# DESIGN AND CONSTRUCTION OF PORTABLE DRINKING WATER TREATMENT EQUIPMENT USING PALM OIL FUEL ASH (POFA) MEMBRANE INNOVATION ACTIVATED BY EGG SHELL POWDER (ESP) FOR PEAT WATER

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**Abstract**

Membrane is a clean technology that is environmentally friendly because it does not have a bad impact on the environment. Membrane technology can reduce organic and inorganic compounds in water without the use of chemicals in its operation. The use of membrane technology is very developed so that this technology can be combined in an absorption method that will produce good quality. The water treatment used is a combination of absorption in the form of a membrane that utilizes POFA (Palm Oil Fuel Ash) and ESP (Egg Shell Powder) as filter materials for drinking water processing. This material can be used to process peat water into drinking water. The aim of this research is to determine the characteristics of ESP-activated POFA membranes and to determine the effect of ESP-activated POFA membranes on the quality of drinking water from peat water. Method for making POFA filter material with ESP ratios of 50:50, 70:30 and 90:10. As well as analysis of the results using analysis of membrane characteristics and analysis of the quality of drinking water produced according to the 2023 Ministry of Health standards.

**Keywords** : Membrane, Palm Oil Fuel Ash, Absorption, Peat Water

## 1. Introduction

Water used and consumed by humans has quality standards that are strictly controlled because it affects the quality and aesthetics of the water. The pH level in water is greatly influenced by the chemical content in it. Water with a pH that is too high or too low each has side effects. Highly acidic water can corrode or even destroy metal. Meanwhile, water that is too alkaline usually tastes bitter and can cause sediment to coat pipes and tools. Water quality includes physical and chemical conditions that can affect the availability of water for human life, agriculture, industry, recreation and other water uses.

The water treatment technology currently being developed is *membrane* and absorption technology. The absorption method can be applied in the form of *membrane* technology with filters so that it becomes one technology in combination that produces good quality. In this research, water treatment is used in combination with absorption in the form of membrane technology which utilizes POFA ( *Palm Oil Fuel Ash* ) as a filter material for drinking water treatment.

## 2. Literature Review

### 2.1 Peat Water

Peat water contains solute organic compounds, causing the water to be colored and acidic. The organic compounds which are among the highest substances in peat water include humic acid, consisting of sulvic acid, humic acid and humin. Humic acid is an organic compound that has a high molecular weight and has a brown to blackish color (Kiswanto *et al* , 2019).

### 2.2 Drinking water

According to Wiyono (2017), drinking water must have a physical test standard, namely turbidity, where good water quality is water that is clear and not cloudy. It has no

smell and tastes fresh, good quality water will be odorless and have a fresh taste, both of which greatly affect the quality of clean water. The amount of floating solids, if the water is good and suitable for drinking does not contain floating solids and the permitted amount is (1000 mg/L). Temperature and color also greatly influence the quality of drinking water.

Drinking water is water that has gone through a processing process or without a processing process. Environmental health quality standards for water media have parameters that serve as a reference for safe drinking water. This environmental health quality standard for drinking water media is a reference for drinking water providers, environmental sanitation officers at health centers, provincial health services, district or city health services, and related stakeholders. This effort is carried out through securing and controlling the quality of myonum water providing significant benefits for public health (Permenkes, 2023).

## 2.3 Water Treatment Technology

In modern drinking water processing is carried out using membrane technology. Membrane technology is a clean and environmentally friendly technology because it does not have a bad impact on the environment. This technology can also reduce organic and inorganic compounds in water without the use of chemicals in the operating process. Membranes can be defined as thin layers. This membrane technology has been widely used in separation, purification and concentration processes in the chemical industry and food industry. The main advantage of this technology is that there is no phase change between the components being separated and it also uses a low processing temperature. So the energy required from membrane technology is quite low and material damage caused by high temperatures can be prevented. The membrane is also a semipermeable barrier that is able to pass certain components but retain other components so that this is influenced by the

separation mechanism and the size of the material being separated. Based on how the membrane is used, it is divided into five types, namely Microfiltration (MF), Ultrafiltration (UF), Nanofiltration (NF), Reverse Osmosis ( *RO* ), and *Electrodialysis* (Safentry & Rully, 2020).

