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Effectivity Of Multi Tray Aerator As Pretreatment Process For Reverse Osmosis Membrane To Utilized As Raw Water At Sungai Itik Village

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ABSTRACT

The community in Sungai Itik Village and its vicinity use river water for their daily needs, such as irrigation for agriculture, fish ponds, washing, bathing, and more. The quality of the river water has an iron (Fe) content of 2,64 mg/L, Total Dissolved Oxygen (TDS) of 347 mg/L, Dissolved Oxygen (DO) of 4,7 mg/L, a temperature of 29°C, and a pH of 5,4. The iron (Fe) content exceeds the standards set by PerMenKes No. 32 of 2017, requiring treatment using a multiple-tray aerator. This study aimed to determine the effective distance and number of trays in treating Sungai Itik's raw water, understand the coefficient of gas transfer (K_{La}) in the aeration process, and find the optimum aeration time. This study employed a multiple-tray aerator consisting of 5 trays with variations in the tray distances at 30 cm, 40 cm, 50 cm, and 60 cm. Three repetitions were performed for each treatment, both without gravel and with gravel. The results of this study showed that the best reduction in Fe content was achieved by the treatment with gravel at a tray distance of 60 cm using 5 trays, resulting in a 6,64% reduction in Fe from an average value of 1,51 mg/L to 1,41 mg/L. The average pH value was 6,19, and the TDS was 890 mg/L. The highest oxygen transfer rate (K_{La}) was obtained at a tray distance of 60 cm with gravel, averaging 0,2857/minute, and the optimum aeration time was 10 minutes.

Keywords: Aeration, River Water, Oxygen Gas Transfer Coefficient (K_{La}), Multiple Tray Aerator.

Introduction

River water is a source of raw water which contains high levels of phosphate, nitrite, iron (Fe), organic substances, manganese (Mn), ammonia (NH_3) and others. This is because river water receives various kinds of pollutants from the surrounding environment which result in it not being able to function according to its use and being dangerous for health. People in Sungai Itik Village and its surroundings use river water to fulfill their daily needs such as irrigation for agriculture, fish ponds, washing, bathing and so on. The physical condition of the river water is yellow-brown in color, cloudy and smelly, and if used for daily purposes it has the potential to cause various diseases. In addition, this river area is located close with the Sungai Kapuas estuary being influenced by sea tides and rainfall, so it has the potential to bring other pollutants into the river body due to experiencing many sedimentation processes originating from upstream and downstream of the river.

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Based on preliminary research conducted in 2021, river water in the Sungai Itik Village area, Sungai Kakap District, Kubu Raya Regency has an iron (Fe) value of 1,15 mg/L, Total Dissolved Oxygen (TDS) 257,9 mg/L, Dissolved Oxygen (DO) 5,8 mg/L, temperature 27^0C and pH 6,80. Water used for human needs and sanitation hygiene needs must meet established quality standards, so that it is safe to use. The policy was set out in Regulation of the Minister of Health of the Republic of Indonesia No. 32 of 2017 concerning environmental health quality standards and water health requirements for sanitation hygiene purposes, swimming pools, aqua solutions and public baths. The quality standard values that have been determined include standard iron (Fe) content of 1 mg/L, Total Dissolved Oxygen (TDS) 1000 mg/L, Dissolved Oxygen (DO) ≥ 4 mg/L, air temperature ± 3 and pH 6,5- 8,5. Parameter levels in river water that is higher than the specified quality standards can affect the environment and human health.

Magnesium (Mg) and iron (Fe) levels can be reduced by the aeration process. The process of adding oxygen (O_2) from free air to treated water is called aeration. The purpose of filling oxygen (O_2) is to allow the cations in the treated water to react with the oxygen (O_2) in the air. Oxidation of metals that are difficult to dissolve in water and can precipitate is the result of the between reaction of oxygen and cations. When sprayed into the air, Fe^{2+} or Mg^{2+} cations will precipitate Fe_3O_3 and MgO oxides [1].

