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Local and Low-Cost Filter Media of Simple Water Filtration

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ABSTRACT

Commonly the Installation of a Drinking Water Supply System (SPAM) in Indonesia consists of Coagulation-Flocculation, Sedimentation, Filtration and Disinfection Processes as a complete Process Unit for surface feed water such as rivers or lakes. Similarly, the clean water treatment process in Banjarbaru, South Kalimantan, Indonesia uses intake water sources from irrigation. The intake water from irrigation used by the local Regional Drinking Water Company has good quality with a low turbidity value below the quality standards set by the central government. Based on these qualities, the right process unit to treat the water is by filtration only. Therefore, it is necessary to conduct evaluation and research to improve the efficiency of the process unit and the economic value of the water treatment. The purpose of this study is to investigate and evaluate irrigation feed water treatment by filtration using local and low-cost filter media. The filter reactor is designed with a rapid media filter type. The media is characterized using energy dispersive X-ray spectroscopy (EDS) and a scanning electron microscope (SEM) which is plugged in with EDS to find out the primary constituents and morphological information and after knowing the characterization of the media, and followed by tested the media placed in the water filter reactor with data collection. The results show that the size of the filter media has great effect on the quality of the processing water, which the smaller the media diameter conducted high selectivity and speed up filtration time. The greatest result obtained from testing feed water with media is 87.64%. Turbidity of the feed water sample process, which was previously 0.34 NTU, could be decreased to 0.02 NTU. Effective size of 0.4 mm and uniformity coefficient of 1.35 mm are the optimal allowable values.

1. Introduction

Clean water and proper sanitation are one of the targets of the SDGs in 2030, which aims to provide decent and safe water. However, some areas experience water shortages and are a major problem faced by several countries, especially developing countries such as Indonesia [1]. In this case, the Indonesian government, the Ministry of Public Works and Public Housing (PUPR), continues to endeavour to increase access to safe drinking water for all Indonesians by improving the piped clean

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water service network of the Drinking Water Supply System (SPAM). Regional-scale SPAM development is prioritized to fulfil domestic needs so that people enjoy quality drinking water at affordable prices, sustainable for 24 hours, and improve public health improvements related to clean water. One of the Regional SPAMs built by the government is Banjarbakula Regional SPAM, and this SPAM can increase PDAM services in Banjarbaru City, Banjar Regency, and Tanah Laut Regency of South Kalimantan range 60-80% with house connections (SR) totalling around 74 thousand. With the establishment of SPAM, the duty of local governments is required so that existing investments can be utilized optimally to serve the community.

The feed water source utilized by Banjarbakula SPAM comes from runoff from the Riam Kanan Hydroelectric Power Plant (PLTA). In quantity, the turbidity parameter can still be fulfilled as a source of feed water for the next few years because of the low pollution. Turbidity is one of the leading water quality parameters in environmental monitoring, water treatment or industrial process operations [2]. The pollution problem concerns the costs of producing feed water into drinking water [3-5]. As a consequence of pollution, it increases the costs incurred for operational costs. Increased river pollution can potentially occur in PDAMs in Indonesia and cause a high economic burden [6].

Water pollution risks access to clean water sources and impacts clean water treatment by Regional Drinking Water Companies (PDAMs) [3]. Feed water must be treated first to meet water quality standards [7]. Proper treatment is essential to remove contaminants in feed water. The effectiveness of treatment facilities will significantly affect the quality and cost of treated water [8].

Waters generally have multiple functions, technically and ecologically. Water sources are technically useful for feed water sources, irrigation sources, power generation, industry, tourism, and water transportation, as well as aquaculture development land [9]. Riam Kanan Reservoir is one of the reservoirs whose feed water sources are utilized as feed water sources for the drinking water supply industries. Lakes and reservoirs are stagnant water habitats basins that accommodate water and store water from rainwater, groundwater, springs or river water [10]. Guaranteed availability in quality and quantity of feed water is essential to maintain services because water is one of the basic human needs.

Various methods are carried out for water treatment other than chemical methods, and physical methods can be a choice because they are safe and free from the risk of chemical exposure to the body. An example of a physical method is the filtration method [11]. Filtration is one of the water treatment system processes by flowing fluid through a layer of solid particles. Fluid flow through a layer of solid particles is essential in water treatment [12]. Moreover, it is generally influenced by the porosity of the media [13]. In other hand, membrane technology is also widely used for treating water with outcomes as drinking water [14-25]. Both of inorganic and organic membranes affordable for producing potable water from saline, peat, wetland, and river water as feed water [19,21,25-33].

In determining the type of filter to be used, it should be researched and observed in advance the solids contained in the feed water and several factors that affect it [34]. from several studies on filters, including research conducted by Kazemi Noredinvand *et al.,* [35]. Investigating the performance of single-media filters and double-media silica sand media can increase organic matter removal efficiency (TOC, COD). Likewise, the research results with feed water sources from dug wells filter with media type and thickness variations also affect the decrease in TSS and Fe concentrations. Filtration results have met clean water quality standards [36].

Various previous testing studies have been conducted to obtain water quality by filtering or filtration using different filter media, both of the type, size, shape, and content of the filter media or filter. With the existing feed water quality information, the turbidity of the feed water is 2-14 NTU, so by using filter media without other processes, how effective the filter is in reducing existing contaminants in the hope that the use of coagulant chemicals can be reduced. This research is vital because pollutants and water quality are different in each region, so the question arises whether the results of water quality treatment with filtering methods using different materials and types produce the same water quality or different water quality, and how does the type, size of sand grains as filter media affect water quality. This process is carried out to analyse the media used as filter media and how effectively each media removes contaminants in feed water. Processing is related to feed water sources and production costs incurred in processing feed water into drinking water that is distributed and utilized to fulfil the community's fundamental rights for daily needs. So, there is a guarantee to distribute the quality following Government Regulation of the Republic of Indonesia Number 22 of 2021 about the Implementation of Environmental Protection and Management, which concerns protecting and managing water quality. Furthermore, it improves health in terms of guaranteeing decent and safe water.

When selecting water treatment technologies and systems, it is crucial to provide as complete a picture as possible of the quality of the feed water source that will be utilized and available. Knowing what contaminants are present in the feed water before designing the treatment system is essential. Maintaining all existing treatment monitoring is equally important to ensure that each stage of turning feed water into clean water is effective and efficient.

2. Methodology

The test begins by analysing the sand content that will be used as a filter media. To determine the mineral content of sand samples. Before testing the sample, the drying process is carried out first, followed by the grinding process up to 100 mesh and the test sample is pressed until it is formed like pellets. This palletisation process is widely used because it is simple and can create homogeneous samples for analysis. A 40 mm mould with a load force of 30 Tons within 30 seconds and pellets measured with XRF up to 30 KVA XRF test was conducted at the Energy and Mineral Resources Laboratory of South Kalimantan Province. Testing is carried out again at the National Research and Innovation Agency Directorate of Laboratory Management to determine characterization using the SEM tool, the use of this tool aims to see the morphology of the sample. And EDS is used to find out the elements contained in the sample. After knowing the sand media that is the next choice, sand specific gravity testing and sieve analysis were carried out at the Soil Mechanics Laboratory of Lambung Mangkurat University. The filter media selection follows the single media filter media criteria. The selection of filter media to be used is carried out by filter analysis. Filter media filter results are depicted in a distribution accumulation curve to find the desired effective size and uniformity of media as the coefficient of uniformity. Uniformity Coefficient (UC) or uniformity coefficient is a filter media for uniformity numbers expressed by a ratio between the size of the diameter at the weight fraction of 60% with the effective size or can be written with the equation:

$$\text{UC} = \frac{d_{60}}{d_{10}} \tag{1}$$

The filter media is placed into a filter reactor with Ø 4" acrylic pipe and various effective size (ES) (0.4; 0.5; 0.6, and 0.7). There are several UC measurements, such as 1.2; 1.35; 1.5 and 1.65. The thickness of the sand and supporting gravel medium is 60 cm and 20 cm, respectively.

The feed water used in this work is taken from a reservoir flowing in the intake building that is transmitted by a pump with a piping system to the drinking water treatment system. Analysis of hydraulics in pipes considers the value of the strength of the flowing water, the cross-section of the diameter of the pipe and the speed at which it affects the flow by the equation of flow rate (Q)= velocity (v) x surface area (A)

$$Q = A \, . V \tag{2}$$

Analysis of head pump calculation describe in Eq. (3) below,

$$\text{Head pump = Head static + Total head loss + } \frac{v^2}{2.g} \tag{3}$$

Pressure loss in pipes with equations

$$\text{Head Loss } = \left[\frac{\text{Q}}{0{,}2785\text{xCHwxD}^{2{,}63}}\right]^{1{,}85} \text{x L} \tag{4}$$

$$\% \text{ R} = \left[\frac{\text{C in} - \text{C out}}{C\ in}\right] \text{x } 100\% \tag{5}$$

Testing of the results of the feed water filtration process and the results of the filtration process are accommodated in a water sample place and tested completely in accordance with the Regulation of the Minister of Health of the Republic of Indonesia Number 2 of 2023 concerning the Implementing Regulation of Government Regulation Number 66 of 2014 concerning Environmental Health is carried out at the Banjarbaru Industrial Standardization and Services Centre Laboratory. Testing and calibration laboratory accredited by the National Accreditation Committee (KAN) in accordance with the requirements of SNI ISO 17025: 2017.

