Pancasakti Journal of Public Health Science and Research
Vol. 5, No. 1 January 2025: Hal. 83–89
Doi: 10.47650/pjphsr.v5i1.1715
ISSN (Online): 2777-1296
OJS: http://journal.unpacti.ac.id/index.php/pjphsr

The Effectiveness of Gravity Fed System with Varying Media Thickness for Household Water Treatment

Pitriani*, Kiki Sanjaya, Muh. Gymnastiar
Public Health Studies Program, Faculty of Public Health, Tadulako University, Central Sulawesi, Indonesia

***Correspondence Address:** pitriarifinkl07@gmail.com

Article Info

Article History
Received: Jan 13, 2025
Revised: Jan 19, 2025
Accepted: Jan 22, 2025

Keywords:
GFS, Filtrasi, TDS, TSS, Total coliform

ABSTRACT

The availability of clean water becomes difficult during a flood disaster, one of the simple technologies that has the potential to be developed in flood-proneareas is the Gravity Fed System (GFS). The aims of the study to know the influence media thickness in GFS efektivity to reduce TSS, TDS and Total coliform. This research uses an experimental design with a laboratory test approach to see the effect of varying filter media thickness on the effectiveness of GFS. Samples were taken from the Pewana river Rogo Village in Sigi Regency. Organoleptic tests showed a significant change in color and odor parameter, from cloudy to colorless and mud smell disappears after treatment. pH (7.2-8.1) and temperature (29-32 °C) still within a quality standard. The highest effectiveness develop in sample I with a media thickness of 25 cm (TSS 96 mg/L decreased to 10 mg/L and TDS 338 mg/L to 243 mg/L), the effectiveness of 72% and 27%. GFS is effective in improving the physical quality of water where all parameters have met quality standards after treatment. The thickness of the filter media has an effect on reducing the TSS and TDS parameter, but has no effect on decreasing total coliform. Media thickness needs to be increased to improve TDS and total coliform reduction efficiency.

INTRODUCTION

Floods can contaminate water sources, reducing the quality of clean water available from primary sources. Clean water infrastructure, including pipes and water treatment facilities, is also vulnerable to damage, leading to the disruption of clean water supply (Firmansyah & Tuti, 2021). According to Sari & Intan (2023), issues related to clean water scarcity after a disaster can arise from disturbances in water sources due to changes in water quality (such as becoming turbid or saline), damage to piping systems, damage to treatment facilities, disruptions in distribution systems, or water shortages in evacuation areas.

One area that is almost annually affected by floods and requires sufficient clean water is Rogo Village, Dolo Selatan District, Sigi Regency, Central Sulawesi Province. Rogo Village has a population of 552 households with 1,782 inhabitants. This situation underlines the need to introduce appropriate technology in the provision of clean water so that during disasters, clean water can be supplied to evacuation areas. One promising technology that can be developed in flood-prone areas is the Gravity Fed System, which is a water treatment technology combining fast sand filtration and slow sand filtration techniques. This device can be made using readily

available equipment and materials, and its design is simple and easy to operate, making it feasible for household-scale use. Most importantly, this device does not require electricity to operate, which makes it suitable for use during floods. Common filter media used include sand, gravel, and activated carbon (Handoko & Ananda, 2020).

Previous research found that the gravity-fed system with a flow rate of 10 mL/second and a filter media thickness of 15 cm was not optimal in reducing TSS and TDS in the water. However, a noticeable change in water quality occurred, as the water, which was initially murky and had a muddy odor before treatment, became clear and odorless after the treatment (Pitriani et al., 2023). Therefore, this study will explore variations in filter media thickness to examine their effects on reducing TSS, TDS, and Total coliform levels, as well as on changes in color and odor. This study will test variations in the thickness of the sand filter media, including 15 cm, 20 cm, and 25 cm, with the aim of determining the optimal recommendation for developing appropriate technology that can produce clean water and meet the minimum clean water quality standards. This study aims to assess the effect of media thickness on the effectiveness of the Gravity Fed System in reducing TSS, TDS, and Total coliform.