This research will carry out water treatment through an aeration process using the Multiple Tray Aerator method which uses Itik River water as raw water. The Multiple Tray Aerator method is a water treatment method that consists of several levels of trays equipped with perforated tray bases that are interconnected at each level of the tray, so that they are able to distribute and drop the water into the reservoir below. Using the tray aerator method has the advantage of not requiring maintenance. The choice of this tool was based on its simple arrangement, low cost, and not requiring a large space [1]. The aeration method using the Multiple Tray Aerator principle using 4 tray levels is able to reduce iron (Fe) levels in water with a removal efficiency level of 98,34% with initial Fe levels of 1,68 mg/L and final Fe levels of 0,00298 mg/L in day-7 [2].

The complete RO desalination process includes 4 stages, that are water intake, pretreatment, reverse osmosis treatment and posttreatment. Reverse osmosis process accounts for about 71% of consumption the overall energy of the process, followed by water intake (maybe some differences in energy consumption due to the influence of water source location) [3].

This aeration process is included in the pretreatment stage which functions to remove polluting elements such as Fe, Mn and organic compounds, so that larger sized particles do not enter the RO membrane. The pretreatment process functions to avoid major damage that occurs in reverse osmosis [3]. This also aims to ensure that the RO (Reverse Osmosis) performance in the process of processing raw water into drinking water does not work too hard, more efficient, the membrane does not get damaged quickly and can last longer.

Water treatment in this research only analyzes the reduction in iron (Fe) levels found in raw water through the aeration process. it is hoped that the aeration unit using the Multiple Tray Aerator will be able to treat water in the area which has the potential to become raw drinking water by pretreatment first and then going through a series of Reverse Osmosis processes to become drinking water.

The aim of this research is to get the distance and number of trays that are effective in processing raw water in the Sungai Itik, to find out the value of the gas transfer coefficient (K_{La}) during the aeration process and get the optimum aeration time using the Multiple Tray Aerator.

Methods

Time and Place

This research was conducted in June - September 2022. Research activities took place in the Masjid Darul Jalal RT 025/ RW 004 (S 0°2'8.36" E 109°11'30.71") Dusun Melati, Sungai Itik Village, Sungai Kakap District, Kubu Raya Regency, West Kalimantan which was place of tool making activities, location of surface (river) water sampling, and running of the tool. Meanwhile, the Laboratory of the Faculty of Agriculture, Universitas Tanjungpura, was a place for analyzing the quality of iron (Fe) levels in surface (river) water before (inlet) and after (outlet) processing.

Tools and Materials

The tools used in this research are 3/4 inch 4 PVC pipes, 3/4 inch drat 3 pieces, 3/5 inch hubcaps 3 pieces, Aquarium pump/home water pump, chisel, saw, hammer and pipe saw, shelf angle iron, hole angle iron, 5 trays measuring 40x20x10 cm, 3/4 inch elbows 6 pieces, 3/4 inch stops faucet 3 pieces, 3x4 wooden battens 5 pieces, 4x6 wooden battens 4 pieces, 20 liter storage tank, electric drill, solder, meter, sampling bottle and 300 mL glass bottle for samples, pH meter, thermometer, TDS meter, and DO meters.

The materials used in this research are raw surface (river) water, distilled water, rainwater, nitric acid (HNO_3), seal tape and tissue, bolts, nuts and wire, pipe glue, nails, and stones/gravel.

Method of Collecting Data

Data sources required in this research was primary data and secondary data. Primary data was obtained from direct observations in the field and secondary data was obtained from previous research, was from the results of preliminary research. Primary data required includes:

a. The raw water quality of the Sungai Itik was analyzed in-situ and ex-situ , namely temperature, TDS (Total Dissolved Solid), DO, pH and iron (Fe) parameters .
b. The river water sampling method was carried out using 2 times repetitions (Duplo) composite sampling (Composite Sample).
c. Water quality before (Inlet) and after (Outlet) was carried out by 3 times repetitions.

Research Procedure

1. Preparation of Sampling Containers

River water sampling begins with the preparation and cleaning of sample containers based on SNI 6989.57:2008 concerning Methods for Sampling Surface Water in the Washing of Sample Containers section.The container used for sampling were 14 of 300 ml plastic bottles that had been prepared.