2.4 Membrane

A membrane is a porous medium, in the form of a thin layer, which is semipermeable which functions to separate particles of molecular size (species) in a solution system. This technology has several advantages, namely the separation process takes place at room temperature, its nature varies, it can be adjusted according to needs and most of the membranes produced can be reused, if the membrane is damaged it can be recycled so it produces relatively no new waste and is classified as clean technology *(* Lubis *et al* , 2022).

2.5 Palm Oil Fuel Ash

**Figure 1 .** POFA from PT. Bayungagrosawita

*Palms Oil Fuel Ash* (POFA) or palm oil biomass burning ash is biomass waste in the plantation sector that can be found in high quantities, is easy to obtain at a fairly low cost, has good resistance to high temperatures and another advantage is that it can be renewed. The process of burning palm fiber and shells in a kettle is carried out at a temperature *range of* 500 ℃to 700 ℃ ℃, which produces by-products in the form of *bottom ash* or also known as scale, and *fly ash* . In general, POFA is not utilized because it is usually only thrown into

empty land around palm oil mills (PKS), which ultimately causes new problems, especially for the environment and can pose a risk to health (Oktaviany, 2022).

**Table 1.** POFA Composition

| No | Elements/compounds | Percentage (%) |
|---|---|---|
| 1. | Silica ($SiO_2$) | 51.01 |
| 2. | Potassium ($K_2O$) | 11.27 |
| 3. | Aluminum ($Al_2O_3$) | 2.03 |
| 4. | Calcium (CaO) | 2.79 |
| 5. | Magnesium (MgO) | 9.57 |
| 6. | Chlorine (Cl) | 2.07 |
| 7. | Phosphates ($P_2O_5$) | 7.33 |
| 8. | ZnO | 0.01 |
| 9. | $Rb_2O$ | 0.02 |

*(Source: Yuni et al, 2021)*

2.6 Egg shell

According to Novianti (2019), it is known that chicken egg shells contain Calcium Carbonate ($CaCO_3$). The potassium carbonate content in egg shells is around 87% - 97%. Calcium carbonate is alkaline which can raise the pH of the water. Almost all types of chicken egg shells contain calcium carbonate. Based on the calcium carbonate content of chicken egg shells, if chicken egg shells are used as filter media, the treated water can produce alkaline water, for this reason filter media from chicken egg shells can be used to improve the quality of acidic water.