METHODS

The research is quantitative with a quasi-experimental design. The experiment uses three variations of filter media thickness: 15 cm, 20 cm, and 25 cm. The filter media used is sand with a small diameter, where the smaller the media density, the better the filtration (Urbayanti et al., 2022). The trial can be repeated several times to observe the consistency of the subjects or, in this case, to assess the effectiveness of GFS in reducing the parameters of TSS, TDS, Total Coliform, as well as observing changes in color and odor. Primary data collection was obtained through:

1. Field observation (organoleptic testing of color, odor, and taste parameters).
2. In situ measurement of pH and temperature using a portable pH meter (Ez-9909).
3. Laboratory analysis for TSS, TDS, and Total Coliform parameters. TSS and TDS values are measured gravimetrically (SNI 06-6989.3-2004), and total coliform is determined by the Most Probable Number (MPN) method. Samples are analyzed at the laboratory of the Provincial Environmental Agency of Central Sulawesi.

GFS is considered effective if all parameters meet the quality standards. Effectiveness refers to the extent of the actual reduction in each parameter compared to the target to be achieved, where the reduction of each parameter should align with the quality standards. The effectiveness percentage of GFS is calculated using the following formula:

$$E = \frac{So - S \times 100\%}{So}$$

Explanation:

E = Effectiveness of wastewater treatment (%)

So = Average concentration of the parameter measured at the Inlet (mg/L)

S = Average concentration of the parameter measured at the Outlet (mg/L)

The effectiveness criteria for biofilters in wastewater treatment can refer to:

X > 80% = Highly Effective
60% < X ≤ 80% = Effective
40% < X ≤ 60% = Moderately Effective
20% < X ≤ 40% = Less Effective
X < 20% = Ineffective

RESULTS

Table 1. Differences Between River Water Influent and Effluent

Parameters	Filter Medium Thickness				Quality Standard*
	Inlet	Outlet			
		15	20	25	
Physical					
Color	Cloudy	Colorless	Colorless	Colorless	Colorless
Odor	Mud smell	Odorless	Odorless	Odorless	Odorless
Temperature	29 °C	31.2 °C	32.2°C	31.4°C	*Air Temperature ± 3°C
TSS					
Sample I	96 mg/L	31 mg/L	13 mg/L	10 mg/L	≤40 mg/L
Sample II	20 mg/L	15 mg/L	4 mg/L	9 mg/L	
Sample III	18 mg/L	5 mg/L	24 mg/L	18 mg/L	
TDS					
Sample I	338 mg/L	300 mg/L	336 mg/L	243 mg/L	≤1000 mg/L
Sample II	119 mg/L	90 mg/L	60 mg/L	144 mg/L	
Sample III	82 mg/L	52 mg/L	43 mg/L	25 mg/L	
Chemical					
pH	8.30	7.80	8.20	7.30	6-9
Biologycal					
Total coliform					
Sampel I	27	44	44	27	1.000 MPN/100 mL
Sampel II	93	23	53	29	
Sampel III	43	15	15	29	

Based on Table 1, the organoleptic test showed significant changes in the color parameter, from turbid with small contaminants to clear, with the clearest result observed in the 25 cm filter media thickness. The muddy odor in the water also disappeared after treatment. The pH (7.2-8.1) and temperature (29-32°C) remained within the normal standard quality range. This indicates that the GFS with a 15 cm media thickness is essentially capable of clarifying the water. The highest reduction in TSS and TDS occurred in sample I with a 25 cm media thickness, with TSS decreasing from 96 mg/L to 10 mg/L and TDS decreasing from 338 mg/L to 243 mg/L. The maximum reduction in total coliform occurred in sample II with a 15 cm media thickness.

The data in Table 2 show that the thickness of the filter media affects the effectiveness of the GFS in reducing TSS and TDS, while the reduction of total coliform is not influenced by the thickness of the filter media. The highest reduction in TSS was observed with a filter media thickness of 25 cm, at 72% (less effective). Meanwhile, the reduction in TDS with a filter media thickness of 25 cm was only 27% (ineffective).

Table 2. Effectiveness of the Gravity Fed System in Reducing TSS, TDS, and Total Coliform

Parameter	Average Effectiveness		
	15 cm Media	20 cm Media	25 cm Media
TSS	61%	69%	72%
TDS	16%	17%	27%
Total Coliform	49%	31%	48%

DISCUSSION

Odor parameters can serve as an indication of the presence of compounds or substances in water. Based on Table 1, before water treatment, the water had a muddy odor and was turbid; however, after treatment, the water became odorless and colorless. This demonstrates that the Gravity Fed System (GFS) is effective in improving the physical quality of water. Changes in the color of river water can be caused by various factors, but based on the researcher's observations, the main cause of turbidity in Pewana River is the presence of materials such as soil, mud, and small twigs carried by rainwater.