2. River Water Sampling

The raw water that would be processed through the aeration process is taken directly from river water in Sungai Itik Village, Sungai Kakap District, Kubu Raya Regency. This river water sampling refers to SNI 6989.57:2008 concerning Surface Water Sampling Methods, part of sampling methods for testing water quality in general.

3. Water Sample Preservation

This research carried out preservation of all water samples before (Inlet) and after (Outlet) processing. The sample preservation method was based on SNI 6989.4:2009 regarding how to test iron (Fe) using flame-atomic absorption spectrophotometry (SSA).

4. Aeration Process Using Method Multiple Tray Aerator

The aeration process used a Multiple Tray Aerator, was by contacting water and air by dropping or flowing from a certain height, with varying the distance between trays of 30, 40, 50, 60 cm with treatment using gravel and without gravel. The design criteria for the Multiple Tray Aerator are in this research, as follows:

a. The shape of the tray was an isosceles trapezoid with a diameter (upper side 45 cm long and 25 cm wide), (lower side 40 cm long and 20 cm wide) and 10 cm high.
b. Consists of 5 trays arranged with the total dimensions of the processing unit, namely 64 cm long, 38 cm wide and 320 cm high.
c. Using distance variations of 30, 40, 50, 60 cm based on the design criteria for a distance between *trays* of 30-75 cm [23].
d. The gravel used was 2 cm in size and in the treatment the gravel was filled to a thickness of 5 cm in each *tray*. This functions as additional aeration power, so that the impact/contact of water with air will increase.
e. Downflow flow was a type of flow used in *Multiple Tray Aerators,* by utilizing gravity. So that the water that falls will be evenly distributed from the top to the next tray arranged.

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Figure 1. *Multiple Tray Aerator* Design and Tools

5. Data Analysis

a. Processing Efficiency Calculation

Data inlet and outlet processing with the multiple tray aerator aims to determine the efficiency of the aeration unit.The formula for calculating the percentage of parameter reduction efficiency in the processing unit used can be seen from the following equation [4]:

$$Ep\ (Fe\ and\ TDS) = \frac{preliminary\ results - Final\ Result}{preliminary\ results}\ X\ 100\% \quad (1)$$

b. Gas Transfer Coefficient Calculation (K_{La})

This analysis aims to determine the maximum amount of oxygen that can be added by the aeration unit to raw river water processing. The temperature and partial pressure of oxygen in contact with water affect the saturated oxygen level (Cs) in the water. The gas transfer coefficient (K_{La}) calculation formula used is as follows [5]:

$$Ln\ (Cs - Ct) = Ln(Cs - Ci) - K_{La}\ x\ t \ .....(2)$$

Information :

K_{La} x t = Corrected oxygen transfer at the desired temperature ($time^{-1}$)

Cs = Saturated gas content, mg/L

Ct = Concentration in the experimental time interval, mg/L

Ci = Initial concentration, mg/L

Results and Discussions

Sungai Itik Water Quality

River width was measured using a 100 m measuring instrument, which is measured from the right side of the river to the left. The width of the river in this area is 25,5 m, the distance between segments was 1,7 m and divided into 15 segments. Then, the depth of the river was measured using a wooden tool with a measuring tape added to it. The total cross-sectional area of the river is 157.760 cm^2 or 15,77 m^2. Flow velocity data was obtained manually, by using an artificial buoy, with the result that the water flow velocity in the area was 0,125 m/s.

Table 1. River Hydrometric Data

Data	Analysis Result
River Bottom Conditions	Muddy
River width	25,5 m
Total Cross-sectional Area	15,77 m^2
Water Flow Speed	0,125 m/s
River Flow Discharge	1,97 m^3/s

Source: Analysis Results, 2022

Based on the calculation results, the Sungai Itik discharge was 1,97 m^3/s, the river discharge was (less than) < 5 m^3 /second, so water samples are taken using an *integrated* *sampler* at one point in the middle of the river with a depth of 0,5 times the water surface. This aims to obtain water samples evenly from the surface to the surface basic and in accordance with SNI 6989.57:2008 guidelines. Sungai Itik water quality guided by **(PP RI No. 22 of 2021),** can be seen in the table below.