2.1 Materials

The sand filter media was taken from Liang Anggang District, Banjarbaru City and Sungai Tabuk District, Banjar Regency, South Kalimantan Province-Indonesia. Feed water was from transmission pipes from the Banjar Bakula drinking water treatment plant. Research materials were silica soil size 0.4 mm – 1.65 mm, gravel, valve, Ø 4" acrylic pipe, turbidity meter, pH meter, and spectrophotometer.

2.2 Characterization of Filter Media

Basically, the particles that make up the soil structure have various sizes and shapes, both in cohesive and non-cohesive soils. The nature of a soil is largely determined by the size of its grains and distribution. Therefore, in soil mechanics, grain size analysis is widely carried out to reference soil classification.

Filter media selection is done by *sieve analysis*. Sieve analysis is used to test the soil and find out if the soil content consists mostly of medium sand, fine sand, coarse sand, and gravel [37]. The selection of filter media to be used is done by sieve analysis. The sieve result of a filter media is depicted in the distribution accumulation curve to find the effective size and uniformity of the desired media expressed as uniformity coefficient) [38]. From both soil samples taken produced values of test results.

3. Results and Discussion

Regional SPAM development is an option because the availability of feed water for drinking water is uneven between regions. In terms of quantity, the feed water in the area in the Bakula regional zone has excessive strength, but its quality has yet to be guaranteed for its sustainability. Therefore, the District, City and Provincial Governments form a SPAM system to utilize feed water sources together. The feed water source utilized by Banjarbakula SPAM is feed water taken from the Mandi Kapau weir, upstream of which there is a water dam utilized as a Hydroelectric Power Plant (PLTA). The water discharge from the PLTA flows through the long storage. It is blocked at the Mandi Kapau Dam before being divided into the Riam Kanan River and the Primary Irrigation Channel for agriculture. Based on preliminary data, it is known that the quality of the feed water source from the Riam Kanan Dam, which flows into the Riam Kanan irrigation open channel, has a turbidity value of 14 NTU in 2022, data obtained from the measurement of feed water intake for PT. Intan Banjar Drinking Water.

From this initial information and references to several journals studied, the authors tried to examine filter media without using coagulant chemicals. The initial process of the research began by examining the characteristics of the filter media to be used, starting with examining sand media samples from the Liang Anggang sub-district of Banjarbaru City and sand from the Sungai Tabuk sub-district of Banjar Regency. The sand samples were examined to determine the sand's characterization in the two regions. The following process is to design the filter reactor following the design criteria and conduct experiments using the designed reactor using local sand media that has been tested and known for its characterization.

3.1 Sand Filter Media Characterisation

The forming particles of the soil structure have various sizes and shapes, both in cohesive and non-cohesive soil particles. The nature of the soil is determined mainly by its grain size and distribution. Therefore, in soil mechanics, grain size analysis is widely used to classify soils.

The selection of filter media to be used is done by sieve analysis. Sieve analysis tests the soil and determines whether the soil content consists mainly of medium sand, fine sand, coarse sand, and gravel [37]. The selection of filter media to be used is done by sieve analysis. The sieve results of a filter media are described in the accumulation distribution curve to find the adequate size and uniformity of the desired media (expressed as uniformity coefficient) [38]. The sand used as filter media is taken from the Liang Anggang District of Banjarbaru City and Sungai Tabuk District of Banjar Regency, South Kalimantan Province.

3.1.1 Silica sand from Liang Anggang sub-district, South Kalimantan-Indonesia

The sand was tested in the laboratory, and the results were determined. The result of the physical and chemical properties analyses and a complete picture of the sand's characteristics provided input for further processing and designation. The results of testing and sieve analysis for sand samples from Liang Anggang sub-district using the sand sieve test are shown in the Table 1.

Table 1
Parameter Test Results

No	Parameter		1	2
1	Pycnometer Weight + Soil + Water	g	175.18	183.11
2	Pycnometer Weight + Water	g	156.50	164.40
3	Pycnometer Weight	g	56.6	61.7
4	Pycnometer Weight + Dry Land	g	86.6	90,88
5	Weight of dry soil	g	30	30
6	Temperature	˚C	27	27
7	Temperature Correction		0,9983	0,9983
8	$Gs_{27°}$		2,650	2,665
9	$Gs_{27°}$		2,646	2,661
	Specific Gravity (Average)		2,649	

Sand samples from Liang Anggang Subdistrict, Banjarbaru City and the test results, the specific gravity of Liang Anggang sand was 2.649. The physical value of quartz sand, in general, in Indonesia is 2.65 [39]. As a conclusion, it can be concluded that it is qualified to be used as filter media.

Table 2
Liang Anggang Sand Sieve Analysis

Sieve number	Diameter Hole (mm)	Restrained Weight (gr)	Restrained Cumulative Weight %	Retained Cumulative Percent (%)	Percent who passed (%)
4	4.75	19.18	6.39	6.39	93.61
10	2.00	34.06	11.35	17.75	82.25
20	0.840	54.21	18.07	35.82	64.18
40	0.420	58.22	19.41	55.22	44.78
50	0.297	35.45	11.82	67.04	32.96
60	0.23	33.23	11.08	78.12	21.88
80	0.177	12.00	4.00	82.12	17.88
100	0.149	26.25	8.75	90.87	9.13
200	0.074	13.78	4.59	95.46	4.54
pan		13.62	4.54	100.00	0.00

Sand sieves use sieves with diameters of 4.75 mm, 2.00 mm, 0.840 mm, 0.420 mm, 0.297 mm and size 0.23 mm. In the sieving process, some small pebbles or rocks are still left on the sieve, which will later be separated. From the sand sieving results presented in Table 8 which displays the percentage of the amount of Liang Anggang sand, which is retained on the initial sieve or number 4, the percentage obtained is 93.61 % for coarse aggregate, followed by sieve number 10 = 82.25 %, sieve 20 = 64.18 %, sieve 40 = 44.78 %, sieve 50 = 32.96 %, sieve 60 = 21.88 %, sieve 80 =17.88 %, sieve 100 = 9.13 %, and sieve 200 = 4.54 %.

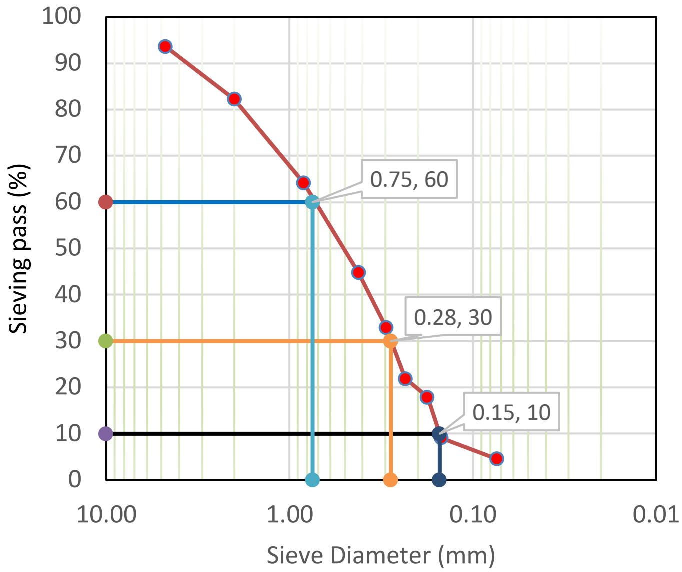

Fig. 1. Liang Anggang Sand Distribution

Where: D10, D30, and D60 are particle diameters corresponding to 10%, 30%, and 60% finer respectively. D10 is also called the effective measure of solids [40]. From the results of the sieve test and depicted on the sieve chart, the value of Effective Size (ES) = d10 = 0.15 mm and d60 = 0.75 mm is obtained. For the size value ES = 0.15 mm, from some existing references (Table 3) meet the criteria for the filter media. The calculation of *the Uniformity Coefficient* (UC) using equation number 1 obtained the size of UC media = 4.94 mm

To add references in the selection of filter media size, several references related to filter media criteria were obtained. Some of these references are shown in Table 3.

Table 3
References Criteria Media

Reference	WHO Manual (Huisman & Wood)	Hazen	IRC Manual (Visscher *et al.,)*	Ten States Standards	SNI 3981:2008
Effective Size (ES) = d_{10}	0.15 – 0.35 mm	0.15 – 0.35 mm	0.15 – 0.30 mm	0.15 – 0.30 mm	0,45-0,55 mm
Uniformity Coefficient (UC)	< 3	< 3	< 5	< 2.5	2 - 3

3.1.2 Silica sand from Sungai Tabuk sub-district, South Kalimantan-Indonesia

The same test was also carried out with sand samples taken from Sungai Tabuk District. The test data is shown in Table 4.

Table 4
Parameter Test of Sungai Tabuk Sand

No	Parameter		1	2
1	Pycnometer Weight + Soil + Water	g	180,84	180,53
2	Pycnometer Weight + Water	g	162,13	161,79
3	Pycnometer Weight	g	60,45	60,25
4	Pycnometer Weight + Dry soil	g	90,45	90,88
5	Weight of dry soil	g	30	30
6	Temperature	ºC	27	27
7	Temperature Correction		0,9983	0,9983
8	$Gs_{27°}$		2,656	2,665
9	$Gs_{27°}$		2,652	2,661
	Specific Gravity (Average)		2,656	

From several tests conducted, it can be concluded that the specific gravity (average) of Sungai Tabuk is 2.656.