3. Research methods

3.1 Research procedure

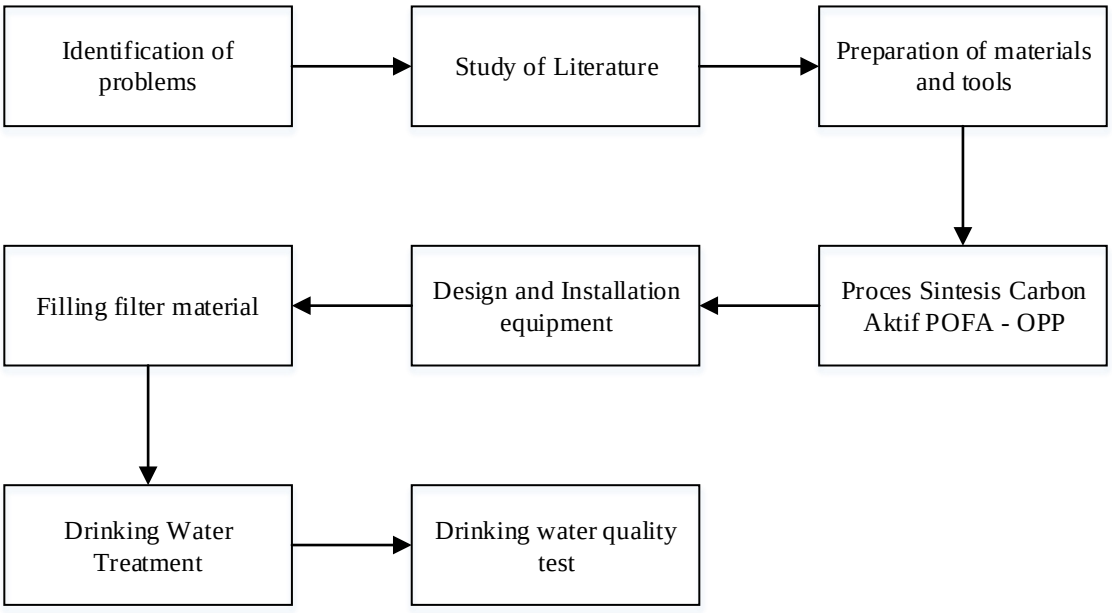



Figure 2. Flow diagram of research activities

In this research, the process begins with identifying the problem, then preparing materials and tools and the POFA – ESP active carbon synthesis process, designing and installing equipment and filling filter materials, processing drinking water and testing the quality of drinking water.

3.2 Work procedures

3.2.1 Pre-treatment Palm oil fuel ash (POFA)

The material used in this research is POFA which is obtained from burning palm oil waste in boilers. Before POFA is used and processed into membrane making material, POFA is first cleaned and sifted using a 100 mesh sieve. Sifting is carried out so that the POFA used is clean and uses the same particle size . After sieving, the POFA is then washed. The washing process is carried out repeatedly until the washing water used is clean. POFA washing is done with a sieve and filter paper because the POFA particle size is quite small. After completion of the washing process, POFA can be used to make membranes.


**Figure 3.** POFA *pretreatment* diagram

3.2.2 Synthesis of *Egg Shell Powder (ESP)* Carbon Activator from Egg Shells

The materials used in this research are egg shell which is obtained from the remains or waste of egg shells. Egg shells will be synthesized which will produce *Egg Shell Powder* (ESP). The initial process carried out is that the shell is washed. Then, the egg shells are roasted using an oven at a temperature of 250 $^{o}$C for 6 hours. Next, the egg shells that have gone through the burning process are crushed or crushed using a crusher. Next, the sieving process was carried out using a 100 mesh sieve. Next, washing is carried out. In this process, *Egg Shell Powder (ESP)* will be produced which will be used as a base activator in making active carbon from POFA.

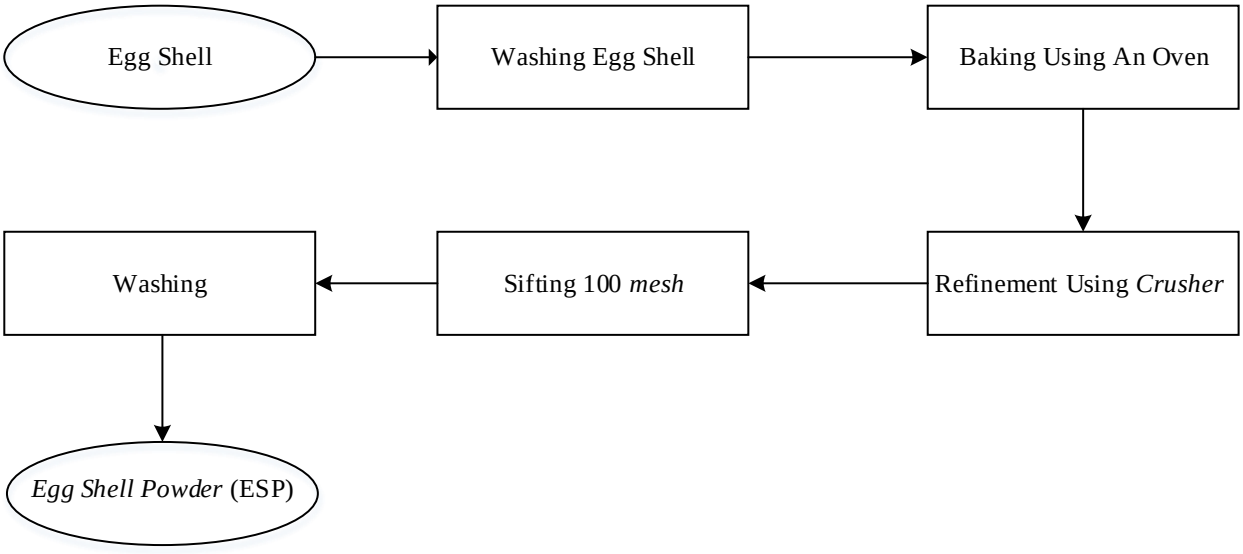



**Figure 4.** Diagram of making *Egg Shell Powder* (ESP) from Egg Shells

3.3.3 Making Activated Carbon from *Palm Oil Fuel Ash* (POFA) and *Egg Shell Powder* (ESP)

The material used in this research is POFA which is obtained from burning palm oil waste in a boiler and ESP which has been previously synthesized. In this research, ESP was used as a substitute for base activation from natural ingredients. Then mix POFA and ESP according