Table 2. River Water Quality Data

Paramaters	P1	P2	Average	Class 1 Quality Standard
TDS (mg/L)	334	360	347	1000
pH	5,5	5,31	5,4	6,0- 9,0
Temperature (°c)	29	30	29,5	Air temperature ± 3 °c
DO (mg/L)	4,6	4,8	4,7	6
Besi (Fe) (mg/L)	2,62	2,65	2,64	0,3

Source: Analysis Results, 2022
Information:
P1: Repetition 1
P2: Repetition 2

The Sungai Itik water quality TDS parameters had met the requirements for class 1 water quality standards according to Republic of Indonesia Government Regulation Number 22 of 2022. Meanwhile, the pH value of the river water quality with an average of 5,4 (acidic conditions), the temperature value with an average of 29,5°c (open space), the DO value with an average of 4,7 mg/L and the iron (Fe) content with an average of 2,64 mg/L, which indicates that several of these parameters do not meet the specified class 1 water quality standard requirements category.

Water Quality Before (*Inlet*) and After (*Outlet*) Treatment

Water quality before processing with *the Multiple Tray Aerator* can be determined by several physical conditions such as color, smell and taste. The color of the river water at the first sampling was yellow-brown in color and had brown dissolved solids. The cause of the brownish color in the water came from organic materials such as tannin, lignin and humic acid which comes from the decomposition (weathering) process of long-dead plants. The high levels of dissolved organic substances, especially in the form of acids, had a pH range of 2-5, high levels of metals, turbidity, low levels of suspended and organic substances [6].

Experiments with variations in the distance between *trays* of 30 cm and 40 cm using treatments with and without gravel. The experiment with increasing the distance between *trays* to 50 cm and 60 cm only used gravel. This was done because it was in accordance with the first hypothesis that the value *(KLa)* would increase if you added height and used gravel. The average *inlet* TDS, pH and iron (Fe) values vary in each experiment due to the sampling process on different days, so they can be grouped, by *inlet* 30 and 40 cm on day 1 and *inlet* 50 and 60 cm on day 2. This was done due to insufficient *running* time and unstable river conditions, due to frequent tide and tides.

a. Total Dissolved Solid (TDS)

The average efficiency reduction that occurred in this processing included, in the experiment with a distance between trays of 30 cm in the treatment without gravel, the TDS level decreased by 18 mg/L or 4,35%, while in the treatment with gravel the TDS level increased by 3 mg. /L. In the experiment, the distance between trays was 40 cm and increased. Meanwhile, in the experiment with a distance between trays of 50 cm and 60 cm, the treatment with gravel experienced a decrease in TDS, respectively of 28 mg/L or 3,03% and 44 mg/L or 4,71%.

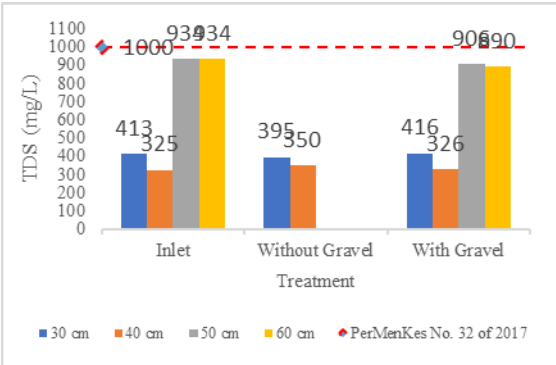

Figure 2. TDS Parameter Graph

Based on the analysis of the processing outlet value as a standard requirement for raw water quality for feed water before entering the Reverse Osmosis unit process, the TDS parameters in all experiments and treatments, had met the requirements as raw water. before

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the RO process namely with a TDS value ≤ 12,000 mg/L[7].

