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Research Article
Clean Water Treatment Technology with an Up-flow Slow Sand Filtration System from a Well Water Source in the Tallo District of Makassar

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Abstract
Background: An alternative for improving water quality is the use of an up-flow slow sand filter, which is a water treatment system with a main medium of sand, active carbon and gravel. **Materials and Methods:** This study aimed to analyze the quality of a water source from a well in Tallo district with parameters of odor, taste, pH, turbidity and bacterial standards in accordance with the regulation of the Minister of Health and then to analyze the effect of the thickness of the sand layer in the filter on the function of the system processing water with values of 60, 65 and 70 cm. **Results:** The results showed that the system has an effect in sustaining the pH value. The results also revealed that the filtering system with a sand thickness of 70 cm is the most effective for being able to raise the pH from 5.47 to 6-7. Sand thickness of 60 cm reduces the turbidity of 56-43 NTU and the thickness of 70 cm reduces it to 21 NTU. In addition, the odor detected before treatment in the filter system was eliminated as was the taste. Finally, some respondents found that no microbes were present in their water after the treatment. **Conclusion:** This study shows the effect of variations in the thickness of the sand layer in an up-flow sand filtration system on the effectiveness of the filter in treating water into clean water, particularly in increasing the pH, reducing the turbidity, eliminating odors and reducing bacteria.

Key words: Up-flow, turbidity, thickness of sand, water treatment, pH, slow sand filter, odor

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Increasing both the quantity and quality of water is a main requirement for more advanced levels of life in a community. Advanced countries certainly have water needs that are greater than those of states in an emerging situation[1,2]. Residents of Indonesia primarily use as sources surface water streams and wells. The dominant pollutants that contaminate rivers originate from domestic waste (waste from households). Improving people's basic access to clean water requires a consideration of the level of technology mastery of the society. One alternative is to use a simple water treatment technology with a medium-grained strainer, namely, sand. Water treatment units with slow sand filtration function as a single package. The raw water fed into the unit can be river water or lake water if the turbidity level is not too high. If the raw water turbidity level is quite high, for example, during the rainy season and to lessen the burden of the slow sand filter, it needs to be equipped with pre-treatment equipment, e.g., an initial deposition bath with or without coagulation materials with chemicals.

This study aims to analyze the quality of water from a well located in the Tallo district based on the parameters of smell, taste, pH and turbidity in accordance with the standards of the regulations of the Minister of Health and SNI[3-6]. The slow sand sieve up-flow method or slow sand filter can also be used, with flow up or down flow referring to the direction of moving through the gravel/crushed stone and quartz/silica media. From the initial filter tub, the water poured into the filter tub has a main flow direction from bottom to top. The water coming out of the tub up-flow sand filter is process water that can be piped into clean water tanks.

With the filtering system operating from bottom to top, if the filter has become saturated or clogged, it can be laundered by opening the drain valve. Clean water is inserted from the top and then the sediment will fall by itself and exit through the faucet. Thus, the laundering does not require power to dredge the system and re-install it. The capacity can be designed according to the needs. For this water treatment, the slow sand filter operates as a single package. The raw water used is river water or lake water if the turbidity level is not too high. If it is too high, such as during the rainy season, to ensure that the burden of the slow sand filter is not too great, it needs to be equipped with preliminary processing equipment, such as an initial deposition. The up-flow sand filter material is the same as that of the down-flow sand filter, with the lying lies in the filtering water flow direction. A gradual decrease of the relative proportion of single water user structures in a water consumption system has made the utilization of water resources in Nanjing rational and diversified[7].

Up-flow systems direct the water in the up-flow direction of the system. The water comes into the water system tank and flows through an upper basket and then down a media riser tube in the middle of the tank. Once the water reaches the bottom of the riser tube, it is then distributed through a lower basket attached to the riser tube. The water then flows from the bottom of the tank through the filter media in a swirling motion. Systems to handle secondary treated domestic effluent from single houses have been constructed and instrumented in Ireland to investigate whether the technology could provide a solution to the problem of on-site effluent disposal in areas with low-permeability sub soils[8].

To design a slow sand up-flow filter, some planning criteria that must be met include a raw water turbidity less than 10 NTU. If it is greater than 10 NTU, it needs to be equipped with a settling basin with or without chemicals. The speed of screening must be between 5-10 m^3/m^2/day. The high-layer sand has a thickness of 70-100 cm and it has a 25-30 cm layer of gravel. The high-water level above the sand media is 90-120 cm and the high free space is between 25-40 cm. The diameter of sand used is approximately 0.2-0.4 mm. The number of filter tubs is at least two. The water treatment units with slow sand filters operate as a package. The raw water used can be river water or lake water as long as the turbidity level is not too high.

MATERIALS AND METHODS

This study applied an experimental method design in which we compared the effectiveness of the media, namely, a sand filter, gravel and active carbon in filtering well water sources. It analyzed the output of water based on the parameters of pH, odor, turbidity and bacteria. The samples were analyzed and surveyed before and after the filtration, which was done using the method of up-flow filtration.