Table 5
Sieve Analysis Sand of Sungai Tabuk Sub-district

Sieve Number	Diameter Hole	Restrained Weight	Restrained Cumulative Weight	Retained Cumulative Percent	Percent who passed
4	4.75	1.87	0.62	0.62	99.38
10	2.00	77.68	25.89	26.52	73.48
20	0.840	68.07	22.69	49.21	50.79
40	0.420	53.93	17.98	67.18	32.82
50	0.297	40.62	13.54	80.72	19.28
60	0.23	20.00	6.67	87.39	12.61
80	0.177	7.23	2.41	89.80	10.20
100	0.149	4.87	1.62	91.42	8.58
200	0.074	1.37	0.46	91.88	8.12
pan		24.36	8.12	100.00	0.00

From the test results presented in Table 11 which displays the percentage of distribution from Tabuk River sand, which is held in the initial filter 99.38% obtained for coarse aggregate, followed by filter 10 = 73.48%, filter 20 = 50.79%, filter 40 = 32.82%, filter 50 = 19.28%, filter 60 = 12.61%, filter 80 = 10.20%, filter 100 = 8.58%, and filter 200 = 8.12%.

Effective size and uniformity coefficient affect the removal of turbidity and pressure loss that occurs in the filtering process. The smaller the effective diameter used as a filter medium, the better turbidity allowance. This is because the smaller the effective diameter, the smaller the porosity which results in solid particles that are larger than the porosity of the filter media will be retained on the surface of the sand media. The sieve result of a filter media is depicted in the distribution accumulation curve to find the effective size and the Uniformity Coefficient.

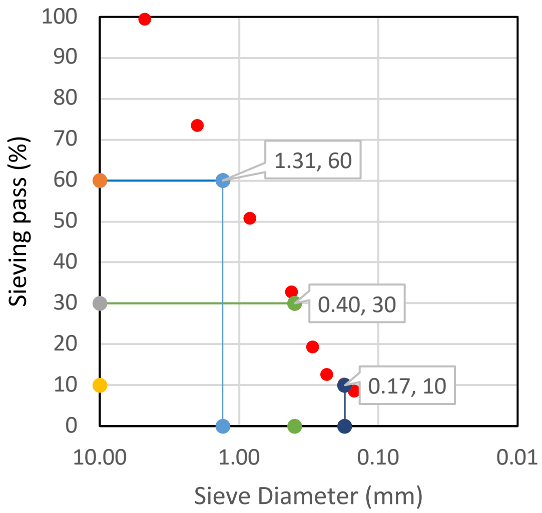

Fig. 2. Sand Distribution in Sungai Tabuk District

From the test results presented in Table 11 which displays the percentage of distribution from Tabuk River sand, which is held in the initial filter 99.38% obtained for coarse aggregate, followed by filter 10 = 73.48%, filter 20 = 50.79%, filter 40 = 32.82%, filter 50 = 19.28%, filter 60 = 12.61%, filter 80 = 10.20%, filter 100 = 8.58%, and filter 200 = 8.12%.

Effective size and uniformity coefficient affect the removal of turbidity and pressure loss that occurs in the filtering process. The smaller the effective diameter used as a filter medium, the better turbidity allowance. This is because the smaller the effective diameter, the smaller the porosity which results in solid particles that are larger than the porosity of the filter media will be retained on the surface of the sand media. The sieve result of a filter media is depicted in the distribution accumulation curve to find the effective size and the Uniformity Coefficient.

3.2 XRF of Media Filter Characterisation

XRF analysis utilizes high-energy X-rays to reflect electrons at the lowest energy level in the sample resulting in an electron transition to fill the position of the excited electron, accompanied by re-emission of characteristic X-rays of lower energy [41]. From the XRF test, the results are shown in Table 6 atomic elements and oxide compounds in mass percentage (%).

From the data shown in Table 6, the silica content in the two regions has a different character; silica sand from Liang Anggang Subdistrict has a SiO_2 content of 96.22%. Meanwhile, the sand sample taken from Sungai Tabuk sub-district has a higher SiO_2 content, reaching 97.74%. The best sand is used for filters if the sand contains quartz (SiO_2) greater than or equal to 90.8% [42]. greater than or equal to 90.8% (Sulastri & Nurhayati, 2014). Another reference is that the silicon dioxide content of silica sand contains at least 85%, as determined by ASTM C114 [43]. The two sand samples tested and used for filter media are from Sungai Tabuk District, which has a more significant SiO_2 content.

Table 6
Atomic elements and oxide compounds in mass percentage (%)

Parameter	Liang Anggang %	Sungai Tabuk %
SiO_2	96.22	97.74
Fe_2O_3	0.26	0.3
Al_2O_3	2.77	1.22
CaO	0.13	0.12
MgO	<0,01	<0,01
TiO_2	0.17	0.04
K_2O	0.08	0.02
Na_2O	0.02	0.02
MnO_2	<0,01	<0,01
Cr_2O_3	0.16	0.01
ZrO_2	0.01	0.01
LOI	0.15	0.5

3.3 X-Ray Diffraction (XRD) of Media Filter Characterisation

XRD analytical AERIS (X-RAY SOURCE COPPER, Cu) X-ray diffraction test is an analytical method that utilizes the interaction between x-rays and atoms arranged in a crystal system. An explanation of the crystal system is first described to understand the principle of X-ray diffraction in qualitative and quantitative analysis [44]. This XRD will produce results in the form of peaks of compounds that make up the sample. XRD test results on the sample are shown in Figure 3 and Figure 4 below. XRD tests were carried out on quartz sand media from Sungai Tabuk, because it is the choice for filter media and has a more significant silicon oxide SiO_2 content of 97.74%.

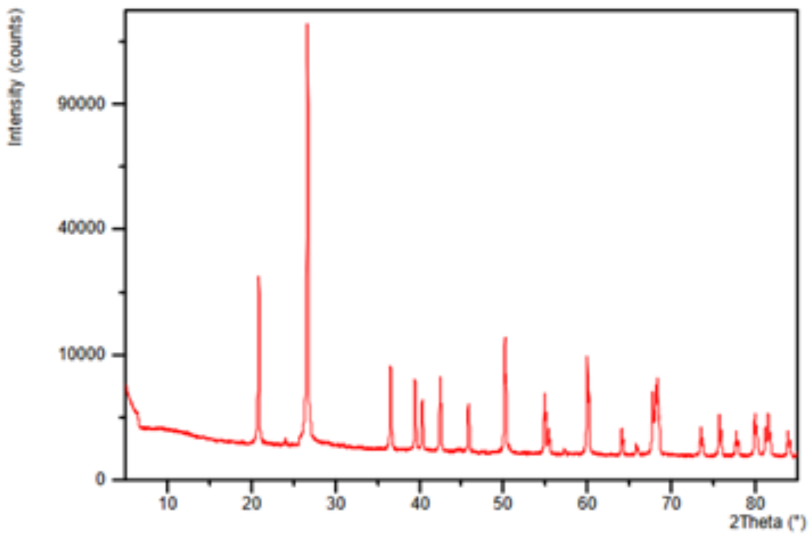

Fig. 3. X-Ray Diffraction (XRD) Result of Sungai Tabuk subdistrict

Based on the results of sample tests using XRD with X-ray wavelength (λ) = 1.54060 Å and refraction order (n) = 20 - 80, the results in the following table are obtained to measure the degree of crystallinity of silica based on the XRD pattern described. The highest peak in the tested sample is located at 2θ of 26.6°. It indicates the presence of silica, which is still amorphous. In addition, there are peaks present in the sample. These results follow the results of the XRF test, where the most extensive oxide compound content in sand samples from Sungai Tabuk District is one of the silica oxides compounds SiO_2.

3.4 SEM-EDS Analysis Results

Characterization of samples using SEM tools aims to see the morphology and topography of the sample. EDS is a tool used to determine the elements contained in the sample. EDS can be performed on small areas (points), lines and boxes. Sample testing was conducted at the National Research and Innovation Agency Directorate of Laboratory Management. Based on the results of SEM observations, it can be seen that SiO2 particles of size ~ 1 ηm can be observed. However, most appear to be a collection of tiny particles that merge to form large particles (agglomerated). SEM images of Sungai Tabuk sand for magnification (a) 2,500x, (b) 5,000x, (c) 10,000x and (d) 20,000x are shown.