The process of increasing TDS caused by metal levels in the water that was still dissolved and in the form of solids that was not yet ready to settle [8]. Reducing solids in processed water can be done by increasing the residence time of processed water in the holding tank. The residence time functions to purify the water which makes the sedimentation process produce larger solids and this process will make it easier for particles to settle by gravity, so that the TDS value can be reduced in the water. The high TDS value was also caused by the high levels of iron (Fe), potassium, sodium, chloride, colloidal compounds, organic ions and others dissolved in water. Another factor that causes the TDS value to increase was due to the erosion of the gravel layer due to impact with water during the continuous aeration process, causing small particles of gravel to dissolve in the water and increasing the TDS value.

The varying changes in TDS values are influenced by the size of the TDS, which was very small and dissolved in water, which makes it difficult to separate. According to [21], dissolved solids had a diameter of <10^{-3} **π**m or <10^{-6} mm. Dissolved solids which had a small size can be reduced by further processing methods such as sedimentation, flocculation coagulation, and filtration. In addition, in order to reduce salt levels, suspended particleswhich has a size of 1 micron, colloid, and maximum microorganisms in the water, then it can also be done by pumping water under high pressure into Reverse Osmosis [3] .

b. Degree Of Acidity (pH)

The average pH value after processing (outlet) with a distance of 30 cm between trays in the treatment without gravel was 5,92 and in the treatment with gravel was 5,99. At a distance between trays of 40 cm, the treatment without gravel was 6,10 and the treatment with gravel was 5,89. Meanwhile, the distance between trays was 50 cm and 60 cm for treatment with gravel, respectively 6,13 and 6,19.

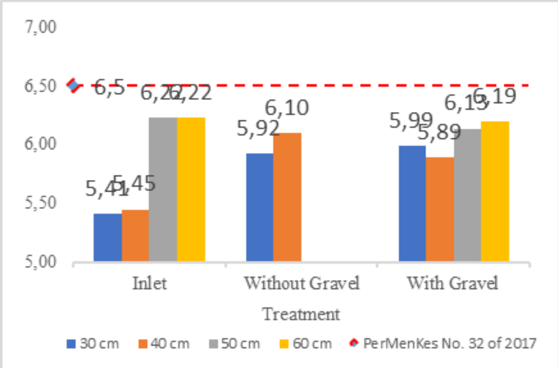

Figure 3. Graph of pH Parameters

Low pH value (pH<7), it affected the solubility of iron and other metals in water. A long aeration process caused the pH value to increase to an alkaline condition. This is caused by the longer the aeration time, the more oxidation reactions the dissolved iron has with oxygen, which would change form into a sediment [9].

According to [10], the increase in pH value is due to the loss of CO_2 levels during the aeration process. The more acidic the pH value, the greater the solubility of the metals in the water, the more alkaline the metal's solubility, the smaller it is. So, it could be seen by the presence of sediment at the bottom of the processing or storage tank. Some of the pH increases which tend to increase not yet fulfilled the best pH value in terms of reducing iron levels in water, so that the value of iron produced after water treatment does not significantly decrease. Water that has dissolved oxygen and a neutral acidity concentration can oxidize Fe^{2+} to Fe^{3+} and become sediment [11].

c. Iron (Fe)

The average reduction efficiency that occurred in this processing included, in the experiment with a distance between trays of 30 cm in the treatment without gravel, the Fe reduction value was 0,26 mg/L or 9,20%, while in the treatment with gravel it was 0,36 mg/L. or 12,62%. Experiment with a distance between trays of 40 cm increased Fe content values, was the treatment without gravel was 0,31 mg/L and the treatment with gravel was 0,08 mg/L. Meanwhile, in the experiment with a distance between trays of 50 cm and 60 cm, treatment with gravel decreased in Fe, each by 0.07 mg/L or 4,65% and 10 mg/L or 6,64%.

