ISSN: 03875547
Volume 45, Issue 01, February, 2022

PHYTOREMEDIATION: AN ECO-FRIENDLY TECHNOLOGY TO IMPROVE PUBLIC HEALTH AND ENVIRONMENTAL QUALITY

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Keywords:
Phytoremediation, Eco Friendly, Clean Water, Water Quality, Water Pollution

ABSTRACT

Water is one of the elements of the environment that is critical for the development and growth of all living things, including people. Due to rapid population expansion, not everyone in society has access to clean water [1]. In addition, river water pollution due to household and industrial waste disposal also became a source of problems in clean water availability. The low availability of clean water adversely affected all sectors, including health, such as cholera, ringworm, scabies, diarrhea/dysentery, typhus, and other diseases. This research was an analytic, experimental, and observational study with a pretest-posttest control group design. The independent variables of this study included Water Hyacinth, beach sand, gravel, palm shell charcoal, and palm fiber. Meanwhile, the dependent variables comprised the levels of physical parameters, chemical parameters, and microbiological parameters. Water Hyacinth (*Eichhornia crassipes*) could reduce the content of Chemistry Parametric, Physics Parametric and Microbiology Parametric. After the testing, based on physical parameters, the muddy water became clearer while dissolved oxygen was higher, indicating a good water quality on Day-28. In addition, the chemical parameters, i.e., COD and bacteriological examination on *E.coli and Total Coliform* indicated a decrease compared to all elements in Day-0. It suggested significant change in the water quality from Day-0 to Day-28 through the filtration of phytoremediation kit. The benefits from this research are: can decrease muddy water, can grow Water Hyacinth easy to use, priceless and beneficial. Further recommendation from this research is The Phytoremediation kits must be cleaned every week to prevent moss.

1. INTRODUCTION

Water is one of the elements of the environment that is critical for the development and growth of all living things, including people. Due to rapid population expansion, not everyone in society has access to clean water. [1]. In addition, river water pollution due to household and industrial waste disposal also becomes the source of problems in clean water availability. The low availability of clean water adversely affects all sectors, including health, such as cholera, ringworm, scabies, diarrhea/dysentery, typhus, and other diseases [2].

According to WHO data in 2017, 71% of the global population, or 5.3 billion people, consumed clean and uncontaminated water, while a total of 2.2 billion people did not have access to clean water, and more than 220 million people required treatment for diseases caused by parasites found in contaminated water. There were 435 million people who took water from improper places, and as many as 144 million people took water from lakes, ponds, and rivers. Globally, at least two billion people consumed contaminated water with feces and health problems. An estimated 485,000 people died each year as a result of contaminated water [3].

In Indonesia, many people have not consumed proper and clean water. The survey results conducted by BPS show that households with access to safe drinking water over the last five years reached 70.35% [4]. In 2017, households with safe drinking water sources amounted to 71.27%, while in 2018, it increased to 72.99% [4]. However, in 2018, most households obtained drinking water by buying, amounting to 46.72% [4]. Based on *Studi Kualitas Air Minum Rumah Tangga* (SKAMRT) 2020 in Indonesia, 7 out of 10 Indonesian households consumed drinking water contaminated with E. Coli. E.coli is Gram Negative Bacterial which found on skin, gut, water and pus [5]. Bacteria, viruses, protozoans, and helminths are the most common biological pollutants. Pathogens such as *Campylobacter, Clostridium, Salmonella, Staphylococcus, colon bacillus, enteroviruses, human caliciviruses, Entamoeba histolytica, Giardia lamblia, Microsporidia spp., Anabaena, Microcystis, Schistosoma mansoni, and Taenia saginata* are the most common biological water contaminants [6]. The study was conducted by the Center for Public Health Research and Development of the Research and Development Agency, the Ministry of Health. A study conducted in 2020 indicated that 31% of households in Indonesia consumed refillable water, 15.9% from protected wells, and 14.1% from drill/pump wells [7]. According to [8].

Water pollution is caused by heavy metal contamination, which can decrease water quality and poison humans [9]. To overcome this problem, aquatic biota can be utilized, such as Water Hyacinth (*Eichhornia crassipes*), which captures heavy metal pollution. The process starts from plant roots that absorb pollutants in the water, then through the transportation process of plants, the water containing pollutants flows throughout the plant body. As a result, the pollutants in the water become clean [9]. The other benefits from Water Hyacinth are as a In addition, water hyacinth can be used as a handicraft raw materials, and water hyacinth for sale and woven in moist or dry conditions [10].