Maintaining the water temperature within normal ranges is crucial, as temperature directly or indirectly influences and regulates various aquatic ecological processes. From an ecological perspective, temperature is related to the mechanisms of aquatic life (Ouellet et al., 2020). Temperature is a key abiotic factor affecting the structure and function of aquatic ecosystems, and its changes can significantly impact biological communities (Bonanica et al., 2022). Increased temperature accelerates chemical reactions in water bodies, increases viscosity, chemical reactions, evaporation, and volatilization, and reduces the solubility of gases in water such as O2, CO2, N2, and CH4. The ideal temperature for fish growth is 25-32°C (Machdar, 2018). Likewise, the pH levels before and after water treatment still meet the quality standards, ranging from 7.20 to 8.30. pH is a measure of acidity used to assess the acid-base level of a solution. A pH greater than 8.5 can cause an unpleasant taste and some chemicals to become toxic, which may pose a health risk (Pitriani et al., 2021). In this study, all samples at the inlet point tended to show basic pH levels, but after treatment, the pH value shifted closer to the ideal range, indicating that the gravity filtration system can improve the pH of water. pH is a crucial parameter for assessing water quality because of its impact on chemical and biological processes occurring in water bodies (Dewangan et al., 2023). If pH does not meet standards, it can result in several negative effects, such as alkalosis.

Total Suspended Solids (TSS) refer to suspended materials that are retained by a filter with a particle size of 2 μm or larger than colloidal particles (Pitriani et al., 2021). TSS includes mud, clay, metal oxides, sulfides, algae, bacteria, and fungi, most of which are caused by soil erosion into water bodies. TSS contributes to turbidity by limiting light penetration and visibility in water, which leads to a reduction in dissolved oxygen released into water through photosynthesis. Eliminating TSS causes sudden changes in microbial composition and nutrient concentrations, leading to a decrease in nitrifying bacterial load and facilitating the growth of pathogenic bacteria (Soaudy et al., 2023). Meanwhile, Total Dissolved Solids (TDS) refer to all organic and inorganic materials in ionic, molecular, or microgranular form present in water.

Dissolved solids may include sulfates, chlorides, carbonates, bicarbonates, nitrates, phosphates, sodium, magnesium, organic ions, and others. The GFS method, an improvement of the water treatment model with a filtration concept, is more effective at reducing TSS than TDS. In this study, GFS was able to reduce TSS much more effectively than TDS.

The filter bed in the GFS consists of zeolite, sand, and activated carbon. Zeolite and sand function as binding agents for pollutants in water (Aswar & Wijaya, 2020). This filtration reactor is produced continuously. Silica sand and zeolite are often used in filtration processes because, in addition to being efficient, they are also very affordable (Dvorak & Skinton, 2008). Zeolite can filter out finer impurities in water, while sand can remove sediments, mud, and foreign particles. Zeolite also has a surface that can effectively absorb pollutants. Besides its high absorbency, zeolite also has the effect of absorbing cations, thus helping to reduce water pollution. The results of this study align with research by Zharifah et al. (2024), which states that pollutants causing turbidity are more likely to be retained in thicker media with slower flow rates. The irregular pores in the filter media serve to trap particles that would otherwise separate from the water. Thicker filter media are more effective in reducing suspended and dissolved particles.

In terms of total coliforms, the thickness of the filter media did not show a consistent impact. At a 15 cm filter thickness, the effectiveness of GFS reached 49%, while at 20 cm and 25 cm filter thicknesses, effectiveness was 31% and 48%, respectively. This result contrasts with research by Mangallo et al. (2023), which found that sand filters could reduce E. coli by up to 95%. This effectiveness is believed to be related to the sand density, as prior filtration had been conducted multiple times, so the maximum result was achieved in the sixth sample. Nurhanifah et al. (2021) found that a 110 cm thick media effectively reduced total coliforms by 95.33%, using a filter media composition of silica sand, activated carbon, and gravel (70:20:10). Further research is needed to increase the media thickness with various media types, and to find specific references on the optimal filter media thickness and type to achieve maximal removal in the GFS water treatment method.

CONCLUSION

The Gravity-Fed System is effective in improving the physical quality of water, such as color, odor, and temperature. The highest effectiveness in reducing TSS (Total Suspended Solids) and TDS (Total Dissolved Solids) values was observed at a media thickness of 25 cm, while the highest effectiveness in reducing total coliform values was observed at a thickness of 15 cm. The thickness of the filter media has an impact on the reduction of TSS and TDS, but it does not affect the reduction of total coliform. Increasing the thickness of the media is necessary to enhance the effectiveness of the GFS. Further research is needed to determine the optimal media thickness for all water parameters.

