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Sea Water Characterization at Ujung Kulon Coastal Depth as Raw Water Source for Desalination and Potential Energy

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Abstract. Fresh water is basic need for life while the source is limited. Therefore, sea water is used as fresh water through desalination process. Sea water has different physical and chemical properties ranging from the surface to the seabed. The energy potential that can be obtained from the hydrostatic pressure also changes according to the depth. As part of the research of the utilization of sea water into fresh water, the aim of this study is to know the characteristics of sea water in the depth that can be utilized as source of fresh water. The sea water samples were taken at 11km from Ujung Kulon beach with depth of 0m, 20m, 40m, 60m, 80m, and 100m under the surface. The results showed that the physical properties at every depth were below the maximum allowable drinking water except for the amount of dissolved solids. Chemical characteristics at any depth above allowable level were fluoride, hardness (CaCo3), chloride, sodium, sulphate, and (KMnO4). In addition to the properties, pressure is one of the considerations in this study to determine the depth of sea water as sources for desalination. Pressure increased by 36.11% as the depth of the sea increased.

1 Introduction

Fresh water is a necessity for every creature on earth to stay alive. Population growth in Indonesia has a direct impact on the use of freshwater in the soil. This situation is completed with the reducing of water absorption area in various places due to the increase of buildings and factories. This resulted in the availability of clean water become threatened. UNICEF reports that 1 in 4 children will live in rare areas of water[1]. The condition is compounded by the decline in the soil surface due to the increasing amount of clean water taken from the soil[2]. Globally, water usage has tripled in the last 50 years[3], while the amount of fresh water on the surface of the earth is only 2.8% and the rest of 97.2% is sea water[4]. Therefore, the utilization of sea water as clean water becomes very potential. The problem is that seawater contains a greater amount of dissolved salt than fresh water, especially NaCl. Table 1 shows the dissolved salt content in different oceans and oceans in different parts of the world. Therefore, efforts to convert sea water into fresh water and efforts to eliminate salt content from seawater are widely practiced.

Various desalination technologies and their combination with renewable energy are shown in Figure 1. The utilization of solar energy for the desalination process is the least costly way, especially in tropical regions such as Indonesia. Direct heating method with solar heat is the most suitable way to produce fresh water up to 200 m^3/day[5]. For larger scales, the use of solar energy coupled with other energy sources such as heat collectors, waves, and geothermal is sufficient[6].

Table 1. Mean Value of Total Dissolved Salts in Various Seas and Oceans[4]

Sea or Ocean TDS (ppm)	Sea or Ocean TDS (ppm)
Baltic Sea 7000	Indian Ocean 33,800
Caspian Sea 13,500	Mediterranean near Crete 37,900
Black Sea 20,000	Mediterranean 39,000
White Sea 28,000	Red Sea 43,000
North Atlantic 29,000	Arabian Gulf 50,000
Pacific Ocean 33,600	Australian Shark Bay 70,000
Atlantic South 36,000	Kara Bogas Gulf 164,000
North Atlantic 36,200	(in Caspian Sea)
Adriatic Sea 31 ,400	Dead Sea 220,000

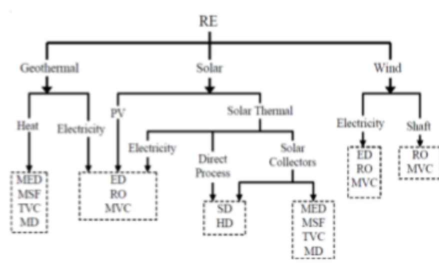

Fig. 1. Possible technological combinations of the main renewable energies and desalination methods[18]

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Renewable energies are energy sources that are continually replenished by nature and derived directly from the sun (such as thermal, photo-chemical, and photo-electric), indirectly from the sun (such as wind, hydropower, and photosynthetic energy stored in biomass), or from other natural movements and mechanisms of the environment (such as geothermal and tidal energy)[7]. The solar energy collector is one of the tools that developing in renewable energy. The various types of collectors such as flat-plate, compound parabolic, evacuated tube, parabolic trough, fresnel lens, parabolic dish, and Heliostat field collector (HFC) widely used as a tool for collecting solar energy[8]. Wind, solar, and other renewable technologies that can be used for desalination are rapidly emerging with the promise of economic and environmental viability on a large scale[9]. Renewable energy provides solutions to lower energy costs. One of the energy that can be utilized for the desalination process is hydrostatics pressure10. Hydrostatic pressure reduces the electricity consumption for the reverse osmosis process from 10 kwh/m^3 to 2.98 kwh/m^3[11]. Efficiency of hydrostatic usage as energy source is 80% in desalination process with RO[12].

Fig. 2. Deep sea reverse Osmosis scheme[19]

At the depth of the ocean, the available pressure and power generated by the turbine can be estimated using the following equations[13]:

$$P = \rho \cdot g \cdot H \tag{1}$$

$$P_T = Q \cdot \rho \cdot g \cdot H \tag{2}$$

Where

P is the pressure due to the height difference ($\frac{N}{m^2}$),

P_T is the power generated turbine (*watt*),

Q is Flow Rate ($\frac{m^3}{s}$),

ρ is the density ($\frac{kg}{m^3}$),

g is gravity 9,81($\frac{m}{s^2}$), and

H is head difference (m).