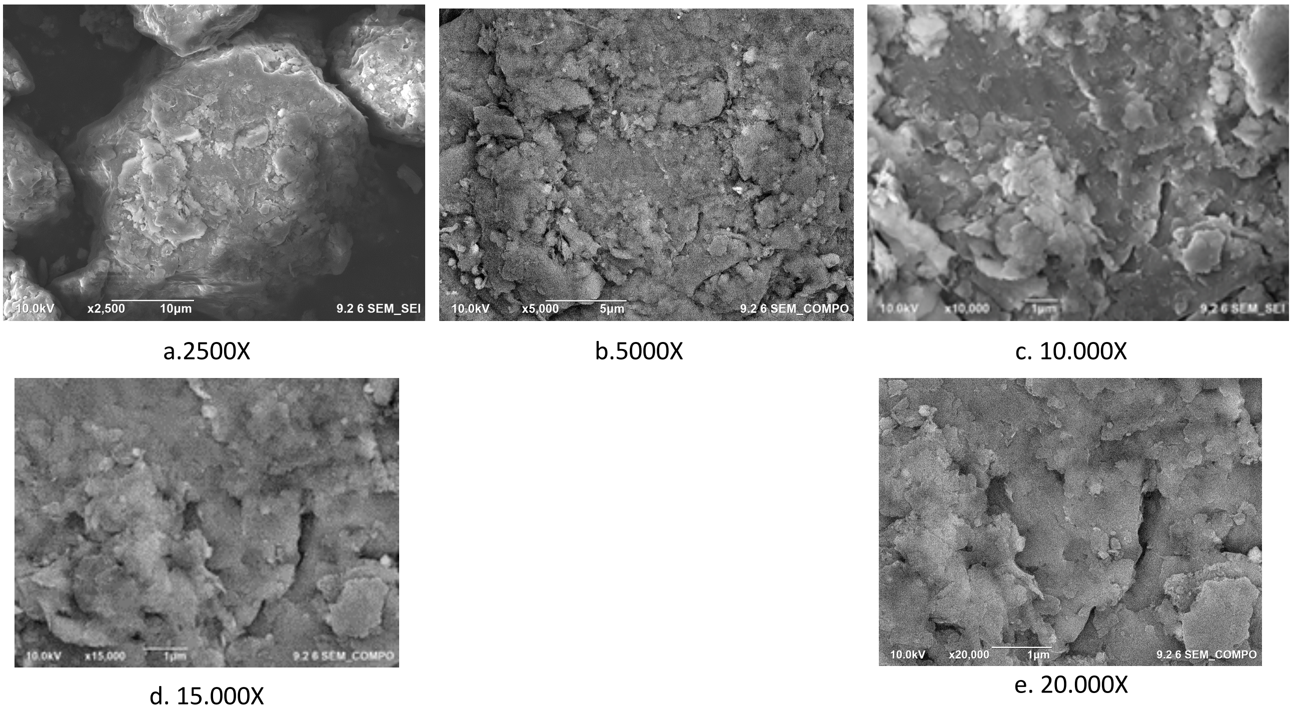

Fig. 4. SEM images of Sungai Tabuk sand for magnification (a) 2,500x, (b) 5,000x, (c) 10,000x, (d) 15.000 and (e) 20,000x

Silica powder samples were observed using an SEM instrument to determine the characteristics of the microstructure and particle size. Observations were made with varying magnification, as shown in Figure 3. Testing of sand material from Sungai Tabuk using EDS (Energy Dispersive Spectroscopy) technique. Most SEMs have this capability, but not all SEMs have this feature.

The SEM photograph (Figure 4) shows the microstructure of the surface of the sand sample from Sungai Tabuk sub-district. The microstructure produced for the sample shows more homogeneous grains with various shapes, and the boundaries between grains are clear. The microstructure of the sand sample shows agglomeration with the presence of small particles with homogeneous grain size.

This SEM analysis is complemented by EDS analysis, which can show the sample's chemical composition, as shown in Figure 5. The results of EDS analysis identify the elements contained in the sample, including oxygen (O), silicon (Si), carbon (C), aluminium (Al), iron (Fe), potassium (K), Chromium (Cr), and. Ti These elements then form oxide compounds such as SiO_2, Fe_2O_3, Al_2O_3, CaO, MgO, TiO_2, K_2O, dan MnO_2. Compounds other than silica remain from before and after the extraction process. The EDS (Energy Dispersive Spectroscopy) analysis found that the Si and Al content was relatively high. With a Si compound value of 36.1%

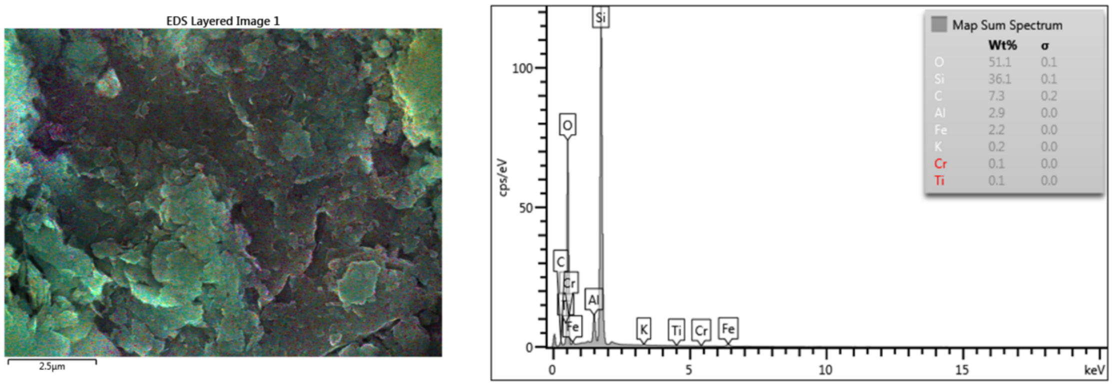

Fig. 5. DES analysis result Sungai Tabuk Sand

The results of SEM characterization on Sungai Tabuk sand samples found elemental content dominated by Silicon (SiO_2) which is bright white. This result is reinforced by XRD characterization with a crystal phase of 26.6% (SiO_2). Other morphologies and crystal phases, such as Aluminium (Al_2O_3) were also found in the sample by 11% and in the SEM results by 36.1%.

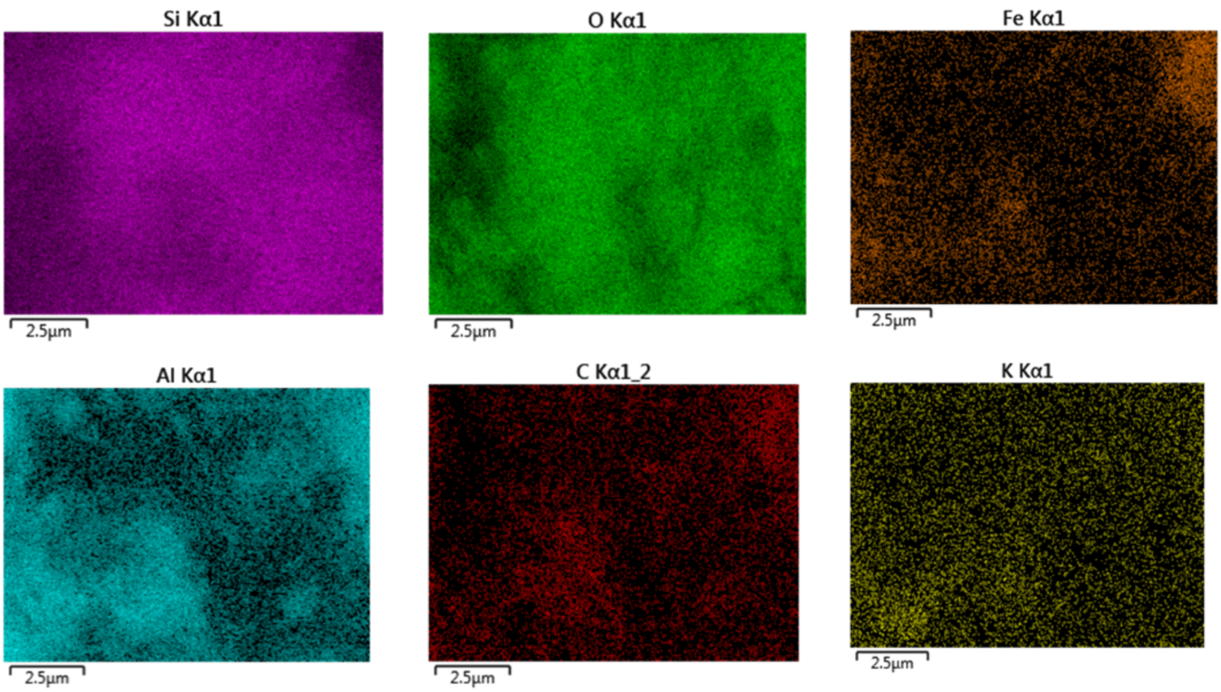

Fig. 6. DES Analysis Results Elements Sungai Tabuk sub-district

3.5 Characteristic of Feed Water

Feed water from Mandi Kapau weir has flowed with a pump with a capacity of 3 x 400 l / s with a diameter of 1200 mm diameter transmission pipe used. A transmission pipe is one of the networks that brings feed water from the source to the processing location and from the collection building to the initial point of distribution [45]. The length of the pipe from the intake location to the production site is 14,997 meters directly into the water treatment. Before feed water is flowed to customers, feed water must go through the processing stages in the clean water treatment process.

The conventional treatment process is carried out by providing coagulants or the Coagulation process by providing injection and rapidly stirring the coagulant solution using PACL (Poly Aluminium Chloride Liquid) solution. PACL, which is more of a coagulant aid, is based on the frequent changes in the turbidity value of feed water. This unit will have a colloidal destabilization process and the merging of fine particles into coarser aggregates (micro flocs).

The next step of the coagulation process is the flocculation process, where water from the Coagulation Tub flows into the Flocculation Tub to get slow and continuous stirring so that micro flocs will form macro flocs that reach a form that is easily removed through the process of precipitation or filtering, which must be a concern in this coagulation and flocculation process is the value of G and td so that the process can run perfectly.

The sedimentation or deposition process is carried out after the water has gone through the flocculation process, where the flocculent particles, namely the particles resulting from the merger between colloidal particles and coagulant material, will have an increasing settling speed because the particle density increases. In the sedimentation basin, the flow must be conditioned to remain calm,

The last process in conventional system processing is filtration. The processed sedimentation results flow into open filtration tanks with quartz sand media. This filter tub will separate fine floc that does not settle in the previous process. Filtration speed must be considered in addition to other requirements so that the filtering process can run as expected. With this filtration process, there will be an increase in the quality of processed water. Then, it is accommodated in the reservoir.