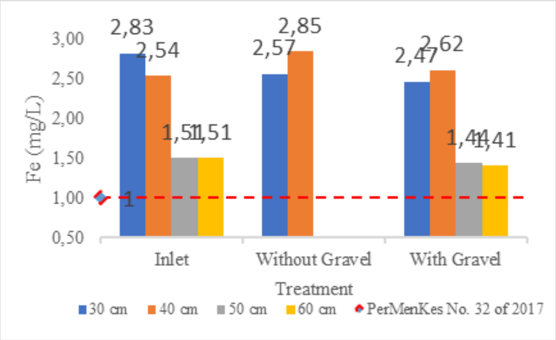

Figure 4. Graph of Iron (Fe) Parameters

Based on the analysis of the processing outlet value as a standard requirement for raw water quality for feed water before entering the Reverse Osmosis unit process, the Fe parameter that fulfilled the requirements for raw water before the RO process was only in the experiment with a distance between trays of 50 cm and 60 cm, namely with an Fe value ≤ 2,00 mg/L [7].

In general, the decrease in Fe content values was not yet optimal, this was because the dissolved solids from the aeration process are still in colloidal form, so it took a long time and further processing are needed to precipitate the colloids. According to [21], total solids had a size classification, which was dissolved solids with a diameter of $<10^{-3}$ πm or atau $<10^{-6}$ mm, colloids with a diameter of 10^{-3}-1 πm or 10^{-6}-10^{-3} mm, and solids suspended >1 πm or > 10^{-3} mm in diameter. The optimum settling time required for colloidal solids was 15-20 hours to complete coprecipitate metal ions [12]. This study only had a settling time of 5-10 minutes, so there was not enough time to settle the colloid. Multiple tray aerator designed to consist of 4-6 trays arranged with a height of 1, 2 to 3 metersreduces iron levels on average a decrease from the initial value of 2,21 mg/l to the final value of 1,12 mg/l or 68,01%. The running process carried out for 30 minutes and after running, the processing water is left for 10 minutes in holding tank. The decrease was not optimal because there were surface active substances and dissolved solids in the water [13].

Accelerating colloid deposition could be done by carrying out the coagulation process after the aeration process. According to [14], binding of colloids by Al^{3+} coagulant chemicals can form flocs and bind with OH^- ions to stabilize flocs which would quickly settle. Colloidal particles would stick to each other and form larger flocs. The specific gravity of the particles/floc which was greater than the specific gravity of water would then settle to the bottom. The acceleration of floc deposition was affected if the particles increase in size and specific gravity [22].

The degree of acidity or pH in water could affect iron (Fe) levels. A pH value of 7,5-8,5 was the best value for the oxidation reaction process in iron. According to [15], levels Iron reduced by the aeration method can affect the pH value in the water. A pH value of more than 7,5 was the best pH for reducing iron (Fe) levels during the oxidation process. The higher the pH value, the faster the oxidation reaction process accelerates, this was because the collision between electro ions is faster. So, Fe levels in water in an alkaline state will easily react with oxygen and become $Fe(OH)_3$ which was not dissolved in water.This research has a pH value of 5-6 in acidic conditions.

Another factor was also caused by the influence of rainfall intensity, as is known the raw water used was Sungai Itik water which was located close to the mouth of the Sungai Kapuas. If it rains in the upstream area it will cause an influence on levels The levels of other parameters in the water unstable, especially metal levels. According to [16], high intensity rain could increase water discharge. The higher the water flow entering the river, the lower the metal content will bedissolved weight. Decreased river water discharge could have an impact on concentrating pollutant levels in the water. The effect of the season could also affect levels, this was because heavy metal levels tend to be lower during the rainy season because they are diluted by rainwater.

The Fe value from several experiments has increased due to the possibility of saturation occurring in the transfer of dissolved oxygen gas in the water, so that the iron content couldn't be reduced effectively and optimally with the aeration process. High concentration of Fe in wateralso influenced by low dissolved oxygen [11].

An increase in high temperature affects the degreesolubility of minerals and could be a factor in reducing oxygen dissolved in water so the Fe value in water was high.

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Unstable temperature changes could affect the physical, chemical and biological processes of water. An increase in water temperature could increase the metabolism and respiration of aquatic organisms, causing an increase in oxygen consumption by living creatures in the water[11].

In line with research [17], the low Fe reduction efficiency was due to the long aeration process resulting in saturation of gas transfer levels in the water in converting Fe^{2+} into $Fe(OH)_3$, so further processing was needed such as adding a coagulation process and sedimentation, to maximize the reduction in iron levels to meet clean water quality standards. Further processing of raw river water into drinking water was carried out by adding filtration and reverse osmosis processes to the drinking water processing system.