Utilization of hydro energy storage, where the water is taken from the depth of the ocean, the water will be different from the water on the surface, such as temperature. Since ocean's temperature decreases steadily with depth, although the ocean's surface temperature varies from 40°C to -2°C, the average temperature in ocean's depth is almost constant and around 3 - 4°C[14]. In addition, sea water content will also change where salinity increased 4.52%, pH decreased an average of 1.46% and the conductivity increase an average 0.03% in line with the addition of depth[15].

In this study, the sample of sea water content was taken from depth 0*m*, 20*m*, 40*m*, 60*m*, 80*m*, and 100*m*. Tests were performed using drinking water standards. In addition, the potential power at each depth to be obtained will also be calculated

2 Method

The sea water used in this study was taken from offshore of Ujung Kulon, West Java, Indonesia. The depth of sampling is 0*m*, 20*m*, 40*m*, 60*m*, 80*m*, and 100*m*. Samples at each depth were taken as many as 40 *liters* and stored in jerrycan. Sampling is done by using 2 *inch* hose that closed at the end by using valve. The sample test was conducted at the Mechanical Engineering Laboratory, Prof. Dr. HAMKA University and at the Regional Health Laboratory (LABKESDA) of DKI Jakarta, in Rawasari. The comparative standard used is the drinking water standard applicable in the Republic of Indonesia, Permenkes 492 Tahun 2010[16].

3 Result and Discussion

In this study, the testing of sea water content taken from a depth of 0 m, 20 m, 40 m, 60 m, 80 m, and 100 m. The test is performed using the Drinking Water Standard as shown in Table 2.

Table 2. Physical Properties according to 492/2010

Parameter	Satuan	Kedalaman						Kadar Maksimum yang Diperbolehkan untuk Air Minum
		0 M	20 M	40 M	60 M	80 M	100 M	
Smell	-	Tidak berbau	Tidak berbau	Tidak berbau	Tidak berbau	Tidak berbau	Tidak berbau	Tidak berbau
TDS	mg/l	29,535	30,125	29,425	29,928	30,076	30,927	500
Turbidity		0.36	0.27	1.84	0.33	77.1	0.34	5
Temperature	Skala NTU	25.6	25.3	25.8	25.5	25.9	25.8	Suhu udara ±3°
Color	Skala TCU	tt<2	tt<2	tt<2	tt<2	tt<2	tt<2	15

Table 2 is the result of testing of seawater physical properties that follow to the standard on drinking water testing. The test results showed that TDS (Total Dissolved Solid) was in the range of 30,000 *mg/l*, while the standard allowed for drinking water was 500 *mg/l*. In addition, turbidity at a depth of 80*m* differs from other

depths. At a depth of 0*m*, 20*m*, 40*m*, 60*m*, and 100*m* average turbidity is 0.628 below the drinking water standard, 5. Turbidity at a depth of 80*m* is different because at that depth there is undersea water flow. This is evidenced by the carrying of a hose by the water current at the depth. Furthermore, the chemical properties of seawater are shown in **Table 3**.

In Table 3, it appears that parameters that exceed the maximum permissible levels of drinking water are Flouride, Hardness, Chloride, Sodium, Sulfate, and Organic. This is consistent with that stated by Vassilis Belesiotis, et. Al[4].