All process flows are stages carried out to meet the standard quality of clean water before it flows to consumers. This standard follows the literature from WHO, which explains that the selection of process units depends on the quality of feed water entering the treatment plant process and the expected water quality [46].

3.5.1 Hydraulics analysis of transmission pipe network

The transmission pipe from the intake is transmitted to the Water Treatment Plant at a distance of 14,997 meters. Pipe diameter 1200 mm of HDPE material.

Transmission pipe system data:

- Pipe diameter : 1200 mm
- Pipe type : (High Density Poly Ethylene) HDPE
- Transmission pipe length : 14.997 m

Analysis of hydraulics in transmission pipelines to ensure the ability of existing pipes to distribute feed water to treatment plants. Determination of pipe diameter is done by calculating the volume of feed water to be flowed according to the needs for production. Until 2023, the Banjarbakula SPAM has built a Water Treatment Plant with a total installed capacity of 750 l / s. To determine the ability of the installed diameter to operate the Installed IPA, it is assumed that the flow velocity in the pipe is 0.70 m/s, so to measure the pipe diameter:

Flow velocity, (v) = 0.70 m/s (Assumption)
Maximum daily discharge = 750 L/s = (Built-up capacity)
Using formula number 2 and the speed is assumed to be 0.7 m/s
$Q = 0.25 \times 3.14 \times 1.2^2 \times 0.70$

D = 1.167 mm

If it is assumed that the use of people/day = 150 L/person/day with an installed IPA capacity of 750 L/s, SPAM Banjarbakula can serve 432,000 people.

3.5.2 Feed water pump head

Pump Head = Static Head + Total Head loss + v^2/ (2.g)

Static head = highest water level at WTP - lowest water level at Intake
= (27 m + 3 m) - 8 m
= 22 m

HL mayor pipa discharge = $\left[\frac{1,2}{0.2785 x 140 x 1.2^{2.63}}\right]^{1,85} x12$
= 0.0079 m

HL mayor transmission pipe = $\left[\frac{1,2}{0.2785 x 140 x 1.2^{2.63}}\right]^{1,85} x14.997$
= 9.86 m

HL mayor total = 9.87 m

HL minor = 20 % x HL mayor
= 20 % x 9.87 m
= 1.97 m

HL total = 9.87 m + 1.97m
= 11.83 m

$\frac{v^2}{2.g}$ = $\frac{8xQ^2}{\pi^2 x D^4 x g}$
= $\frac{8x1.2^2}{\pi^2 x 1.2^4 x 9.81}$
= 0,057 m

Head Pump = 22 m + 11.83 m + 0.057 m
= 40.9 m

3.5.3 Calculation of feed water pump power

Hydraulic power (Nh) = Q.H.g.ρ (watt)
= 1.2 x 40.9 x 9.81 x 996.5
= 479.80 watt
= 479 KW

Pump shaft power (P) = $\frac{Nh}{\eta p}$ ➔ ηp = pump efficiency
= $\frac{479.80\ KW}{0.85}$
= 564,47 KW

Start driving force (Nm) = $\frac{P(1+\alpha)}{\eta t}$
= $\frac{564.47\ (1+0.2)}{0.95}$
= 713.024 KW

The calculation results show that if using a capacity under the installed IPA capacity, it can be ascertained that there is a power loss in using electrical energy to reduce the installed cost of the transmission pump using several pumps with a capacity according to the water needs used. The current pump has three intake capacities of 400 L / s head 40 meters.


Transmission Pipe Banjarbakula SPAM

Location Banjarbakula SPAM

Fig. 7. Research Location

3.6 Performance of Reactor and Filter Media

Filter media testing using one filter reactor is designed with a rapid sand filter type. Rapid sand filters are generally used in Conventional IPA; SPAM also uses this type of filter in Indonesia, one of which is SPAM Banjarbakula. The filter is designed using a single media with silica sand media. The selection of silica sand media is based on the ease of finding silica sand media materials. One of them is local sand from Sungai Tabuk Subdistrict, which has been tested for mineral content and from the initial test results, it meets the specifications for use as a filter media.

3.6.1 Reactor design specifications

The initial test reactor was carried out with a filter made of transparent pipe with a diameter of 4" (0.1016 meters) with a filter height of 1.5 meters from the bottom. With the same thickness, the head loss of the pump will be greater if the diameter of the media grains is the smaller size.

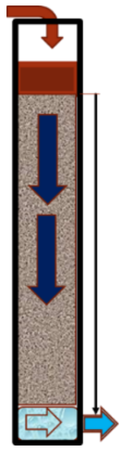

Fig. 8. Reactor Design

Head loss at the beginning of filtration is a linear function of and inversely proportional to the diameter of the grains with the same thickness head-loss will be greater if the diameter of the media grains is a more diminutive grain.

As a reference for designing filters following previous studies and filters used for conventional water treatment, the design calculation refers to the general filtration criteria.

Table 7
General Criteria of Filtration

Description	Value	Unit
Flow velocity through media	6 - 12,5	m3/m2/day
Media Thickness		cm
Sand	60 - 90	cm
Anthracite	30 - 40	cm
Buffer media thickness (gravel)	20 - 50	cm
media size Sand	0,5 -1,4	mm
buffer media size	3 - 60	mm
Backwash time	5 - 10	menit
porosity	0,38 - 0,40	
Specific gravity of sand	2.65	Kg/m3
maximum expansion	20-30	%

From the general criteria above, the calculation results for the filtering test reactor are obtained and summarized in Table 8 below

Table 8
Design criteria of Filter Reactor

Description	Value	Unit
Q Planning	1	l/min
	0.0166	l/s
Reactor Height	1.5	m
Diameter	4	inch
	4 x 2,54	cm
	10,16	cm
Media		
- Gravel		
Media Thickness	20	cm
Diameter (d)	1	cm
Porosity (e)	0.40	
- Silica		
Media Thickness	60	cm
Spericity (Ψ)	0.95	
Porosity (e)	0.38	
ρ	2.656	Lab results

3.7 Effect of Filter Media Variation on Filtration Performance

Filter reactor testing uses gravel media thickness = 20 cm and silica sand media = 60 cm. testing variations with changes in effective size and uniformity. To obtain effective size values and uniformity in accordance with the previously researched filter media size plan, sand was selected using the re-sand filter method. The diameter used is in accordance with the diameter that has been planned for the filter media size. The filter media sizes used are Effective size: 0.4; 0.5; 0.6; and 0.7 with Uniformity Size (UC): 1.35; 1.45 1.55; and 1.65. From the results of the existing filter, the size obtained is as shown in one of the graphs below with the initial sand weight according to the total filter media requirement.

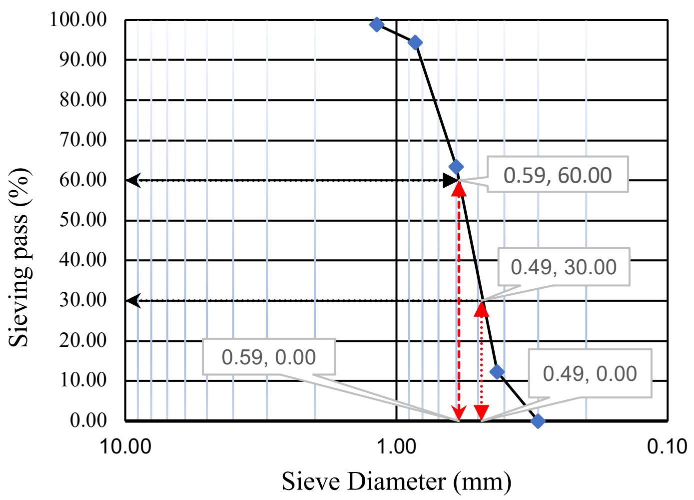

Fig. 9. Distribution of Filter Sand Media

Sampling is taken every 20 minutes of filter operation. Quality measurement by comparing the quality before and after the feed water goes through the process by passing through the filter media. Filtration is the process of removing suspended solids from the air by passing air through a permeable fabric or layer of porous material [47]. Granular filtration is a process in which water is purified by passing it through a porous material [48]. Several parameters in choosing the right filtration media take into account the ability to remove turbidity, the frequency of filter media cleaning cycles during the filtration process. Pressure loss is slower than ordinary sand filters, and has a greater output than ordinary sand filters over a certain period [49]. The filtration system must be designed and made from the best media materials with priorities that meet the effective size and coefficient of uniformity [50].

The results of filtering feed water for turbidity parameters produce a higher percentage reduction in turbidity levels due to the smaller diameter of the sand used, namely 1 mm and the suspension will separate from the water because the suspension cannot pass through the pores of the filter media used, resulting in reduced turbidity values. where the turbidity value increases along with the number of particles or suspensions contained in the water. Water containing high turbidity will experience difficulties when processed to make clean water or drinking water. Turbidity in water is caused by the presence of suspended water, such as clay, mud, organic substances, plankton and other fine substances. Turbidity measurements in this study used a turbidimeter. Turbidity in water can reduce water quality from an aesthetic perspective. Therefore, according to Minister of Health Regulation number 2 of 2023, the maximum permissible turbidity for drinking water is 3 NTU. Turbidity analysis is carried out on the inlet and filter effluent every 20 minutes, the test results are displayed in the graph below. Variations in media size were used using Effectiveness size (ES) 0.4, 0.5, 0.6, 0.7 and Uniformity Coefficient (UC) 1.55 with sampling every 20 minutes of filter operation. Turbidity quality is measured by comparing the quality before treatment using filter media and after the feed water has gone through the process by passing the feed water through the filter media.