Gas Transfer Coefficient (K_{La})

The value (K_{La}) has units per time ($time^1$) in the entire gas transfer process oxygen. Value analysis (K_{La}) requires data such as air pressure (mmHg), DO levels (mg/L), and water temperature (^{0}C). The DO level measured from each experiment increases. The DO level would increase the longer the aeration process was carried out. The factor to consider was that the DO concentration value in water would be become saturated if the oxygen level in the water is too high [18].

The research was carried out in 2 trials/running grouped into the first run, by variations with a distance between trays of 30 cm (with gravel and without gravel), 40 cm (with gravel and without gravel) and a running time of 7 minutes. The second running was a variation with a distance between trays of 50 cm, 60 cm (with gravel) and a running time of 10 minutes.

Table 3. Results of DO Level Measurements (*Running* – 1)

Test	Time (Minute)	Temperature °c			DO mg/l		
		P1	P2	P3	P1	P2	P3
30 cm (Without Gravel)	0	31	31	31	4,2	3,9	4,3
	3	31	31	30	4,5	4,6	4,6
	5	31	31	30	4,7	4,7	4,9
	7	31	31	30	5,0	5,5	5,4
30 cm (With Gravel)	0	30	30	29	3,6	4,0	4,6
	3	30	30	29	4,2	4,3	4,9
	5	29	29	29	4,6	4,8	5,4
	7	29	29	29	5,6	5,8	5,9
40 cm (Without Gravel)	0	30	31	30	4,3	4,5	4,7
	3	30	31	30	4,7	4,7	5,3
	5	30	31	30	4,8	5,1	5,4
	7	30	31	30	5,1	5,4	5,6
40 cm (With Gravel)	0	31	31	30	4,4	4,7	4,6
	3	30	30	30	4,9	5,0	4,9
	5	30	30	29	5,5	5,7	5,7
	7	29	29	29	5,8	6,2	6,7

Source: Analysis Results, 2022

Table 4. Results of DO Level Measurements (Running– 2)

Test	Time (Minute)	Temperature °c			DO mg/l		
		P1	P2	P3	P1	P2	P3
50 cm (With Gravel)	0	30	30	30	4,6	4,5	4,6
	3	30	31	30	4,9	4,7	5,0
	5	31	30	30	5,4	5,0	5,4
	7	30	30	30	5,9	5,5	5,7
	8	31	31	31	6,3	5,7	5,8
	10	31	31	31	6,5	6,3	6,1
60 cm (With Gravel)	0	30	30	30	4,3	4,4	4,1
	3	30	29	30	4,5	4,7	4,4
	5	29	30	30	5,2	5,2	4,8
	7	30	30	29	5,6	5,5	5,3
	8	29	30	30	6,1	5,8	5,7
	10	30	30	30	6,5	6,4	6,5

Source: Analysis Results, 2022

The value (K_{La}) was analyzed by calculating the difference between saturated DO levels and DO levels at a certain time point (Cs-C). Plot the In (Cs-C) value vs time on a graph for determine the optimal value (K_{La}). Decline (slope) linear line formed on a graph represents the value (K_{La}). Air pressure barometric and saturation pressure of water vapor has an impact on saturated oxygen levels (Cs) during the running process. The Cs value throughout the experiment at a pressure of 772 mmHg had a value of 7,522 mg/L – 7,898 mg/L.

All the graph plot results of In values (Cs-C) and time in this study indicate that the values (K_{La}) have relatively decreased.The value reduction graph (K_{La}) shows that dissolved oxygen in water experiences saturation, if the processing process was carried out over a longer period of time, but also results in a relative increase in the DO level value at any given time (Cs-C). Other conditions are also influenced by analysis of the difference in ln (Cs-C) values. The Cs value is the saturated oxygen level that could be used, and the C value was the total oxygen level during the experiment.

