DEEP WELL WATER TREATMENT PLANNING IN KLUNGKUNG REGENCY WITH GRANULAR ACTIVATED CARBON (GAC) UNIT PROCESS

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Abstract
Deep wells are one of the sources of water to meet the daily needs of the people in Klungkung Regency. The well water still contains high levels of aluminum and color. For this reason, proper processing planning is needed for the characteristics of wells in Klungkung Regency. One of the appropriate process units to use is the Granular Activated Carbon (GAC) adsorbs. The purpose of this study is to find out the details of the unit area and the need for GAC used in treating well water in Klungkung Regency. The land area required for this unit is 3.82 m^2, where this area already includes 2 GAC units. The GAC requirement for each unit is 3209.4 kg with a regeneration time of 6.6 months.

Keywords : *filtration, GAC, deep well, aluminum, color*

INTRODUCTION

Groundwater used by parties in Klungkung Regency is directly distributed after going through a disinfection process with chlorine gas. During the distribution process to the customer's house, the quality of the well water is likely to change due to several factors, one of which is leakage or corrosion from the pipes, so that the water that arrives at the customer may have poorer quality than the quality of the water at the source (Novalinda, 2019; Apritama et al., 2020). This is very influential for customers because many Balinese people use water directly as drinking water without going through the cooking process first. From the observations made, water has only flowed into a tube made of rock so that simple filtration occurs.

The aluminium content of deep wells in Klungkung Regency ranges from 0.2 mg/L to 0.35 mg/L. Aluminium can generally be contained in food because it comes from contamination of aluminium-based cooking utensils or food wrappers made of aluminium. In addition, the aluminium content in food can also be caused by the addition of additives in food, and this content is mainly found in dairy products, grains, and food and soft drinks (Parulian, 2009). According to WHO, the permissible intake of aluminium from food additives is 2 mg per day.

Meanwhile, the colour content of deep wells in Klungkung Regency ranges from 20 TCU to 40 TCU. Colour in water is an indication of the presence of organic content and the presence of metal ions such as iron, manganese, and turbidity (Davis, 2010). Colour is one of the physical components of water quality. The presence of colour will interfere with the aesthetics of the water and be an indication of polluted water. In Permenkes No. 492 of 2010 concerning Drinking Water Quality Requirements, colour is one of the mandatory parameters that must be met standard. According to these regulations, the maximum colour content in drinking water is 15 TCU (True Color Unit). Colour in water is divided into two types, namely true colour and apparent colour. Colour in water bodies can reduce aesthetics and environmental health (Suryawan et al., 2021; Septiariva et al., 2021; Detiar et al., 2021). True colour comes from the decomposition of organic compounds, such as hummus, lignin, tannins, and other organic acids (Davis, 2010). The presence of this compound causes the colour in water to be difficult to remove. Water that contains true colour generally has a characteristic yellow to reddish-brown or relatively clear colour

With the parameters that exceed the quality standard, it is necessary to add a treatment unit for deep well water in Klungkung Regency. One technology that is often used in processing aluminium and colour is Granular activated carbon or GAC. GAC can be divided into 3 (three) types based on their pore size, namely micropores, mesopores, and macropores (Water Quality Association, 2016). According to IUPAC, micropores have a pore size of <2 nm, mesopores have a pore size of 2 nm-50 nm, while macropores have a pore size of >50 nm. The choice of pore size depends on the type of adsorbate to be adsorbed. GAC as an adsorbent, pore size and pore structure are the most important things that need to be considered. The size and configuration of these pores depend on carbon activation and the relative area of the carbon (Water Quality Association, 2016). This study aimed to design an appropriate treatment unit to remove aluminium and colour with GAC adsorbents in Klungkung Regency.

METHOD

This research was conducted in Klungkung Regency, Bali Province (Figure 1) with a scope located on the mainland of Bali Island (excluding Nusa Penida and Nusa Lembongan). This research was conducted from March to December 2020. The secondary data used in this study was obtained from PDAM Klungkung Regency. Secondary data used in the form of data on the quantity and quality of deep well water in Klunkgung Regency. After the data used were complete enough, a literature study was carried out regarding the procedures and stages in designing the aluminum and color water treatment process with GAC adsorbents.

