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Reverse Osmosis (RO) Drinking Water Management as the Best Solution to Overcome the Clean Water Crisis in Pinang Island

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ABSTRACT

Reverse Osmosis (RO) drinking water management can be the best solution to overcome the clean water crisis in Pulau Pinang. RO is a process that allows water to pass through a semi-permeable membrane and separates most of the dissolved salts, organic matter, bacteria, and other substances from the water to produce clean water. The use of the RO method in drinking water management is one of the best alternatives to overcome the clean water crisis, especially in the Pinang Island area with surface water sources that are not dominated by freshwater can ensure the availability of sustainable clean water. However, RO-based drinking water management is water demineralization, so further management is needed such as remineralization to meet mineral standards in drinking water.

KeyWords: Reverse Osmosis (RO), Drinking Water, Clean Water Availability, Pulau Pinang.

INTRODUCTION

Water is an essential environmental component of life. Living things on this earth cannot be separated from the need for water. Water is a basic necessity for the process of life on earth, so there will be no life without water on earth. However, water can be a disaster if it is not available in the right conditions, both in quality and quantity. Water is a current problem that needs serious attention. Obtaining good water according to certain standards is currently costly as the water is polluted by various industrial activities. Thus, water resources have decreased in quality. Likewise, in the amount that can no longer be fulfilled, while the demand continues to grow (Warlina, 2004).

Malaysia is a country located in the equatorial region where there will be 3000 mm of rain a year. The country is rich in water sources from rainwater, and lakes and has 189 watersheds that contribute to water sources, so there is no shortage of water sources in Malaysia. However, as time progresses and the population increases, these water sources are threatened by pollution and climate change. In addition, rapid economic development to become a New Industrialised Nation has also led to high levels of water usage. (Sudarti & Puspitasari, 2021).

The highest domestic water use in Malaysia is Pinang Island. In 2011, the average per capita domestic water usage in Pinang Island was 285 liters each day with the lowest tariff being RM0.31 per 1,000 Litres. Residents in Pinang Island are subsidized with RM58.9 million a year in cheap water bills from the Perbadanan Bekalan Air Pulau Pinang (PBAPP). As a water-stressed state, Penang has limited water resources, and water users

need to adopt water-saving practices. A total of 62.9 km² of land in the state of Penang is reserved as catchment areas, which represents 6% of the total land area in the state. However, this catchment area only supplies about 20% of Penang's clean water needs. The remaining 80% is supplied by the Dua Sungai plant, which sources water from Sungai Muda in Kedah (Sungai Muda provides water supply to both states) (Leng et al., 2010).

The state of Kedah uses water from the upper reaches of Sungai Muda, putting Penang at a higher risk if Kedah's water demand is increased. Penang's water supply capacity accommodates a maximum consumption of 1.273 million liters each day (MLD). According to Penang's water authority, the Penang Water Supply Company (PBAPP), domestic daily water consumption in Penang was high at 285 liters each day per capita (LCD) in 2011, while the average Malaysian domestic user used only 203 LCDs. Neighboring Singapore recorded a good domestic water consumption of only 158 LCDs, lower than the United Nations (UN) recommended average daily consumption of 165 LCDs. There is pressure on the island's water supply. Pinang, with population growth averaging 1.7% per year from 2000 to 2010. Further increases in population and economic growth could lead to an exponential increase in water use. Therefore, even if domestic per capita consumption remains constant over the next 10 years, Pinang Island may be impacted by future water shortages (Rukmana, 2022).

One way to avoid a water crisis is to conserve water. Another solution taken by Pinang Island in overcoming the clean water crisis is to utilize the RO method in the production of drinking water to avoid polluted water that can be consumed.

METHODS

The research method used by the author is using direct observation method during the visit to Pinang Island. This research aims to provide information about RO drinking water in terms of management and knowing the benefits of RO in drinking water production on Penang Island.

RESULTS

3.1 Definition of RO Drinking Water Management

RO is a method of water treatment by filtering through a semi-permeable membrane. The separation of water from contaminants such as dissolved solids, organic substances, pyrogenic substances, submicron colloidal matter, color, nitrates, and bacteria is based on the principle of filtration by applying high pressure over the osmosis pull which forces water to pass from high concentration to low concentration (Garud et al., 2011; Syahid et al., 2019). RO technology is applied as a groundwater, surface water, or seawater purification technique depending on the situation and conditions as well as the availability of water sources, each of which produces permeate (result water), which is water that penetrates the membrane pores which is almost Entirely free of minerals and concentrate (wastewater), which is water that does not penetrate the membrane pores (Vingerhoeds et al., 2016). RO technology in addition to being used for drinking water treatment is also used for hazardous waste treatment, separation processes in the food, beverage, and paper

industries, and as an alternative method for recovering organic and inorganic substances from chemical processes (Garud et al., 2011).