The steps in this study were as follows; firstly, the quality of the well water was tested before the filtration to obtain preliminary data on the smell, taste, pH, turbidity and *E. coli* contents. Then, tests were carried out in the laboratory to verify that the sand meets the density requirements for use as a sand filter. The analysis were performed to determine the effective size and filter media uniformity coefficient. Given that the thickness of the sand filter is 60-70 cm (ISO 3981-2008), this study used three different thicknesses of sand filters of 60, 65 and 70 cm.

RESULTS AND DISCUSSION

Physical, chemical and microbial testing on the water before and after screening were done in the Health Laboratory in Makassar, tested by experts using samples collected directly from the field in the Tallo region and regulating the water temperature before the test. Testing was conducted to determine the conditions of the water after filtration, including the physical properties of turbidity, smell and taste, the chemical property of pH and the microbiological analysis for *E. coli*.

For the output to be recommended as clean water, it should not exceed the maximum reference values or otherwise it does not meet the requirements and standards of the clean water, such as physical, chemical and microbial standards. The physical and chemical testing of the water performed before and after filtering is described in Table 1.

From the test results, the obtained density values range between 2-4 NTU, with an average value of 3 NTU and this figure is still lower than the standard that is 5 NTU. Odor and taste testing surveys were conducted directly in the field and after filtration through the media available and the water was found to be odorless and tasteless. It was also found that the media can increase the pH of the water resources from 5.6 to 6-7. Some respondents found that it can remove microbes, especially *E. coli*. The average temperature is 26°C. This shows the effectiveness of up-flow water filtering and how its assists the community in the provision of clean water. A similar program was conducted in Hanjiang and an optimal water resource allocation and water supply risk analysis were proposed and applied in the mid-lower reaches of the Hanjiang River basin[9]. For microbial removal, a five year study showed a bacterial removal efficiency of 97% on average with a level of fecal coliforms of 2±2 Colony Forming Units (CFU)/100 mL in the treated water. A study conducted by Schifman *et al.*[10] evaluated two tree filters: A conventional unit (CTF) with a sand/shale mix as the filter media and a modified tree filter, which also effectively reduced the bacterial content in the water source[10].

Table 1: Some parameter results from tests on well water sources in Tallo region and standards

Parameters	Unit	Test result average	Standard
Density	NTU	3	5
Odor	-	No odor	-
Temperature	°C	26°C	30°C
Taste	-	No taste	-
pH	pH	6-7	6.8-7.2
Microbial	Colonies	0	0

Water quality complaints related to particulate matter and discoloration can be trouble some for water utilities in terms of the need for follow-up investigations and the implementation of appropriate actions because particulate matter can enter from a variety of sources. Theses pollutant may affect the biota in the water and lead to a double contaminant that results in a poor water source quality[11,12].

Turbidity was visibly removed during the treatment. When the water was retrieved from the filter through a manual pump for long consistent time intervals (60 min), the fecal coliform counts increased from 4-10 CFU/100 mL on average compared to those using shorter pumping intervals (5 min). However, the treated water did not comply with the requirements of the Hlenschlaeger[13]. In line with this study, it was found that the effect of the distance from the pollution sources was more pronounced for the fecal and total coliform counts, which decreased with the increasing distance from the waste dumps. The use of slow sand filter methods was also tested in other studies, a different result was found by Elliott *et al.*[14], who used triplicate columns loaded with accu sand silica or crushed granite. Bench-scale experiments provided confirmation that increased schmutzdecke growth as indicated by a decline in the filtration rate is the primary factor causing *E. coli* reductions of up to $\log^{10}(5)$. However, in fact, the filter media type (accu sand silica vs. crushed granite) did not influence the reduction of *E. coli* bacteria[15]. The qualities of the well water samples were therefore not suitable for human consumption without adequate treatment[16]. In addition, it is suggested that this technique might be an effective strategy to reduce water consumption and promote sustainable water resource management. In addition, studies found that for clear tap water, the bacteria concentration can be reduced by at least three orders of magnitude up to flow rates[17] of approximately 20 L h^{-1}. The different technology applications can lead to varying performance in the reduction of the microbial level[18].

The technique will be more effective when it is offered to the community in a partnership with a third party that could provide support in terms of basic data and complete responsibility for the theory of regional water resources planning[19-22]. It is then suggested that the local government can promote the sustainable use of simple sand filter technology to maintain community health and provide safe drinking water. In addition, it is necessary to monitor the water quality parameters by measuring the suspended solids, chemical oxygen demand, dissolved oxygen, pH, nitrate-nitrogen and phosphate concentrations[23].

CONCLUSION

The application of water treatment units with slow sand filtration clearly represent an effective method to supply clean water in an emergency situation where the water source for the communities does not meet the requirements for health. Based on a laboratory analysis, it is revealed that all filtrated water is much cleaner in terms of odor, density, taste and pH.

SIGNIFICANCE STATEMENTS

To improve communities' abilities to meet their clean water basic needs, it is necessary to adjust solutions according to the level of technological mastery of the society. In this experimental study, we present an up-flow system of slow sand water treatment that is urgently required by communities in areas where water is scarce and does not meet the requirements for daily needs and consumption. This simple technology has made a significant contribution to the health and water needs of the Tallo region as the materials for the construction are readily available. This technology is also supported by the local government as a program for improving the coverage of clean water access that is planned by the health department. Having this efficient technology clearly generates clean and safe water for daily consumption for the Tallo communities and improves the public health.

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