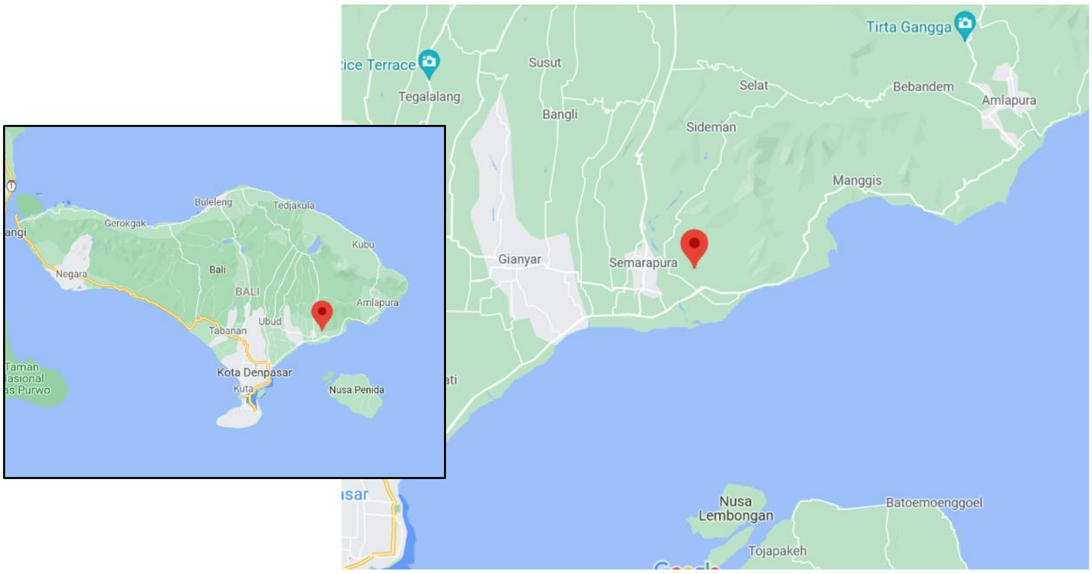

Figure 1. Location of Deep Well Water Treatment Planning in Klunkung Regency

The design process begins with the problem identification stage, then continues with a literature review on the problems to be discussed, then collects secondary data in the form of water quality, existing configuration, deep well profile data, land area data, design criteria, and previous research on aluminium and colour removal. After obtaining the selected processing unit, the dimension design, unit configuration design, and hydraulic profile calculation are carried out. The calculation of the basic design in this study is calculated based on equation 1 and equation 2 (Metcalf & Eddy, 2004).

The amount of loading in general that is fed into the reactor based on the Hydraulic Retention Time (HRT) which is defined as how long the treated air stays in the reactor in this case GAC (equation 1). The wastewater discharge used is the discharge from the existing conditions required in the planning of the GAC Unit in Klungkung Regency. With the loading applied based on the predetermined HRT, the rate of loading for water treatment is defined as the product of the influent concentration and the treated air discharge. Meanwhile, to determine the pollutant load, it must be determined from the mass of the incoming pollutant (m_{in}) and the mass of the outgoing pollutant (m_{out}), so that a mass balance is obtained in the processing process (equation 2).

$$\mathbf{V = HRT \times Q} \qquad (1)$$

$$\%removal = \frac{m_{in} - m_{out}}{m_{in}} \times 100 \qquad (2)$$

RESULT AND DISCUSSION

The design data and design criteria needed to carry out this design are listed in Table 1. Based on the planning data and design criteria in Table 1, the design calculations are carried out as follows:

$Vunit = Qunit \times t$ = 8 L/s × 10 $menit$ × 1 m^3/1.000 L × 60 s/1 $menit$ = 2.4 m^3

Cross-sectional area = 1/4 × π × d^2 = 1/4 × π × (1 m)^2 = 0.810 m^2

H =V/Cross-sectional area = 1.6 m^3/0,810 m^2 = 1.974 m

The planned adsorption tank has a diameter of under 3 m. According to Reynolds (1996), the design of adsorption tanks with diameters below 3 m usually follows the designs on the market. Therefore, this design uses an adsorption tank design from the Indonesian market, with a diameter specification of 1,560 mm and a height of 2,400 mm. Based on these specifications, the diameter of the tube to be used is 1.56 m with a tube height of 2.4 m. With the change in the diameter and height of the tube, it is necessary to check the h/D value and Empty Bed Contact Time (EBCT) value to keep it following the design criteria.

h/D = 2.4 m/1.560 m = 1.54

A = 1/4 × π × d^2 = 1/4 × π × (1.56 m)2 4 = 1.91 m^2

$EBCT = A \times h / Q$ = 1.91 m^2 × 2.4 m / 14.4 m^3/h = 0.32 h = 19.1 $m$in

Based on the calculation, the h/D value is 1.54 and the EBCT value is 19.1 minutes. Both of these values still meet the design criteria so that market dimensions can be used in this design. After confirming that the unit meets the design criteria (Table 1), the value of the land area needed to build the unit is calculated.

