100%, Cl 58.823%, Na 25%, and Pb 67.924% which showed that the test was successful. Test results for fecal coliform and nonfecal coliform bacteria before processing were 43 MPN / 100 ml and 7 MPN / 100 ml while after processing was 23 MPN / 100 ml and 4 MPN / 100 ml. There
was a decrease in the value of fecal coliform bacteria 46.511% and nonfecal coliform 42.857% which showed that the test was successful. The use of electrodes needs to be replaced periodically so that the results of clean water production remain optimal.

1. Introduction
Global warming causes the ice in the north and south poles to melt. This also causes the rise of sea level, which can have implications for the occurrence of tidal waves in coastal areas [1]. The impact of climate change is felt in Demak Regency and Kedungkarang village, Center Java Province, Indonesia, especially in the coastal area. It causes the water crisis, floods, abrasion, and rob. Therefore, it is difficult for residents to find clean water while it is a crucial component in carrying out activities of daily life. The sources of clean water in Kedungkarang village are from well water and bought water. As a coastal area, the Kedungkarang villagers’ well water are contaminated by seawater. So, they are salty. This causes the limitation of using well water. Well water can only be used for washing and mopping [2]. Seeing these conditions, a solution is needed to help Kedungkarang villagers in providing clean water. One solution that can be given is to make a tool that can treat salted wells’ well water into clean water.

The most abundant content in the seawater is sodium chloride (NaCl) while other minerals in low concentrations include calcium salts (calcium carbonate, magnesium sulfate, and magnesium bromide). Seawater averagely contains 3.5% of salt. This means that there are 35 grams of salt (not all NaCl) in 1 liter (1000 mL) of seawater [3].

Previous research on processing seawater into freshwater has been done by [4] using the distillation method with heat sources from electric stoves. This research succeeded in producing freshwater from seawater. However, it used electric stoves with high power to transform electrical energy into heat energy so that it is not economical to be applied [4]. Moreover, another research has been done by using the distillation method with vacuum pumps and ultraviolet lights [5]. This research also succeeded in producing freshwater from seawater. Nonetheless, the weakness of this study is that electric of vacuum pumps and ultraviolet lights also use high power so that it is not economical to apply. Therefore, we need a method that does not require high electrical power, such as electrolysis, filtration, and ozonation.

Electrolysis can separate mineral salts such as sodium chloride (NaCl), calcium carbonate, magnesium sulfate and magnesium bromide from water compounds (H₂O) to produce clean water with a small total dissolved solid value or TDS (Total Dissolved Solids) [6]. Filtration is the process of separating solids or colloids from liquids. Filtering is done by making multilevel filters, which are coarse filters, medium filters to fine filters [7]. Ozone is a natural gas molecule that is easily soluble in water and non-toxic. Ozone can destroy germs, bacteria, viruses, fungi, spores, cysts, mosses, and other organic substances. Besides, it can also neutralize excessive or toxic organic and mineral substances [8].

From the problem mentioning above, the proposing team tries to provide a solution in the form of this technology (Water with Electrolysis Filtration Ozonation) by using the combination of the three electrolysis, filtration, and ozonation methods. It is expected that this creative initiative will be able to produce clean water.

2. Materials and methods

2.1. Time and place of implementation this technology
This research was carried out in the Material Physics Laboratory, Diponegoro University. It spent 5 months in implementing this research. This research used fixed parameters, which are raw materials, frameworks, and mechanical systems for electrolysis, filtration, and ozonation. Meanwhile, the parameters assessed of this study are physical, chemical, and biological parameters of clean water. The tools used in this technology are an ozone generator, aluminum plate, multimeter, TDS meter, pH meter while the materials used in this research are plastic boxes, stainless electrodes, adapters, cable rollers, cables, pipes, gravel, sand, glass glue, water contaminated with seawater.
2.2. Description of research in this technology

First, Description of the Electrolysis System. The electrolysis system is made in sizes 15 cm for length, 15 cm for width and 30 cm for height or adjusted with the size of plastic boxes sold on the market. The electrodes used are aluminum and stainless metal with the sizes 20 cm for length, 4 cm for width and 0.5 cm for thick. This electrolysis system used an adapter to convert AC into DC, and reduce the voltage value from 220 volts (from State Electricity Company) to a maximum voltage of 12 volts. Second, Description of Making A Filtration System. The design used is a flow filtration system from the bottom up (against gravity). The size of the coarse sand used is 1 - 0.5 mm. The size of the fine sand used is 0.25 - 0.1 mm. Third, Description of Making an Ozonation System. In an ozonation system, 1 ozone reactor is needed. Ozone reactors are composed of ozone generators, power supplies, and air pumps. An ozone generator will be placed on the appliance.