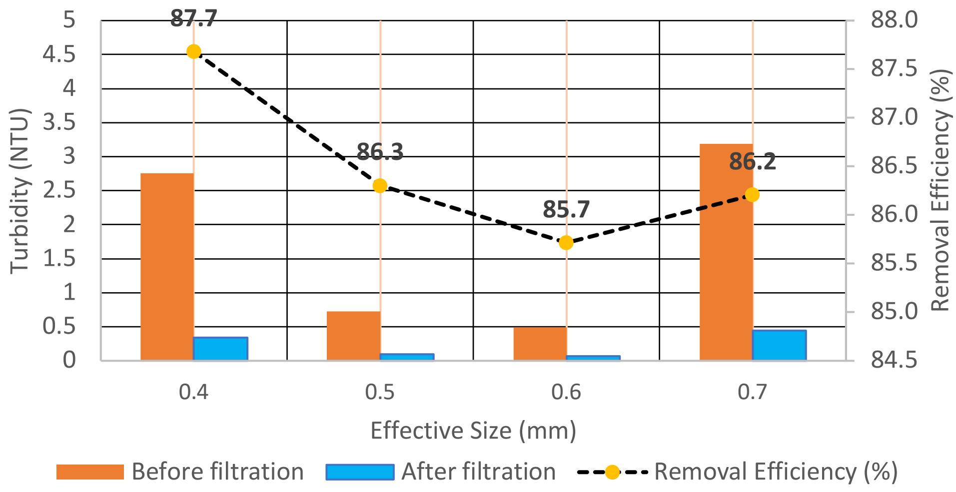

Fig. 10. Turbidity with Variation in Size Effectiveness

Test results with variations in Effective Size, the test was carried out in 3 trials with feed water quality collection times every 20 minutes for 1 operational hour. From the three sample measurements to determine the filtering efficiency, the best result was 87.64%, with the feed water sample process which previously had a turbidity of 2.76 NTU, which could be reduced to 0.34 NTU. The feed water value itself at the time of measurement had a turbidity value of 2.76 below the Quality Standards (Minister of Health Regulation No. 2 of 2023) which limits turbidity parameters to less than 3 (< 3 NTU).

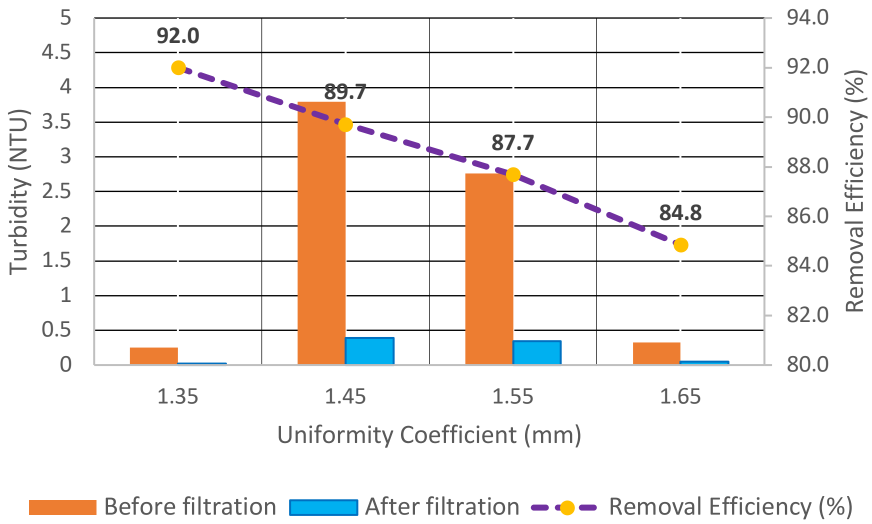

Fig. 11. Turbidity with Size Variation Uniformity Coefficient

Tests with variations in the Uniformity Coefficient size were carried out in 3 experiments with sampling times corresponding to the first experiment every 20 minutes with filter operation of 1 hour. The media used had a uniformity coefficient of 1.35, 1.45, 1.55, and 1.65. From the four sampling times to determine the filtering efficiency, the best result was 92.89%, with the feed water sample process which previously had a turbidity value of 0.25 NTU, which could be reduced to 0.02 NTU. The feed water value itself at the time the measurement was carried out had a turbidity value of 0.25 NTU. The value is below the Quality Standards Minister of Health Regulation No. 2 of 2023 which limits turbidity parameters to less than 3 (< 3 NTU).

The results of feed water filtration using quartz sand media decreased from the colour of feed water with a content of 4.67 TCU to 3.19 TCU so that the highest removal at the time of testing reached 31.73%. Drinking water quality standards according to Minister of Health Regulation 2 of 2023 state that the maximum level allowed for colour parameters is 10 TCU, after filtration with a silica sand filter media composition, the colour parameters decreased to 3.19 TCU. With the media used, the effective size is 1.35 mm. Varying media using effective size, the optimal size for reducing colour parameters was 0.4 mm with a water colour removal percentage of 26.3% from the previous 6.76 to 4.98 ptCo.

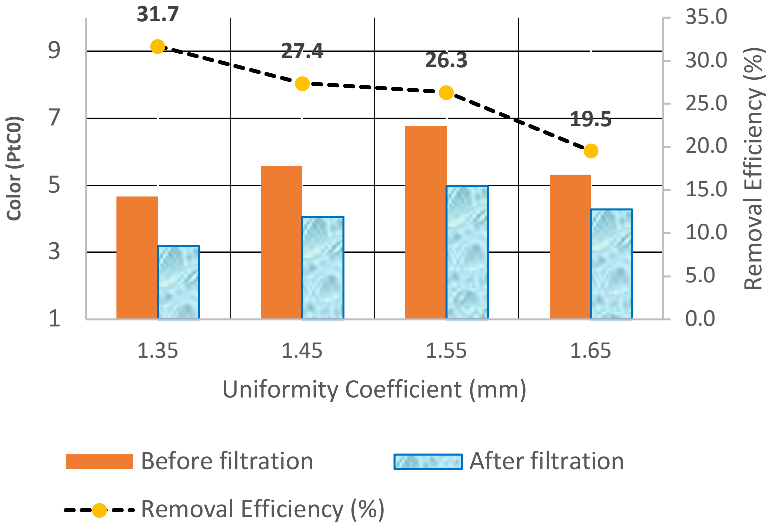

Fig. 12. Colour with Variation of Uniformity Coefficient

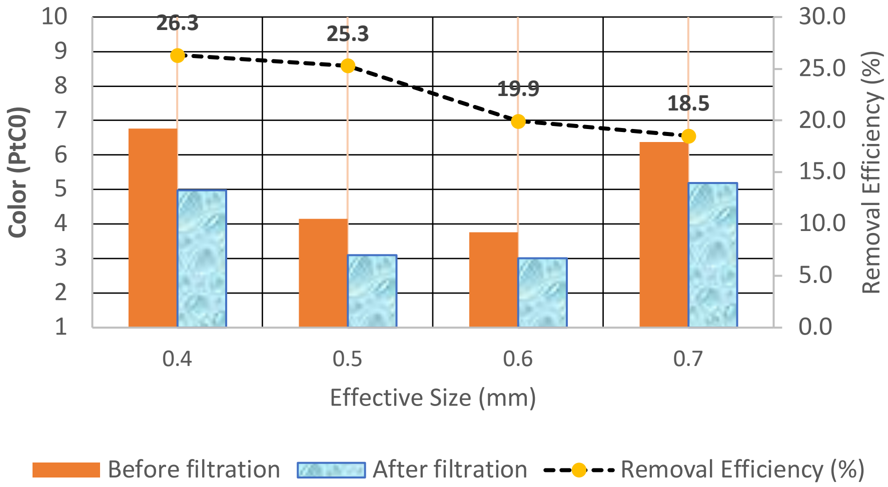

Fig. 13. Colour with Effect Size Variations

The results of testing feed water with media on pH parameters with the filter media arrangement using effective sizes of 0.4, 0.5, 0.6, and 0.7, and UC 1.55 using an effective size of 0.4 mm can increase the pH by 2.7% from feed water which previously had a pH value of 7.16 increased to 7.36. The quality standards of Minister of Health Regulation No. 2 of 2023 for pH parameters are in the range 6.5-8.5.

In general, feed water and water resulting from the filtering process are still in the range of 6.5-8.5 in accordance with the quality standard value that is the standard for drinking water.