Table 1. Results of the Recapitulation of Design Criteria and Planning Data

Components	Design Criteria	Source	Planning
Q		Reynold (1996)	8 L/s
$V_{approach}$	5-15 m^3/h	Reynold (1996)	-
h/D	1.5-4	Reynold (1996)	1,54
Empty bed contact time	5-30 min	Reynold (1996)	-
Density	350-550 g/L	Reynold (1996)	350 g/L
Unit liquid flowrate	<5 L/s.m^2	Reynold (1996)	-
Hydraulic flowrate	1.4-3.4 L/s.m^2	Reynold (1996)	-

Water treatment processes with activated carbon can be carried out to remove substances that are difficult to remove such as color (Septiariva et al., 2021). The absorption by activated carbon is physical adsorption, so the process is fast and the saturated carbon can be regenerated again. Adsorption occurs because of the attractive force between the molecules of the substance being absorbed/adsorbate and the adsorbent. The advantages of granular activated carbon are: easy operation because air flows in the media, the travel process is fast because the sludge clumps up, the media does not mix with the mud so it can regenerate. So that in the deep well water treatment process in Klungkung Regency only consists of adsorption parts, whereas before being distributed disinfection is to prevent contamination by pathogenic microbes (Figure 2). The addition of disinfection in water treatment needs to be considered because it will be consumed by humans (Hasnaningrum et al., 2021).

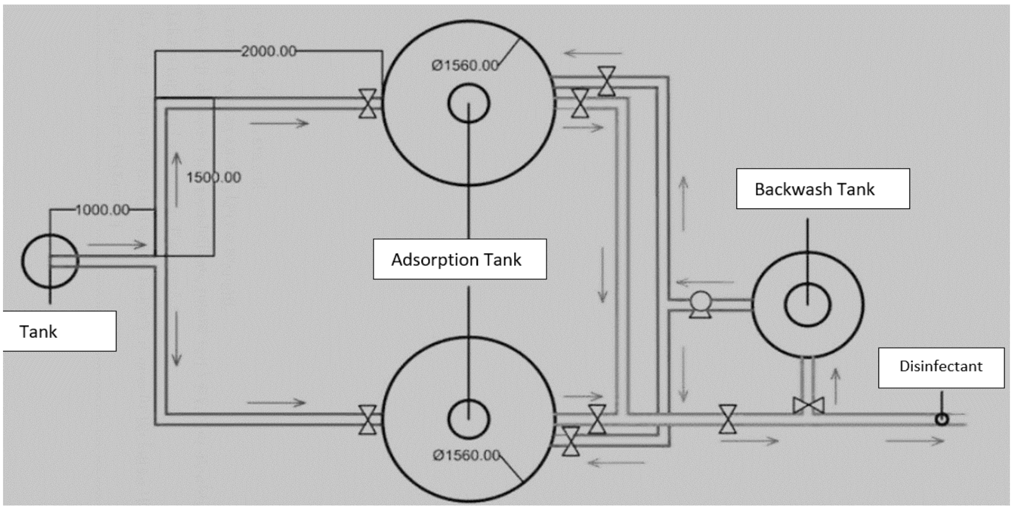

Figure 2. The results of the planned adsorption tank design in Klungkung Regency, Bali Province

Based on the results of the design, the detention time required is 20 minutes. Based on Goher (2015) research, the efficiency of aluminium removal using activated carbon adsorbent continues to increase until it reaches the optimum reduction in the 10th minute. If it is continued until the 60th minute, there is no significant change in the value, and the efficiency value is still around the importance of 99.2%. According to Irawan (2019) research, the efficiency of colour removal from groundwater reaches 98%. The optimum efficiency of colour removal ranges from 10-120 minutes (Afifah et al., 2021; Zahra et al., 2014). This shows that the design results with a detention time of 20 minutes can still set aside colour optimally. Therefore, in this design with a detention time of 20 minutes, the aluminium removal can still reach 99.2% and 98% colour removal, so that the aluminium concentration and colour in the effluent can be calculated (equation 2) as follows:

Allumunium efflunet (Ce) = $Co -$ (%removal × Co) = 0,35 mg/L × (99,2% × 0,35 mg/L) = 0,35 $mg/L -$ 0,347 mg/L = 0,003 mg/L
Colour efflunet (Ce) = $Co -$ (%removal × Co) = 20 TCU mg/L × (98% × 20 TCU) = 20 $TCU -$ 19,6 TCU = 0,4 TCU

Based on the calculation results, the aluminum concentration after processing was 0.003 mg/L while the color concentration was 0.4 TCU. Both values are already below the quality standard stipulated in the Minister of Health Regulation No. 492 of 2010, which is 0.2 mg/L for aluminum and 15 TCU for color.

