Utilization of Bio-sand Filter Technology to Reduce The Hardness of Groundwater in Bangunjiwo Village, Yogyakarta

C Widodo¹, S P D A Worokinkkin¹, M N Aridito¹, H A Nurusman¹ and W Widyawidura²

¹Environmental Engineering Department, Universitas Proklamasi 45, Sleman, Indonesia
²Center of Energy and Environment Studies, Universitas Proklamasi 45, Sleman, Indonesia
Email: widodoocahyo@gmail.com

Abstract. Water is the most critical requirement for the community for daily needs. Groundwater in Bangunjiwo Village, Yogyakarta has a high level of hardness, groundwater in the village contains high Magnesium (Mg²⁺) and Calcium (Ca²⁺) reaches more than 180 ppm. The purpose of this study is to reduce the level of hardness of water in Bagunjiwo Village using bio-sand-filter technology. The sampling of groundwater in Bangunjiwo Village is done randomly at several different points. Water filtration with bio-sand-filter technology uses sand media by growing biofilm layers. Biofilm layers made from layers include gravel with a diameter of 2 cm, small gravel with a diameter of 1 cm, zeolites with a diameter of 0.5 cm, and layers of clay. Each layer is bordered by gauze. The arrangement is soaked in water for 21 days, resulting in biofilms in the media. The results of screening with bio-sand-filter technology showed a decrease in hardness of groundwater reached 78.67 % with a discharge of 0.5 litres per minute. Bio-sand-filters can absorb the content of Magnesium and Calcium even pathogens in the water. Bio-sand-filter technology is expected to be able to overcome community problems in Bangunjiwo Village, Yogyakarta. Keywords: groundwater, water hardness, biosandfilters, biofilms, water purification

1. Introduction

1.1. Background
Water is one of the most important natural resources in the world. Water has become a basic need for living things, one of which is to fulfil drinking water. In some areas, ground water is used in fulfilling basic daily needs, especially in Bangunjiwo District, Bantul Regency. Water is not only the main commodity of daily basic needs but also affects the basic life of the community both in the economic, social and sustainable development sectors [1]. On the other hand, the quality of groundwater in some regions of the world is not suitable for consumption. Some cases of water resources do not meet good quality standards such as hardness levels, nitrate contaminants, heavy metals, and dissolved metals [2].

Hardness is a condition where water contains Ca²⁺ and Mg²⁺ ions with concentrations of more than 60 ppm [3]. The hardness of water in the area of Bangunjiwo reaches levels greater than 180 ppm. Hardness levels in the area exceed the maximum allowable limit of 180 ppm. In the long run water
hardness will affect health and reduce water solubility. In general water hardness will reduce the reaction level of soap with water [3]. In order to overcome this problem, a technological solution is needed that is able to reduce the level of hardness in water. This is the main driver of this applied research so that the goals of millennium development are achieved.

There are several ways to reduce the hardness of water in the form of chemical precipitation, absorption, ion exchange, extraction, and membrane filtering [4]. Some of these methods have weaknesses such as increased sludge, water becomes harder, water salts such as sodium, formation of sediments in water effluent and require maintenance, and costs are quite high [4]. In conventional technology transient hard water can be removed by heating but special handling must be carried out for permanent hard water. One of the technologies used in water purification is bio-sand filter technology [5]. This technology can reduce the water hardness concentration caused by compounds containing Ca\(^{2+}\) and Mg\(^{2+}\) ions. Not only reduce hardness, bio-sand filter technology can improve water quality by eliminating coliform, e. coli, dissolved iron, pathogens, arsenic, turbidity with more costs cheap from several other techniques [6].

Water quality parameters can be seen from the physical and chemical properties contained in water. These parameters are temperature, transparency, pH, electricity, conductivity, hardness, total salinity, total dissolved solid [9]. Handling water hardness in the Bangunjiwo area of Bantul Regency using bio-sand filter technology is expected to be able to improve water quality in the area so that the goal of the concept of sustainable development is created.

2. Purpose
The purpose of this applied research is to determine the level of water hardness uptake, and provide technological solutions for the Bangunjiwo community in Bantul Regency to improve water quality. Improved water quality in the form of decreasing salinity, solid total dissolution, neutralizing pH, and killing pathogens.

3. Methods and Material

3.1. Description study area
Bangunjiwo Village is located in Bantul Regency, Province of D.I. Yogyakarta. This area has an area of 15.43 km. This area is about 10 km from the center of Yogyakarta province. With a height of about 25-100 meters above sea level. The Bangunjiwo area is located at coordinates -7.839790, 110.313329. Groundwater sources in Bangunjiwo people come from ground water and soil structure in the form of limestone which allows the washing of minerals by ground water which causes hardness in ground water. The climate in the Bangunjiwo region is a tropical climate with two seasons in the form of a rainy season and a dry season. Temperatures in this region range from 26-30°C.
3.2. Sampling and Sample Collection
Water samples were taken in PP (Poly Propylene) plastic bottles with a capacity of 1500 ml with hardness levels of 601 ppm. Hardness levels in the area exceed the maximum allowable limit of 180 ppm. The water bottle was washed with clean water to avoid samples from contaminants. This water was then tested for water quality in the laboratory of the energy and environmental study (PSEL) University of Proclamation 45 in Yogyakarta.