Table 3. Chemical Properties according to 492/2010

Parameter	Satuan	Kedalaman						Kadar Maksimum yang Diperbolehkan untuk Air Minum
		0 M	20 M	40 M	60 M	80 M	100 M	
Mercury	mg/l	tt<0.0005	tt<0.0005	tt<0.0005	tt<0.0005	tt<0.0005	tt<0.0005	0.001
Alumunium	mg/l	tt<0.0127	tt<0.0127	0.0586	tt<0.0127	0.0851	tt<0.0127	0.2
Arsen	mg/l	tt<0.0021	tt<0.0021	tt<0.0021	tt<0.0021	tt<0.0021	tt<0.0021	0.01
Barium	mg/l	tt<0.0023	tt<0.0023	tt<0.0023	tt<0.0023	tt<0.0023	tt<0.0023	0.7
Ferrous	mg/l	tt<0.0178	tt<0.0178	tt<0.0178	tt<0.0178	tt<0.0178	tt<0.0178	0.3
Fluoride	mg/l	1.65	2.14	1.62	1.8	1.73	1.9	1.5
Cadmium	mg/l	tt<0.0003	tt<0.0003	tt<0.0003	tt<0.0003	tt<0.003	tt<0.0003	0.003
Hardness ($CaCO^3$)	mg/l	6313	6653	6473	6693	6633	7515	500
Chloride	mg/l	20621	20783	20358	20648	20855	20771	250
Chromium Total	mg/l	tt<0.0004	tt<0.0004	tt<0.0004	tt<0.0004	tt<0.0004	tt<0.0004	0.05
Manganese	mg/l	tt<0.0007	tt<0.0007	tt<0.0007	tt<0.0007	tt<0.0007	tt<0.0007	0.4
Sodium	mg/l	5380	5141	4718	4662	4526	4449	200
Nitrate	mg/l	tt<0.211	tt<0.211	tt<0.211	tt<0.211	tt<0.211	tt<0.211	50
Nitrite	mg/l	tt<0.012	tt<0.012	tt<0.012	tt<0.012	tt<0.012	tt<0.012	3
pH	-	7.67	7.63	7.3	7.61	7.17	6.87	6.5 – 8.5
Selenium	mg/l	tt<0.0021	tt<0.0021	tt<0.0021	tt<0.0021	tt<0.0021	tt<0.0021	0.01
Zinc	mg/l	tt<0.0335	tt<0.0335	tt<0.0335	tt<0.0335	tt<0.0335	tt<0.0335	3
Cyanide	mg/l	tt<0.0015	tt<0.0015	tt<0.0015	tt<0.0015	tt<0.0015	tt<0.0015	0.07
Sulfate	mg/l	2584	2580	2549	2546	2561	2548	250
Copper	mg/l	tt<0.0004	tt<0.0004	tt<0.0004	tt<0.0004	tt<0.0004	tt<0.0004	2
Lead	mg/l	tt<0.0013	tt<0.0013	tt<0.0013	tt<0.0013	tt<0.0013	tt<0.0013	0.01
Ammonia	mg/l	tt<0.02	tt<0.02	tt<0.02	tt<0.02	tt<0.02	tt<0.02	1.5
Organic ($KmnO_4$)	mg/l	111.76	119.46	145.67	116.38	141.04	148.75	10
Nickel	mg/l	tt<0.0003	tt<0.0003	tt<0.0003	tt<0.0003	tt<0.0003	tt<0.0003	0.07

Furthermore, data that is above the maximum level shown in Figure 3. In Figure 3, TDS that is above the maximum level increases with increasing depth. An average TDS increase of 10% for every 20m depth increase. Turbidity at depths of 0m, 20m, 40m, 60m, and 100m below permissible levels except at a depth of 80m.

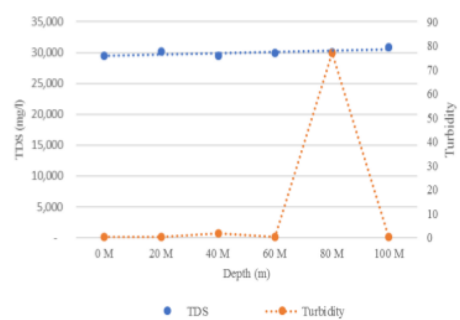

Fig. 3. Physical Properties TDS and Turbidity

In Figure 4, it appears that organic increases by 30% in line with increasing ocean depth. Mean while, on the average of flouride is no increase with the depth of the sea. This is in line with that proposed by Bewers[17] that there is no increase in levels of fluoride along with the addition of the depth of the ocean.

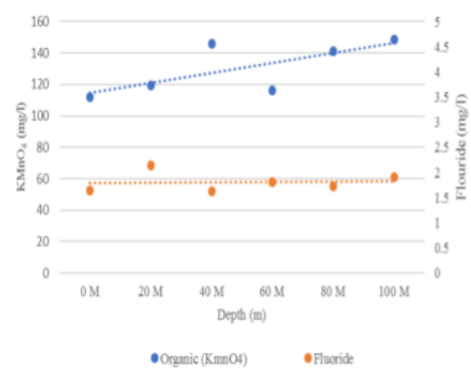

Fig. 4. Chemical Properties Organic and Flouride

The increase also does not occur in Chloride and Sulphate, as can be seen in Figure 5. In contrast to other elements, sodium has decreased by 20% with increasing sea depth, while Hardness is up 23% along with increasing depth of sea depth.

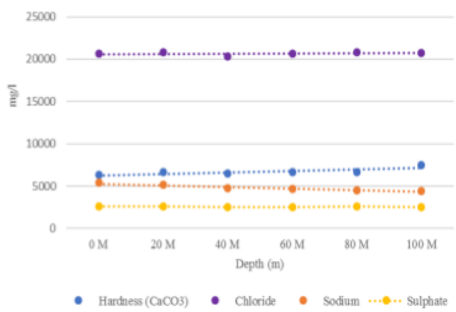

Figure 5. Chemical Properties ; Hardness, Chloride, Sodium and Sulphate

In addition to sea water testing, the potential power obtained by the pressure due to the depth of the sea is calculated, assuming the water requirement is 200 *liters/person/day* with the population on one island is 100 people, then the required debit is 20,000 *liters/day* or 0.8 m^3*/hour*. The gravity of sea water is 1.025 *kg*/m^3 and gravity is 9.81 m/s^2, the increase in hydrostatic pressure is 36.11% with increasing sea depth.

4 Conclusions

Based on the results of the test, it can be concluded that TDS, hardness, sodium, and organic have changed sequentially by 10%, 23%, -20%, and 30%. Flouride, chloride, and sulphate do not change with increasing sea depth. Potential pressure increased by 36.11% with increasing sea depth.

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