Based on previous research regarding the removal of aluminum by adsorption, it was found that the adsorption capacity of aluminum was 120.8 mg/g. Based on this data, the GAC saturation point is calculated, assuming the same type of GAC is used. Based on this capacity, it is estimated that the saturation time of GAC as an aluminum adsorbent is 4.39 years. This result assumes that there is no decrease in the performance of GAC in absorbing aluminum. However, the absorption of adsorbate by GAC will decrease when the breakthrough point is reached, at that time the absorption of GAC will not be maximal and the adsorption capacity of GAC will decrease. To be able to determine with certainty the saturation time of GAC, it is necessary to conduct laboratory-scale experiments first to obtain a breakthrough curve, because each GAC has different characteristics which will certainly affect the adsorption capacity of GAC.

Based on Munfiah (2013) research, the organic content of groundwater in groundwater is 10 mg/L with a colour value of 50 TCU. The soil in the research location has an organic content of about 4.5%, while in this design, the constituent soil has an organic content of about 5% and a colour content in water of 20 TCU. In this case, the relationship between color and organic matter is considered linear, so the total organic matter in well water with a colour concentration of 20 TCU is 5 mg/L. Based on previous research, the adsorption capacity by colour was 200 mg/g. Based on this data, the GAC saturation point is calculated.

Saturation time for colour is based on the assumption that the adsorption capacity of GAC will not decrease over time. In contrast, the adsorption capacity will decrease after passing the breakthrough point. Based on the calculation of the saturation point of GAC by aluminium and colour, it is found that the saturation point of GAC in setting aside colour has a smaller value. In this design, the saturation point chosen is the saturation point for colour, which is 6.6 months. However, keep in mind that the adsorption capacity of GAC will not always be the same over time; after passing the breakthrough point, the adsorption capacity of GAC will decrease. Therefore, it is necessary to conduct a laboratory-scale experiment to determine the breakthrough curve in treating deep well water to obtain a more definite saturation point value. In addition, it is necessary to routinely check the colour and aluminium content during processing to see the performance of the adsorption unit and ensure that the designed unit can set aside the desired parameters.

The required backwash discharge is 0.02 m^3/s, and the backwash volume is 11.46 m^3. The backwash water will be taken from the effluent water after going through the adsorption treatment but before going through the disinfection process. When viewed from the need for backwash discharge, the effluent water intake for backwash is about 25% of the effluent discharge. This effluent water intake is carried out to make the network more efficient and minimize maintenance costs. Figure 3 shows the layout of the unit configuration in Klungkung Regency.

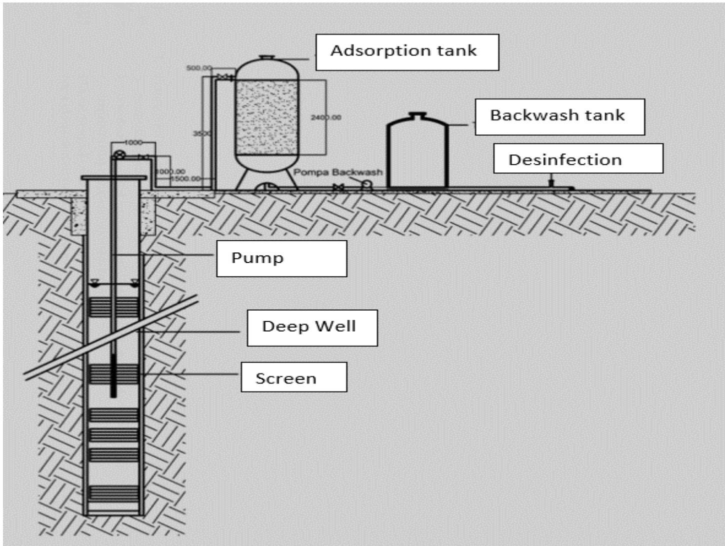

Figure 3. The layout of The Unit Configuration in Klungkung Regency.

CONCLUSION

The dimensions of the adsorption column unit (diameter × column height) in Klungkung Regency are 3.82 $m^{2,}$ with the number of adsorption columns being two units each. The GAC requirement for each deep well is 3209.4 kg. GAC regeneration takes 6.6 months. With this plan, it is hoped that the regional government will consider improving the quality of drinking water services, especially in the water consumed by the community so that it does not contain aluminum and color. In addition, it is necessary to pay attention to sustainable development to increase community participation in making drinking water supply.

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