REFERENCES

Aswar, I., Wijaya, F., 2020. Analisis Pengaruh Jenis Dan Ukuran Pasir Filter Pada Pengolahan Kualitas Air. Universitas Muhamadiyah Makassar, Makassar.

Bonanica L, Fasano F, Mezanotte V and Fornaroli R. Effect of Water Temperature on Freshwater Macroinvertebrates: A Systematic Review. PubMed Central: 2022, 29;98 (1) pp 191-221. DOI: 10.1111/brv.12903.

Dewangan SK, Shrivastava SK and Tigga V. Review Paper on The Role of pH Inwater Quality Implications for Aquatic Life, Human Health and Environment Sustainability. International Advanced Research Journal in Science, Engineering and Technology: 2023, 10 (6). DOI: 10.17148/IARJSET.2023.10633

Dvorak, B.I., Skinton, S.O., 2008. Drinking Water Treatment: Activated Carbon Filtration. G1489. University Of Nebrasaka-Lincon Extension. Institute Of Agricultural and Natural Resources.

Firmansyah dan Tuti R.WD. Implementasi Pembagian Alokasi Air Bersih Kepada Masyarakat di Daerah Rawan Bencana Kota Tangerang Selatan. Transparansi: Jurnal Ilmiah Ilmu Administrasi. 2021: 4 (1).

Handoko W dan Ananda R. Perancangan Filter Gravityfed untuk Saringan Air Kotor di Wilayah Pedalaman Kabupaten Asahan Peranggan Ujung. J-SAKTI: 2020, 4 (2) pp.703-710. EISSN: 2549-7200.

Machdar, I., 2018. Pengantar Pengendalian Pencemaran: : Pencemaran Air, Pencemaran Udara, Dan Kebisingan. Deepublish, Yogyakarta.

Mangallo, B., Alfontus, R., Novitasari, A.D., 2023. Efektivitas Metode Sand Filter Dalam Menurunkan Tingkat Kekeruhan Dan Kadar E. Coliform Pada Air Sumur. Jurnal Natural 19.

Nurhanifah, H., Hanurawaty, N., Purnama, L., 2021. Variasi Ketebalan Media Pada Biosand Filter Terhadap Penurunan Bakteri Coliform Pada Air Bersih di Packing House Xyz. Jurnal Kesehatan Siliwangi 2. Https://Doi.Org/10.34011/Jks.V2i2.727

Uellet V, St. Hilaire, J. Dugdale S, M. Hannah D, Krause S and Proulx-Ouellet S. River Temperature research and practice: Recent challenges and emerging opportunities for managing thermal habitat conditions in stream ecosystems. Science of The Total Environment: 2020, 736 (139679).

Pitriani, Sanjaya K, Arwan, Ansar M dan Suprapto R.F. Effectiveness of the Gravity Fed System in Providing Clean Water in Flood Prone Areas in Rogo Village, Sigi Regency. Jurnal Kesmas UNTIKA Luwuk: 2023, 14 (2) E-ISSN: 2620-8245.

Pitriani, P., Sanjaya, K., Wahid, R.S., 2021. Pengelolaan Limbah Padat, Cair Dan Gas, 1st Ed. Nasmedia, Makassar.

Sari, Intan P. Dampak Fenomena Banjir Terhadap Kesediaan Air Bersih di DKI Jakarta. https://www.researchgate.net/publication/374588117.

Soaudy MR, Ghonimy A, Greco L SL, Chen Z, Dyenchauz A and Li Jian. Total Suspended Solid and Their Impact in A Biofloc System: Current and Potentially New Management Strategies. ELSEVIER; Agriculture: 2023, 572: 739524. https://doi.org/10.1016/j.aquaculture.2023.739524

Urbayanti I, Sriwinarno H dan Basuki. Studi Kelayakan Pengembangan Aspek Teknis Dan Finansial Pengembangan Sistem Penyediaan Air Minum Tingkat Pabrikan Di Daerah Istimewa Yogyakarta. Jurnal Rekayasa Lingkungan. 2022: 22 (1) pp 32

Zharifah, J.A., Meicahayanti, I., Busyairi, M., 2024. Pengaruh Komposisi Ketebalan Media Dan Kecepatan Aliran Pada Reaktor Biosand Filter Dalam Pengolahan Air Permukaan. Jurnal Teknologi Lingkungan Unmul 8.