3.2 RO Technology

Reverse-Osmosis/RO

Membrane RO membranes are the most robust in retaining almost all dissolved inorganic and organic contaminants present in water compared to other filtration membranes such as microfiltration, ultrafiltration, and nanofiltration (Wu et al., 2021) thus allowing only water to pass through the membrane. The RO membrane used is a semi-permeable membrane accompanied by the application of pressure for advanced purification of drinking water. When RO is used to purify drinking water sourced from freshwater, the effect of polarisation concentration on energy used changes significantly as osmotic pressure is negligible (Zhai et al., 2022). The first effective RO membrane in the RO process is an organic membrane, which is a thin-layer composite membrane consisting of the outer active side of a super-thin polyamide layer (0.1-1 μm), a shaft supporting the center position made of polysulfone and a non-woven fabric based on polyester. Inorganic membranes consisting of ceramic or carbon, which are reusable and stable, are also one of the RO membranes in demand because they can be used in the treatment of water with high concentrations of substances such as organic substances, radioactive compounds, lubricants, and oils. The combination of organic/inorganic membranes in the RO process is referred to as a hybrid membrane with a type of material in the form of a mixed matrix membrane known as a material that has excellent performance (Hailemariam et al., 2020).

RO Drinking Water Treatment Process

The RO drinking water treatment process produced in several industries in the Penang area uses the principle of 2 RO stages equipped with high pressure to pass through a semipermeable membrane. Source water used in RO drinking water produced by RO drinking water supply industries (RO Water, 2022) in the Penang area comes from the supply of treated water from the raw water source of the dam which is fed by Muda River water (Kedah) and Perak River water (Perak). The resultant water (permeate) that has undergone 2 stages of RO is then ozonated which functions to oxidize organic compounds, kill bacteria that remain in the resultant water, and reduce oxygen to make it harmless. RO drinking water that has reached 98% purification is also oxygenated to increase dissolved oxygen in the water. Some examples of products produced from several RO drinking water supply industries are shown in Fig 1 below.

Fig 1. RO drinking water products

3.3 Benefits of RO

RO technology is the best separation technology and is energy efficient. The benefits of RO include pressure-dependent RO operation that consumes the lowest energy when

compared to other traditional processes, is carried out at room temperature without phase change, small and simple equipment operation, does not use chemicals during the treatment process, and the resulting water quality is very good which has high efficiency (Jiang et al., 2018). RO technology as a drinking water provider in the Penang area is one of the ways for the local government to overcome the clean water crisis because the Penang area is a coastal area where the dominant surface water supply is seawater. RO drinking water is also one of the main sources of drinking water in the Penang area to meet daily drinking water needs.

3.4 Challenges and Solutions

Continued modernisation on the one hand has resulted in diminishing water resources and poor water quality as people continue to use it to meet their daily water needs. In addition, imperfect water resource management systems and changes in the ecology of the environment also affect the availability of clean water. The application of RO technology in improving the quality of drinking water plays an important role in overcoming these problems (Jiang et al., 2018). One of the 17 points of Sustainable Development Goals (SDGs) or sustainable development, namely point 6, contains guarantees of availability, sustainable management of clean water, and sanitation which are indispensable in supporting healthy living (Syabil et al., 2022; Putra et al., 2023). Clean water has clear, odorless, colorless, and fresh characteristics. (Ronika et al., 2022). So RO technology in drinking water treatment and clean water supply is one of the efforts to ensure the availability and management of clean water in a sustainable manner. RO technology is known for its efficiency in removing almost all contaminants and minerals (demineralization) found in water resulting in almost pure water. However, it is a challenge that the minerals contained in water that have passed through the RO process have low concentrations that do not meet drinking water standards. An alternative is to remineralize the RO water to meet the mineral standards for drinking water (Janna et al., 2016).

CONCLUSIONS

RO-based drinking water management is one of the best alternatives in overcoming the clean water crisis, especially in areas with surface water sources that are not dominated by freshwater such as Pinang Island, ensuring the availability of sustainable clean water, and as one of the energy-saving technologies in the management and supply of drinking water. One of the challenges in RO-based drinking water management is the demineralization of RO-generated water so further management is needed such as remineralization to meet mineral standards in drinking water.

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