to the previously determined ratio, namely 50:50, 70:30 and 90:10, then add 20% water from the total solids as a binding agent. After that, the mixture was burned using an oven at a temperature of 250 $^{o}$C for 2 hours . Then wash the mixture until the washing water is clear. In this process, POFA-ESP active carbon will be produced which will be used as a filter membrane in drinking water treatment.

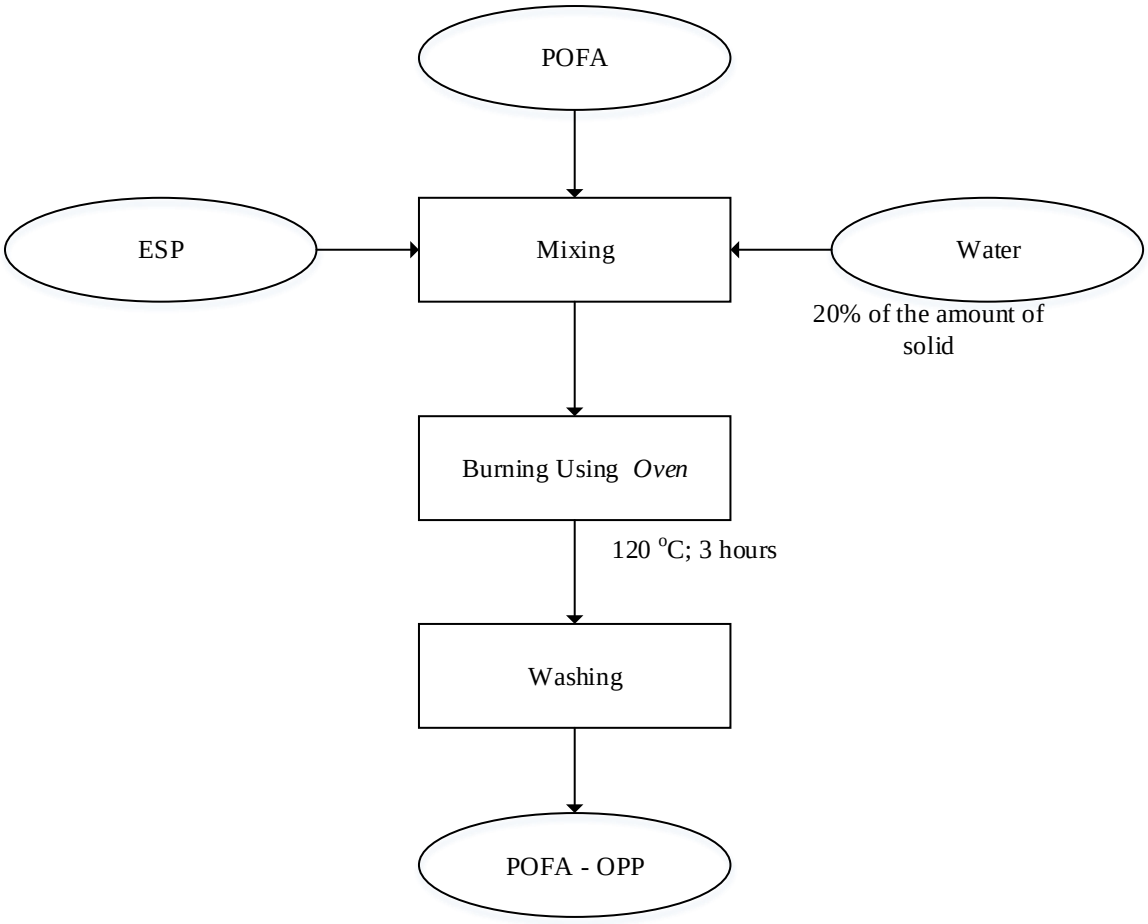
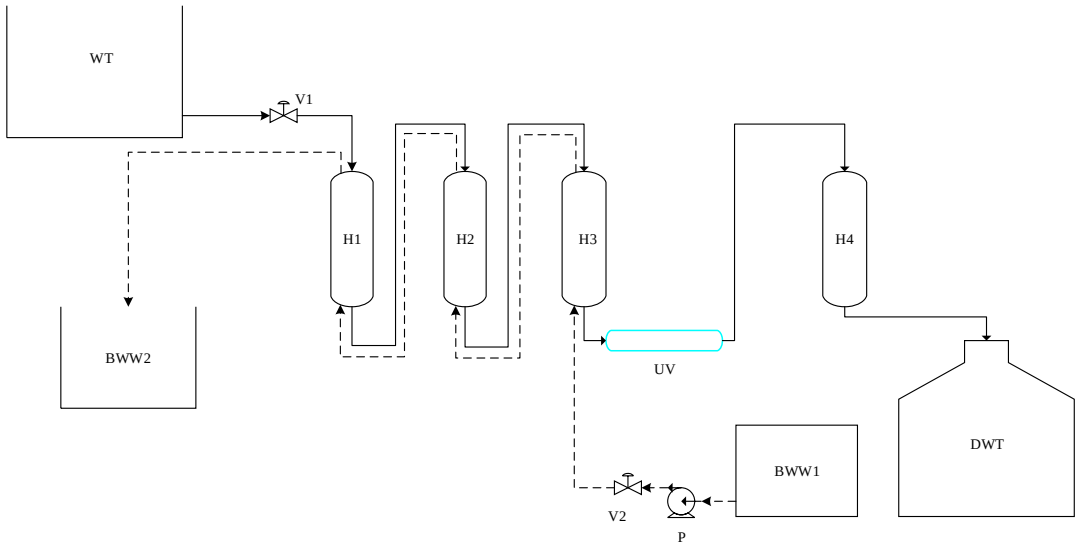