2.3. Visualization of making prototype of this technology

![Visualization of This Technology Design](image)

**Figure 1.** Visualization of This Technology Design.

3. Results and discussions

3.1. The manufacture of the prototype

This technology prototype measuring 90 cm for length, 30 cm for width and 90 cm for height. The capacity of the purification process is 10 liters of water. The electrolysis system uses stainless electrodes on the positive pole and aluminum on the negative pole. The electrolysis system functions to reduce the levels of salt and heavy metals. In the electrolysis process, the electric current can break down H₂O molecules into H₂ and O₂ gas [9]. Therefore, during the electrolysis process, there are bubbles of H₂ and O₂ in the water.

In filtration, systems use flow down (in the direction of gravity) and up (against gravity), this system is most effective compared to horizontal flow, gravity flow, and dual flow filtration systems [5]. In the filtration system, water will flow down first and then flow upwards. In the flow system of the bottom up, impurities will tend to fall downward while clean water will flow upwards. Giving a directional flow of gravity so that the filtration path through the water is longer. The reason of applying a flow system against gravity is that when the water moves upwards the impurity particles will move down due to the influence of gravity. Impurity particles have mass so they are attracted by the force of gravity with
acceleration due to gravity valued at 10 m/s$^2$. Formulated in the physics equation $w = m \cdot g$, where $w$ is the gravity (N), $m$ is the mass (kg), $g$ is the acceleration due to gravity (10 m/s$^2$).

The ozonation system functions to kill bacteria. Ozone ($O_3$) is an unstable atom, while to make it becomes stable, $O_3$ atoms release 1 atom of O ($O^*$) to $O_2$. This $O^*$ works to kill bacteria. The following figure 2 prototype of this technology has been successfully made.

![Figure 2](image)

**Figure 2.** Prototype of this technology.

3.2. **Parameter test results**

This parameter result of the tests performed include: physics parameter test result, chemical parameter test result, and biological parameter test result. The following is the explanation in Table 1.

**Table 1.** Test results for physics, chemical and biological parameter

| No | Parameter | Test Parameters | Results (Unit) of treatment | Method |
|----|-----------|----------------|-----------------------------|--------|
|    |           |                | Before | After     |        |
| 1  | Physics   | Total dissolved solids | 7130 ppm | 2490 ppm | Digital TDS meter |
|    |           | Electrical Conductivity | 310 mA | 88.6 mA | adaptor and multimeter instrument |
|    |           | Turbidity | 0 FAU | 0 FAU | Colorimetry |
|    |           | pH | 5.7 | 6.1 | digital pH meter instrument |
|    |           | Fe | 0.073 ppm | 0 ppm | Colorimetry |
|    |           | Cu | 0.07 ppm | 0 ppm | Colorimetry |
|    |           | Cl | 0.17 ppm | 0.07 ppm | Colorimetry |
|    |           | Na | 0.04 ppm | 0.03 ppm | Colorimetry |
|    |           | Pb | 4.24 ppm | 1.36 ppm | Spectrophotometry |
| 2  | Chemical  | Coliform Fecal | 43 MPN/100ml | 23 MPN/100ml | MPN (Most Probably Number) |
|    |           | Coliform nonFecal | 7 MPN/100ml | 4 MPN/100ml | MPN (Most Probably Number) |

3.2.1. **Total dissolved solids test results.** Based on Table 1, the total test results of dissolved solids of water before processing is 7130 ppm while after processing is 2490 ppm. So, the decrease in the value
of total dissolved solids is 65.077%, which indicates that the test was successful. The function of the filtration system can make the value of dissolved solids decrease [10]. Dissolved solids are retained with mineral salts during the evaporation process [5]. Impurity mass is greater than the mass of evaporating water particles causes impurity particles to be lifted along with water vapour [11]. Dissolved solids are held back by sand which varies in size from large to small. Downward flow system (in the direction of gravity) and upward flow system (against gravity) make the filtration system more optimal.