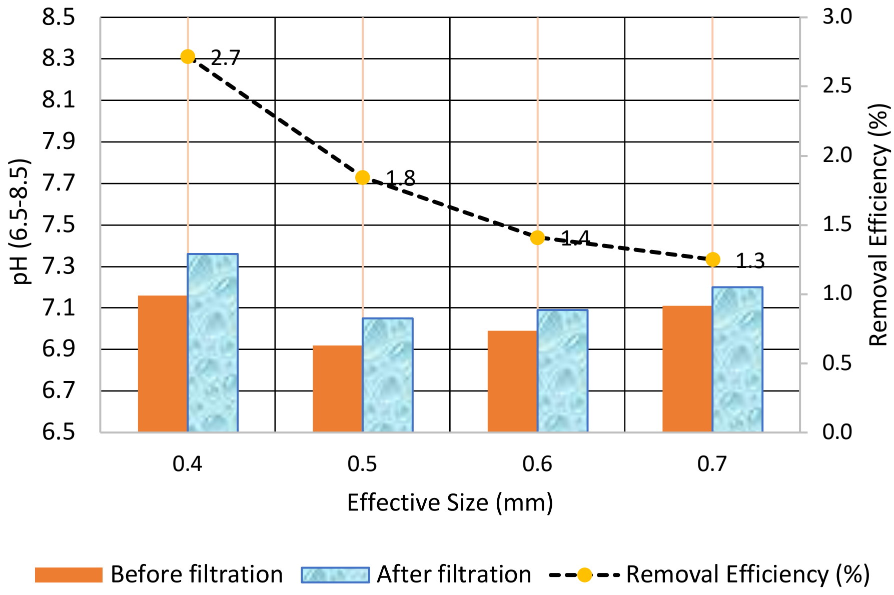

Fig. 14. pH with Effect Size Variations

Efficiency by using different Uniformity Coefficient (UC) media sizes for pH parameters produces pH results between 6.65 – 7.46. This pH value is still at the threshold set in the Quality Standards of Minister of Health Regulation No. 2 of 2023 with a value of 6.5-8.5. The larger percentage of media size is sand media with a size of UC=1.35 with a value of 10.9% and the lowest with a percentage of 0.6% with sand size of 1.65.

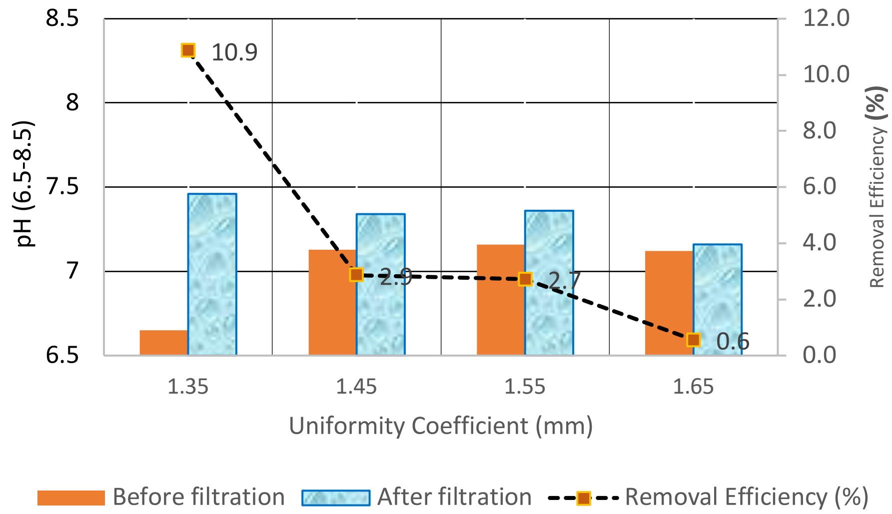

Fig. 15. pH With Uniformity Coefficient Size Variation

Effectiveness of backwashing sand media. Filter backwashing is an operation in which water is drained from the bottom of the filter with sufficient pressure, with the aim that the porosity of the filter media is reopened, and contaminants retained during filtration can be released [51]. The filtration process will usually be stopped when, the head loss on the media has been excessive, or from the quality of the water produced decreases in quality at a parameter size that is unacceptable to the standard that has been set. The effectiveness of washing filter media is intended to restore the performance of the filter so that it can be restored to optimal function. The fast filter washing technique can be done using *back washing*, with a certain speed so that the filter media *is fluidized* and collisions between media occur. Collisions between media cause the release of dirt attached to the media, then the dirt attached to the media is released and carried away along with the flow of water [52]. Backwashing is done by pumping water from the bottom up. When the speed of *up flow of* washing water, on the substrate layer begins to fluidize, that is, the grains of sand begin to separate from each other and float freely. Fluidization of the sand releases suspended solids that are retained on the medium, this process can be assisted by air bubbles through the sand bed (air *scouring*) which causes the sand grains to rub against each other releasing solids that are retained on the surface of the sand [53]. Based on the results of observations when washing Backwash with water alone with fluidization media is a less-than-optimal cleaning process due to limited abrasion and impact between fluidized particles. From the theory of fluidization is the interaction between the flow of liquid or gas with the basic solid fraction (*bed deposits*) which is generally in the form of granular granules causing the granules to lift, agitate and move from their original position [54]. Fluidization of the filter can be observed when washing with a water pump, the sand particles move away from each other and their movement accelerates with increasing speed, but the average density at a certain speed is the same in all directions The bed in the fluidization process is characterized by a fairly large but uniform expansion of the bed at high speeds.

The performance of filtration can be monitored by regularly checking the flow rate, the development of pressure loss and effluent quality characteristics (e.g., turbidity) [55]. Filter media is the most important part of the filtering process, the characteristics that affect the efficiency of the filtering process are the size of the media, the shape of the media grains, the porosity of the media and its thickness [51].

In this study, filter washing to release sludge attached to sand media with *up flow* until the sand is expanded begins with water with a pressure of 1 bar with a washing duration of 3-15 minutes. The washing time varies depending on the quality of the feed water, the quality during the rainy monsoon has high turbidity and usually the washing process is most frequent [51]. When washing the media, the process of washing the media from particles attached to the media occurs and at pressures exceeding 0.5 bar the process of *expansion of* wasted sand occurs at the outlet. Most engineering manuals state that the expansion of the filter layer should be 30 to 50 percent. Realistically, an expansion of 15 to 20 percent of the area will get the filter clean just right [56]. The duration of the backwash resulted in smaller grains of sand collecting in the upper layer, this event is also in accordance with research conducted by *Cleasby* which states that backwash causes media mixing. On the other hand, the process of using a high rate of water backwash causes some stratification of the medium, in which fine-sized grains of sand filter collect in the upper layer [57]. The reverse washing process results in the release and removal of material trapped or attached to the filter media due to factors from the shear movement of water and the effect of scour resulting from contact between suspended grains [58]. The frequency of the filter washing process not only depends on the characteristics of the sand media but is also influenced by the quality, especially the particle load of the filtered feed water [59]. The frequency of backwashing varies between about 24 and 72 hours depending on the type of media and the quality of the influent water [60]

Follow up the results of previous tests with selected sand media and used media with Effectiveness Size = 1.5 mm and Uniformity Size = 1.35 mm. from observations get better results and are in accordance with research that has been done also which states that, smaller UC values produce slightly better quality filtrate [61]. At the time of the reverse washing process, the nature of the medium affects the flow rate required for washing with water. Some criteria, for example, the distribution of sand grain size and porosity can change during the filtration process and affect the performance of the filter. Inefficient or improper backwashing can cause many problems. For example, mud ball formations. loss of filter media due to solvent drain or friction poor filter performance [62].

Pressure gauge Filter before Washing Filter During Washing

Fig. 16. Documentation filter reactor before and during washing

Water is a basic human need, and one of its uses is for drinking water. Drinking water has standards, with good quality because this is related to body health, because this water is a substance that enters the body. Drinking water is safe for health if it meets the physical, microbiological, chemical, and radioactive requirements contained in the mandatory parameters and additional parameters. The mandatory parameters referred to are drinking water quality requirements that must be followed and adhered to by all drinking water operators. The requirements and supervision of drinking water quality that apply in Indonesia are based on the Regulation of the Minister of Health of the Republic of Indonesia Number 2 of 2023 concerning Implementing Regulations of Government Regulation Number 66 of 2014 concerning Environmental Health.

Apart from providing beneficial benefits to humans, water can also have a negative influence on human health. Apart from that, water that does not meet the requirements is a good medium for breeding and transmitting disease. Drinking water producers face challenges in selecting suitable feed water for drinking water production, but this is limited by hydrogeological conditions in the local area, land use, and applicable laws and regulations. A cost-effective solution for drinking water producers inevitably results in the utilization of feed water with a certain level of contamination, that is, a mixture of known and unknown potentially toxic substances in varying concentrations, often exhibiting seasonal and other concentration fluctuations [63].

These parameters for drinking water standards can be said to be drinking water quality standards. The results of research from feed water and the results of the filtering process with reference to these regulations are analysed in the laboratory of the Banjarbaru Centre for Standardization and Industrial Services which has testing services, supported by a testing and calibration laboratory that has been accredited by the National Accreditation Committee (KAN) in accordance with SNI ISO 17025:2017 requirements. Chlorine disinfection is a prominent achievement in the health community by providing microbiologically safe drinking water and protecting humans from acute diseases transmitted through water [63]. From the results of the filter media size test used, the best allowance value is the effective size of 0.4 mm and the uniformity coefficient of 1.35 mm. With test results displayed in Table 10.