**Figure 5.** Activated carbon manufacturing diagram from POFA - ESP

3.3.4 Installation and Design of POFA *Portable Drinking Water Treatment Equipment - ESP*

*portable* drinking water treatment tool , a tank is used as a water storage area before processing is carried out. The water storage tank is placed at a higher place to utilize gravity in the process of flowing water to the water treatment tool. In the processing process, researchers assembled 4 *house filters* and also *ultraviolet. The first filter house* contains previously made

POFA–ESP active carbon, the second *filter house* contains silica sand, and the third *filter house* contains manganese sand. After that, the researchers used ultraviolet for the next series of tools, and continued with the assembly of the fourth *house filter* which contained a pH *stabilizer* .




4. Comparison of Results from Journals Based on Drinking Water Processing from Peat Water

**Table 2.** Comparison of results based on materials and methods for water treatment

| Material (gr) | method | References | Results |
|---|---|---|---|
| Fly ash and ultrafiltration | adsorbent | Nasir et al (2020) | The fly ash/Uf combination can increase the pH of well water from 5.43 to 7.0-8.1 with a turbidity reduction efficiency of 99.48%. The use of adsorbents as pretreatment before the ultrafiltration process will help in removing iron and manganese metal ions and at the same time preparing feed that meets the criteria for ultrafiltration membranes. |

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|---|---|---|---|
| Palm oil fuel ash | adsorption | Riduan et al (2022). | POFA can reduce batik dye content efficiently by 22%. The absorption capacity of batik dye using POFA reaches 62 mg/g. However, POFA cannot be directly used to adsorb batik dyes but must be modified through acid-base treatment so that it is able to adsorb or reduce dyes from batik waste. |
| Silica, walnut and activated carbon | adsorption | Mukhlisin (2020) | Coconut fiber activated carbon has an absorption efficiency for turbidity parameters of 81.23%, oil and fat 73.07% and Fe metal concentration 66.93%. The filtration test was carried out by combining media in the form of silica sand, activated carbon from coconut fiber and walnuts so that the characteristics of the water were in accordance with the specified quality standards. |

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