3.2.2. Electrical conductivity test results. Based on Table 1, the electrical conductivity test results of water before processing is 310 mA while the after getting treatment is 88.6 mA. A decrease in the current value of 71.419% indicates that the test was successful. The current value can drop due to the reduced levels of salt and heavy metal ions from the water. In the electrolysis process, salt ions and heavy metals have been deposited into solids that stick to the negative pole. The solution that helps to conduct an electric current is ions [12].

The more ions in the water then the greater the current value. Conversely, the fewer ions in water the smaller the current value. A decrease in the value of electrical conductivity also indicates that water becomes fresh because the ionic salt levels have been reduced to solids. So they cannot conduct electricity anymore [13]. This is also proven by the reduced salinity of seawater [14].

3.2.3. Turbidity test results. Based on Table 1, the results of the turbidity test for water before processing is 0 FAU while after processing is 0 FAU. The turbidity value remains 0, which shows the successful of the test. The filtration function to keep the turbidity value stable from the initial turbidity value of 0.

3.2.4. pH test results. Based on Table 1, the pH test result of water before processing is 5.7 while the water after processing is 6.1. An increase in pH value towards pH 7 (neutral) indicates that the test was successful. The electrolysis needed 15 minutes to raise the pH from 5.7 to 6.1.

3.2.5. Test results for salt and heavy metals. Based on Table 1, the test results of salt and heavy metals (Fe, Cu, Cl, Na, and Pb) of water before processing are 0.073 ppm, 0.07 ppm, 0.17 ppm, 0.04 ppm, and 4.24 ppm while after getting treatment are 0 ppm, 0 ppm, 0.07 ppm, 0.03 ppm, and 1.36 ppm. There was a decrease in the value of Fe 100%, Cu 100%, Cl 58.823%, Na 25%, and Pb 67.924%, which showed that the test was successful. The value of Fe, Cu, Cl, Na in water after treatment meets the quality of clean water based on Permenkes 416/Menkes/Per/IX/1990 dated September 3, 1990, concerning a list of clean water quality requirements. Allowed Fe, Cu, Cl, Na standards are 1.0 ppm, 1.0 ppm, 600 ppm, and 200 ppm [16]. This is also proven by the reduced salinity of water [14].

3.2.6. Fecal coliform and nonfecal coliform test results. Based on Table 1, the test results for fecal coliform and nonfecal coliform bacteria before processing are 43 MPN/100 ml and 7 MPN/100 ml while the water after processing are 23 MPN/100 ml and 4 MPN/100 ml. There was a decrease in the value of fecal coliform bacteria 46.511% and nonfecal coliform 42.857%, which showed that the test was successful. Ozonation process that makes bacteria die resulting in a decrease in the number of fecal coliform and nonfecal coliform bacteria.

4. Conclusion
The technology of rob water treatment becomes clean water by using the combination of electrolysis, filtration, and ozonation methods have been successfully done. A systematic study on the effect of combination of electrolysis, filtration, and ozonation methods on the physics parameter, chemical parameter, and biological parameter on the rob water treatment becomes clean water and quality change of seawater during electrolysis, filtration, and ozonation methods have been performed. From The results of the total test of dissolved solids of water before processing is 7130 ppm while water after
treatment is 2490 ppm. A decrease in the value of total dissolved solids is 65.077%, which indicates that the test was successful. The result of an electrical conductivity test of water before processing is 310 mA while the water after processing is 88.6 mA. A decrease in the current value of 71.419% indicates that the test was successful. The use of electrodes needs to be replaced periodically so that the results of clean water production remain optimal.

Through the analysis data obtained related to solutions to solve the problem of rob water crisis in coastal areas, with this rob water treatment technology, it is hoped that it can further process rob water into clean water and improve the quality of clean water products. This treated rob water can be used as an alternative agent for water needs, while this rob water treatment method can certainly be an innovation for a new rob water treatment agent. This idea will raise more serious attention from the government to the marine products of this sector. So, through this treatment technique, one of the government's steps in realizing a generation of coastal residents who are independent and free from rob water crisis can be realized through the implementation of this idea.

Acknowledgments
The author thanks to the Ministry of Research, Technology and Higher Education of The Republic of Indonesia for providing funding for this research through 2017’s Student Creativity Program.

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