In addition to Water Hyacinth, other materials, such as palm fiber (*Arenga Pinnata*), beach sand, palm shell charcoal (*Elaeis guineensis*), and gravel (*Lapillus*) can also be used. Palm fiber has a high level of flexibility, density, solidity so that the impurities in the water are easily filtered and have durable properties so that they do not rot easily even when used for a long time [11] and serves as a durable fine feces sensor [12]. Beach sand is highly effective in filtrating peat water into clean water [13]. Beach sand has the highest absorption efficiency and when compared to other sands, beach sand also contains high silica [14] Fine pieces of skin can be useful as a water purifier and also reduce levels of manganese, iron and other metals because it contains calcium carbonate [15]. Palm shell charcoal (*Elaeis guineensis*) can be utilized as a smell-busting and to remove unpleasant taste in water. It can also purify water [12] and filter dirty water, gas purification, and catalyst [16]. Improve the pH of the air with the addition of palm charcoal, there is an increase in the value of calcium carbonate which can bind free radicals on the surface so that it is amphoteric [17]. If the pH of the water is acidic then the air will be acidic if the water is alkaline then the air will be bitter [18]. Last but not least, gravel (*Lapillus*) is useful for disguising the rough dirt [19]. With various materials to filter dirty water, it can be ensured that the water becomes clean.

Phytoremediation is an environmentally benign strategy that could be a cost-effective solution to revegetate heavy metal-polluted soil [20]. Phytoremediation mechanisms come in a variety of shapes and sizes. Phyto

ISSN: 03875547
Volume 45, Issue 01, February, 2022

stabilization, phytoaccumulation, Rhizosphere biodegradation, Rhizo filtration, Phyto-volatilization, Phyto-degradation are the terms used to describe these processes [21].

2. Materials and Methods

2.1 Study area

This research is an analytic, experimental, and observational study with a pretest-posttest control group design. The independent variables of this study included Water Hyacinth, beach sand, gravel, palm shell charcoal, palm fiber. Meanwhile, the dependent variable covered the levels of physical parameters, chemical parameters, and microbiological parameters.

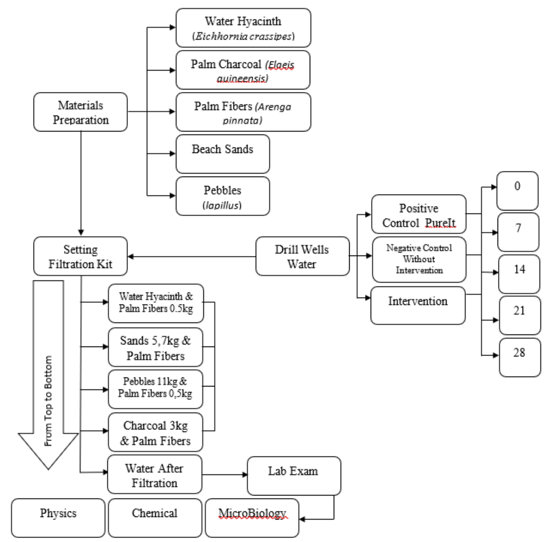

Figure 1. Mechanism of Phytoremediation.

Phytoremediation kit is a multilevel and circular water filter that applies a phytoremediation system and utilizes environmentally friendly materials that are easily obtained, using materials such as palm fiber, palm charcoal, gravel and beach sand.

Figure 2. Sample Pictures

This Phytoremediation kit on the top container is Water Hyacinth after that the second container contain Palm Fibers, third container contain Beach Sands, fourth container contain Pebbles, fifth container contain Palm Charcoal and the last container contain clean water and pump to help circulation.

2.2 Procedures

1. Research Materials

a. Test materials

This research used test materials in the form of dirty water derived from Teladan Barat Village in Medan. We chose this village because not all people can install PDAM pipes so that many still use drill wells water and also to find and utilize water resources.

b. Research Equipment

Equipment employed included acrylic boxes, Water Hyacinth, beach sand, gravel, palm shell charcoal, palm fiber, pipes, tap water, pump 1600, and documentation tools.

2. Sampling

The water samples were obtained from the Teladan Barat Village and community houses to identify the water condition and the daily consumption by the community in real time. The Teladan Barat Village contains household waste because from interviews with people in the village whose water sources are close to bathrooms, septic tanks, and chicken coops. So that it is the best sample to measure the characteristics of good water, physical, chemical, bacteriological, and phytoremediation capabilities of this study.

3. Sample testing

The samples were then sent to a qualified Shafera Environment laboratory for examination. Once the microbiological and chemical circumstances were identified, the research started to test and ensure that the components used for the phytoremediation kit could effectively produce clean water.

4. Assembly Tool for Implementation

The assembling of phytoremediation kits was carried out after all component testing had been ensured effective and useful. The assembly process involved all relevant partner members as well as other communities that would be benefitted from this program. After the completion, the final testing was performed before the phytoremediation kit was widely used by the community.

5. Dissemination of Use

With the partner support, the program disseminated information about the use, benefits, and methods to treat phytoremediation kits as water purifiers. Periodic mentoring and supervision were conducted every two weeks in the first two months, continued to every two months and 12 months. The assistance and supervision were carried out to ensure all components were well-maintained and the program was efficient and sustainable, and to provide solutions to partners in case of problems with phytoremediation kits or its components in the future.