Table 10
The effective size of 0.4 mm and the uniformity coefficient of 1.35 mm

Parameter	Units	Feed water	Filter process results	Allowance (%)	Method	Standard Minister of Health Regulation No. 2 of 2023
Escherchia Coli (*E.Coli*)	Amount /100 ml	25	18	28	APHA,2017	0
Total Coliform	Amount /100 ml	25	18	28	APHA,2017	0
Temperature	^{0}C	26.8	26.8	0	SNI 06-6989.23-2005	Temperatures ± 3
Total Dissolved Solids (TDS)	mg/L	156	109	30	SNI 6989.27-2019	<300
Turbidity	NTU	2.55	1.01	60	SNI 06-6989.23-2005	<3
Colour	PtCo	6,773	7,991	-18	SNI 6989.80-2011	10 TCU
Smell	Odourless	-	-		SNI 3554:2015	
pH	-	7.36	8.45	-15	SNI 6989.11:2019	6,5-8,5
Nitrate	mg/L	0.522	0.361	31	SNI 3554:2015	20
Nitrite	mg/L	0.008	0.001	88	SNI 06-6989.9-2004	3
Chrome Valence 6 (Cr6+)	mg/L	<0.0016	<0.0016		automatic flow	0.01
Dissolved Iron (Fe)	mg/L	<0.006	<0.006		SNI 6989-84:2019	0.2
Manganese	mg/L	0.003	0.002	33	SNI 6989-84:2019	0.1

In general, the microbiological components in drinking water requirements are stated by Escherichia Coli as indicator bacteria, where if there are bacteria in the water, it gives an indication of contamination by pathogenic (disease-causing microorganisms). *E-Coli* lives in humans and mammals, so if there is E-Coli in the water, the water has been contaminated by human or animal faeces. In microbiological requirements, it is expressed by two parameters, namely Escherichia coli (E. coli) and Total Coliform. Both parameters are expressed in MPN units (Most probable number = Closest estimate value) per 100 ml sample.

The results of the research showed that the Escherichia coli (E. coli) number in feed water was 25 MPN and Total Coliform was 25 MPN, after passing through the filter media from quartz sand the value dropped to Escherichia coli (E. coli) in the filtered water was 18 MPN and Total Coliform was 18 MPN or absorption of 18% of feed water. With these results, if the quality standard parameters meet the drinking water standards of Standard Minister of Health Regulation No. 2 of 2023, which requires a value for bacterial parameters of zero (0) in drinking water, it is necessary to give additional injections of disinfectant to kill the presence of bacteria in the produced water. Chemical disinfectants are effective for killing harmful microorganisms in drinking water, but they are also strong oxidants, oxidizing organic matter, anthropogenic contaminants, and bromides/iodides naturally present in most feed water sources (rivers, lakes, and groundwater) [64].

Anticipation of Disinfection by-products or undesirable disinfection by-products (DBP) can be formed from the reaction of chlorine with natural organic matter (NOM) and bromide in feed water sources [63]. Because of the toxicological significance of DBPs, it is important to understand the factors that influence the distribution of DBP groups among individual species. It is widely recognized that bromide plays an important role in the formation of new types of trihalomethanes and halo acetic acids, the two main groups of DBPs formed in the chlorination of drinking water. For THM and HAA (excluding iodinated species), the yield increases with increasing bromide concentration, and the formation shifts from chlorinated species to mixed species, then to fully brominated species with increasing bromide concentration [65]. To minimize DBP formation, many water utilities are turning to DBP chloramine, chlorine dioxide, or ozone for total or partial replacement of chlorine [66].

Low temperature water can cause viruses to survive and the accelerated formation of Trihalomethanes (THMs) increases with increasing temperature. In contrast, if the low temperature causes the dissolved oxygen content in the water to be greater, the corrosion speed will increase. The research results produce a constant temperature at the feed water source and the results of the filtering process, namely 26.8 ^{0}C.

Total dissolved solids can give an unpleasant taste to the tongue, nausea caused by sodium sulphate, magnesium sulphate and can cause cardia disease toxaemia in pregnant women. Total dissolved solids affect taste, hardness, corrosive properties. Drinking water standards Standard Minister of Health Regulation No. 2 of 2023 which requires a TDS value < 300 in drinking water.

The cause of the high TDS value is the presence of inorganic materials in the form of ions in the water. For example, wastewater often contains water-soluble soap, detergent and surfactant molecules, for example in household and industrial washing wastewater. When the research was carried out, the TDS of the water source showed a value of 156 mg/L after filtration, it dropped to 109 mg/L or with filtering media with quartz sand it could absorb 30 % of the TDS value in feed water.

Water turbidity is caused by the presence of many suspended solid substances, both inorganic and organic. Inorganic substances usually result from weathering of rocks and metals, while organic substances generally come from industrial waste. Cloudy water will provide protection against germs. Drinking water standards Standard Minister of Health Regulation No. 2 of 2023 which requires < 3 NTU. with the consequence that if the water turbidity value is high, it will protect microorganisms from the effects of disinfection. The research results showed that the feed water turbidity value was 2.55 NTU, after filtering it became 1.01 NTU, filtering with quartz sand media could absorb 60% of the turbidity in the feed water.

Drinking water should be colourless for aesthetic reasons and to prevent poisoning from various coloured chemicals and microorganisms. Water colour can be observed visually (directly) or measured using the platinum cobalt (Pt Co) scale, by comparing the colour of sample water and standard colour. The value of one Pt Co scale is proportional to the TCU (True Colour Unit) scale unit or it can be said that the value of 1 TCU = 1 mg/L platinum cobalt. The recommended guideline value in drinking water is in accordance with health regulation number 2 of 2023 < 10 TCU (True Colour Unit). The colour of the feed water at the time of the study was 6,773 TCU, after filtering it increased to 7,991 TCU. There was an 18% increase in the colour value of the water resulting from the filtering process.

Odour of drinking water is unacceptable to the public. The smell of water can provide clues to water quality. Apart from causing complaints, odours may be a sign of the presence of poisonous gas or polluted water conditions. Some of the main sources of odour include hydrogen sulphide and organic compounds produced by anaerobic decomposition in the unit which can have detrimental effects on health or environmental impacts.

Drinking water should be neutral, not acidic/alkaline. A pH value lower than 6.5 can cause an unpleasant taste and cause corrosiveness in the piping system and can cause some chemicals to turn into toxins which are detrimental to health. A pH with a high value can also disrupt digestion.

Generally, H2S formation occurs at pH < 7.0. Likewise, the formation of trichloramine occurs at greater values at pH < 7.0. pH also causes an undesirable taste (bitter taste) if the water pH is > 7.0. The results of the filtration process using quartz sand media in the test showed a pH value in the range of 7.36 in feed water, and increased to 8.45 or an increase of 15% from the initial pH value in feed water. The pH value in accordance with Minister of Health Regulation No. 2 of 2023 is in the range 6.5 - 8.5

Nitrites and nitrates in nature can be produced naturally or by human activities. The natural source of nitrates and nitrites is the hydrogen cycle, while sources from human activities come from the use of nitrogen fertilizers, industrial waste and human organic waste. The nitrate value for feed water was 0.522 after filtration to 0.361, a decrease of 31%, while the nitrite value was 0.008 mg/L for feed water and 0.001mg/L after the filtration process with an absorption of 88%.

Chrom can enter water bodies in two ways, namely natural and non-natural. The natural entry of Cr such as erosion or erosion of mineral rocks and dust or Cr particles in the air will be carried down by rainwater and respiratory organs. Cr metal that enters the environment can come from various sources, but the general sources that are thought to have the most influence are from industrial activities, mining, household activities and combustion residues.

The results of the research on feed water point sampling were <0.0016 mg/L and the results of the filtering process were <0.0016 mg/L using the automatic flow method, while the standard from Minister of Health Regulation 02 of 2023 was the quality standard at 0.01 mg/L.

Standard Minister of Health Regulation No. 2 of 2023, Dissolved Iron (Fe) Concentration is 0.2 mg/L. If it exceeds this standard value, it can usually cause a yellow colour, give an unpleasant taste to the drink, deposition on the pipe walls, growth of iron bacteria and turbidity. In this study, the feed water source had a value of <0.006 mg/L and <0.006 after filtering or no change. This water value is below 0.2 mg/L as standard requirements for drinking water in accordance with Minister of Health Regulations.

Mn concentrations greater than 0.1 mg/L cause a bitter taste in drinks and leave brownish stains on clothes. If water containing Mn is brewed with tea, the tea will turn bluish. The results of measurements on feed water have a Mn value of 0.003 mg/L after filtering, it becomes 0.002 mg/L so there is a 33% reduction from the feed water source, while the quality standard is according to the Minister of Health Standards No. 2 of 2023, the Mn content in drinking water is 0.1 mg/L.

Dissolved organic matter is found in natural aquatic environments and is a complex mixture of various compounds such as carbohydrates/polysaccharides, amino acids/peptides/proteins, lipids, humic substances, and anthropogenic organic pollutants. [67]. This organic material can cause an unpleasant taste and odour and can cause stomach upset and cause corrosiveness in metal pipes.

4. Conclusions

The results of XRF analysis of sand samples contain silica and have the highest levels of sand samples taken from Sungai Tabuk District with a SiO2 content of 97.74% higher than samples taken from Liang Anggang District with a SiO2 content of 96.74%. This suitability is also shown by the XRD test results which show that there is the highest peak located at 2θ of 26.6° and this indicates the presence of silica which is still amorphous. Tests using SEM characterization of Tabuk River sand samples show that the element content is dominated by Silicon (SiO2) which is bright white in colour. For feed water samples and process results after several trials, based on laboratory tests, the turbidity test value was 2.55 NTU, colour 6,773 ptCo, pH 3.36 of these three parameters after passing through the filter, still within the quality standard range for turbidity to 1 .01, for the colour parameter it is 7.991 and the pH is 8.45. This parameter value is still at a safe level and in accordance with the quality standards of Minister of Health Regulation No. 2 of 2023. The results of the research show that the influence of the size of the media diameter or size effectiveness has an effect on the quality of the processing results. and it also affects the speed of the filtering process, the smaller the size of the filter media, the quality of the filtering results will be better but the filtering speed will be slower.

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