Table 5. Values (K_{La})

Test	Repetition Experiment	K_{La} (Minute $^{-1}$)	K_{La} Avarage (Minute $^{-1}$)
30 cm (Without Gravel)	P1	0,0384	0,0533
	P2	0,0765	
	P3	0,0449	
30 cm (With Gravel)	P1	0,0784	0,0757
	P2	0,0774	
	P3	0,0712	
40 cm (Without Gravel)	P1	0,0358	0,0451
	P2	0,05114	
	P3	0,0484	
40 cm (With Gravel)	P1	0,061	0,0896
	P2	0,0759	
	P3	0,1318	
50 cm (With Gravel)	P1	0,1565	0,2635
	P2	0,2119	
	P3	0,4222	
60 cm (With Gravel)	P1	0,2889	0,2857
	P2	0,2678	
	P3	0,3004	

Source: Analysis Results, 2022

Based on Table 5, it explains that the oxygen gas transfer coefficient value was the greatest in repetition 3 (P3) when the distance between trays was 60 cm (with gravel), was 0,3004/minute and the average value of the oxygen gas transfer coefficient (K_{La}) was the highest. amounting to 0,2857/minute with an average value of the regression coefficient (R^2) of 0,6766. From the results of the value analysis (K_{La}), the experiment with a distance between trays of 60 cm (with gravel) which has a running time of 10 minutes, states that the longer the aeration process, the oxygen gas transfer value (K_{La}) would increase and be more able to influence the oxidation process in water. processed. In line with research [19], running time for 10 minutes an oxidation process occurs which produces an oxygen gas transfer value (K_{La}) which was an average of 0.052/minute and has an average efficiency of reducing Fe levels of 29,99%, so that the running process takes a long time which would affect the contact time of the water with air and cause more dissolved oxygen in the water to oxidize Fe^{2+} to $Fe(OH)_3$ which would become a sediment.

The results of several experiments on the distance between trays and the addition of gravel show that these factors can produce turbulence in the water, so influencing the increase in the value of oxygen gas transfer in the aeration process. The addition of gravel media also functions to increase the impact aeration power against water so that contact with air would increase. An increase in the rate of turbulence results in optimal oxygen mass transfer, this was caused by experiencing it changes in the rate of exchange of contact surfaces, leading to deficiencies oxygen (*driving-force*, ΔC) was maintained with stability and the value (K_{La}) would continue increased (Benefield, 1980). Experiments with distances between trays of 30, 40, 50, and 60 cm in this study influenced the increase in oxygen gas transfer (K_{La}), the higher the distance between trays the higher the oxygen gas transfer value. In line with research [19], stated that the height factor, distance between trays, greatly influences the transfer of oxygen gas (K_{La}). The use of 5 trays in this research was also a factor influencing the increase in oxygen gas transfer (K_{La}). This was supported by research [20], that the factor of using the number of trays greatly influences the oxygen gas transfer value (K_{La}) in the aeration process, because the number of trays used was 5 tray produces more turbulence in the water.

Conclusions

Based on the results of the research conducted, the following conclusions could be drawn:

1. Multiple Tray Aerator uses 5 trays and the best effectiveness of reducing Fe parameters was with the distance between trays 60 cm which could reduce Fe levels from an average value of 1.51 mg/L to 1.41 mg/L with an efficiency of 6.64% in stone treatment. The average pH parameter was 6.19 and the TDS parameter is 890 mg/L.
2. The lowest oxygen gas transfer value (KLa) was obtained at a distance between trays of 40 cm without gravel, was an average of 0,0451/minute and the highest was obtained at the distance between trays 60 cm with gravel, was an average of 0,2857/minute.
3. The optimum aeration time is 10 minutes.

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Author Contributions
The author contributed as a researcher, data processor and designed the Multiple Tray Aerator tool for processing raw river water into clean water that could be used as raw drinking water.

Conflicts of Interest
This research was a requirement to complete undergraduate education in the Environmental Engineering Study Program, Department of Environmental Engineering, Tanjungpura University. The author plays the role of designing/designing tools, collecting data, analyzing data, and publishing research results as well as serving the community in utilizing clean water in Dusun Melati, Sungai Itik Village, Sungai Kakap District, Kubu Raya Regency, West Kalimantan.

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