3. Results and Discussion

3.1 Content of COD

Table 1. Intervention and Negative Control Laboratorium Result of Chemistry Parametric

No	Parametric	Result day - 0	Result day - 7	Result day - 14	Result day - 21	Result day - 28	Positive Control Result	Standards	Unit	Method
1	COD	47	17.5	8.78	8.4	8.4	10	40	mg/L	SNI 6989.73-2019

Note: COD: Chemical of Demand.

The results of COD content data during the remediation period measured every seven days aimed to identify the efficiency of the decreased content of the parameters against the duration of maintenance with the drill wells water concentration. During applying phytoremediation, COD content indicated a decrease in value with an initial value of 47 mg/L. The major decrease in COD content occurred until Day-7. Then, it gradually decreased to the final COD content of 8.4 mg/L

3.2 Average range of drill wells water quality measurement

Table 2. Intervention and Negative Control Laboratorium Result of Physics Parametric

No	Parametric	Result day-0	Result day-7	Result day-14	Result day-21	Result day-28	Positive Control Results	Standards	Unit	Method
1	Hardness	109	55	55	49	48.5	21.0	-	mg/L	SNI 06-6989.1223-2004

In addition to the chemical parameters, the physical parameters of drill wells water were also measured, resulting in a decrease of Hardness from 109 mg/L to 48.5 mg/L by the end of the process.

3.3 Content of E.coli

Table 3. Intervention and Negative Control Laboratorium Result of Microbiology Parametric

No	Parametric	Result day-0	Result day-7	Result day-14	Result day-21	Result day-28	Positive Control Results	Standards	Unit	Method
1	*T.coli*	101	15	9	-	-	140	10000	Jml/100 mL	MPN
2	*E.Coli*	1	-	-	-	-		2000	Jml/100 mL	MPN

Note: T.coli: Total coliform, E.Coli: Escherichia coli

During other parameter studies, the microbiological parameter was tested, resulting in the largest decrease in T.coli content from 101 unit/100 mL to – (negative) unit/100 mL on Day-28.

The main advantage of phytoremediation applications was its capability to produce secondary wastes with lower toxic properties and to provide more eco-friendly and more economical methods [22]. Physical condition of water can occur with the intervention carried out is there is a physical change in the color and smell of the water. Chemical process occurs in the decrease in the physical condition of the water is from palm charcoal The pores on the surface of palm charcoal absorb absorbents and catalysts, which have a function in the absorption of particles that can generate aromas and the microbial activity surrounding plant roots that decomposes pollutants [23]. *Pseudomonas sp.* and *Bacillus sp.* are two bacteria genera that play an important role in the breakdown of toxic chemicals. [24].

From this study, it was found that the maximum decrease in *T.coli* was on the 28th day. According to [25], Water Hyacinth could accumulate heavy metals through stomata and through the roots [9]. The growing Water Hyacinth (*Eichhornia crassipes*) could reduce the level of metals in wastewater, heavy metals, such as lead (Pb), Cadmium (Cd), and Phosphate (PO_4) [26]. Besides Water Hyacinth, other materials could also be used, such as palm fiber to serve as a durable fine feces sensor [12]; beach sand to effectively filtrate the peat water into clean water [13]; palm shell charcoal (*Elaeis guineensis*) to serve as smell-busting and eliminate unpleasant taste in water, to purify water [12], and to be used for filtering dirty water, gas purification, catalyst [16]; and gravel (*Lapillus*) to disguise the rough dirt [19]. With various materials to filter dirty water, it could be ensured that the water became clean.

After the testing, based on physical parameters, the muddy water became clearer while dissolved oxygen was higher, indicating a good water quality on Day-28. In addition, the chemical parameters, i.e., COD and bacteriological examination on *T.coli* indicated a decrease compared to all elements in Day-0. It suggested significant changes in the water quality from Day-0 to Day-28 through the filtration of phytoremediation kits.

4. Conclusion

After the testing, based on physical parameters, the muddy water became clearer while dissolved oxygen was higher, indicating a good water quality on Day-28. In addition, the chemical parameters, i.e., COD and bacteriological examination on *T.coli* indicated a decrease compared to all elements in Day-0. It suggested significant changes in the water quality from Day-0 to Day-28 through the filtration of phytoremediation kits. it can be concluded that (i) There was significant decrease muddy water using Phytoremediation (ii) Water Hyacinth can growing well on media containing dirty drill wells water (iii) using an ecofriendly material, easy to use, priceless and beneficial.

5. Suggestions

For future research, we suggest:

1. The Phytoremediation kits must be cleaned every week to prevent moss.

6. Acknowledgement

The authors would like to thank: The Directorate General of Higher Education, Ministry of National Education Indonesia for funding the Program Holistik Pembangunan dan Pemberdayaan Desa for 2021

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