3.3. Collection and Preparation of Asbsorban
Material from bio-sand filter technology uses several materials, including large gravel stones with a diameter of 2 cm as the lowest layer, small gravel 0.5 cm in diameter as the second layer from the bottom, the upper layer in the form of zeolite rocks with a diameter of 0.5 cm, and layers uppermost form of sand and clay as the first medium for growing biofilm. Each layer is given a filter screen to backwash each layer. The material used is washed with distilled water to remove other impurities.
3.4. Methods and Arrangements
Some of the prepared materials are arranged in the order shown in chapter 2.3. The container used is a plastic jar with a capacity of 3000 ml with a surface area of 200 cm and a height of 15 cm. The height of each layer is about 1-2 cm, the rest is in the form of gauze and sand filters for biofilm growing media [7]. Biofilm growth is done by soaking the layers for more than 21 days. By doing so, it is expected that biofilms in filtration media grow well [8]. Pre-treatment of hard water needs to be done to optimize bio-sand filter technology. Pre-treatment is done by synchronizing use water diffuser before entering the filtration process. This water separation is done to slow down the flow of water entering the sand layer. This is needed to hold the biofilm that has grown so as not to disturb and change the porosity of the layer [7]. To get definite results, water measurements were taken before being treated and after being treated.

4. Result and Discussion

4.1. Water Purification and Groundwater Hardness
Hard water is a category of water that cannot dissolve soap in water. The hard water is divided into two, namely permanent and contemporary hard water. Permanent hard water is water containing compounds Ca or Mg which reacts with bicarbonate ions (CHO₃-) while contemporary hard water is hard water containing Ca or Mg which reacts in addition to bicarbonate ions. Basically, the classification of water is divided into 4 based on the level of fitness (concentration in ppm). Ordinary water (soft water) is at the hardness level of 0-60 ppm, hard water is at a hardness level of 60-120 ppm, hard water is at a hardness level of 120 - 160 ppm, and very hard water is at more than 160 ppm [10].
Hardness of ground water can be removed using absorption and filtration techniques. This absorption requires media in the form of gravel layers, small stones, zeolite, and sand. sand layer is the most effective layer to absorb impurities in the water. The use of biological agents in water purification is a solution for absorption of heavy metals. Bio-sand filter is a combination of these two technologies in the process of water purification.

There are several ways to purify water to improve the quality of ground water. Bio-sand filter technology is a water purification technique similar to a slow-sand filter. The slow-sand filter uses continuous type water filtration and can be added immediately at any time. In bio-sand filter filtering requires time to stay in the filtering process. Residence time is needed to allow time for the grown biofilm to decompose dissolved solids. The flow rate required is 0.4 m³ / m² / hour [8].

4.2. The Result of Measurement

| Parameter | Before Filtration | After Filtration |
|-----------|-------------------|------------------|
| Salinitas  | 1400              | 200              |
| TDS       | 1200              | 200              |
| PH        | 800               | 200              |
| Conductivity | 600         | 200              |

Figure 7. Comparison Before and After Filtration Bio-sand Filter

Table 1. The Result of Measurement
| Parameter          | Before | After | Decrease (%) |
|-------------------|--------|-------|--------------|
| Salinity (ppm)    | 601    | 128   | 78.67        |
| Total Dissolved Solid (ppm) | 866    | 184   | 78.73        |
| pH                | 7.53   | 7.51  | 0.27         |
| Conductivity (µS) | 1238   | 265   | 78.54        |

The Bio-sand Filter shows great potential for reducing impurities contained in water. From table 1. shows that bio-sand filters can increase groundwater quality by 78%. Decreasing hardness is seen in a decrease in salinity of 78.67%.

4.3. Layers of Sand for Biofilm Growth
Biofilm is a layer of living things that grows on sand media in the bio-sand filter screening process. In this layer zoo algae, protozoa or pseudomonas aeruginosa microorganisms are able to absorb metals dissolved in water. The growth of microorganisms is done by soaking filtering media that has been prepared for 21 days. When water flows through the filtering layers, organic matter is captured in granules of sand, resulting in a slimy layer called zoo algae and develops the bacterium pseudomonas aeruginosa. Biofilms that grow in the bio-sand filter layer are able to absorb metals dissolved in water [9].

4.4. Zeolite Layer
Zeolite layer is a crystalline aluminosilicate hydrate compound with alkaline earth metal with the chemical formula M2/nO Al2O3 x SiO2 yH2O. With M is a cation that can be exchanged with valence n. M is generally group I or II ions [11]. The use of zeolite in water purification can absorb special Group II elements, Mg2+ and Ca2+ ions.

4.5. Gravel Layer
The gravel layer is used to settle dissolved solids. Contained in water. Basically, sedimentation is carried out by gravitational forces to remove particles in the influent. Fluid velocity affects sedimentation of dissolved particles. Sedimentation in bio-sand filters uses the entire surface of the gravel facing upwards.

4.6. Mechanism Bio-sand Filter
Water purification in bio-sand filters includes the process of transportation mechanisms, attachment mechanisms and purification mechanisms. In the transport mechanism there is sedimentation and sedimentation due to filtration of water by sand [12]. The transportation process allows organic material to spread throughout the surface of the sand and grow biofilms. In attachment mechanism there is a withdrawal of the electrostatic filter by the particle in water which has an opposite charge. The purification stage is the stage of biofilm formation in the form of protozoa, bacteria derived from organic particles.

In filtering bio-sand filter requires maximum limit a discharge of low water flow rate, maximum of discharge produced from the bio-sand filter is 400 liter / m2 / hour [8]. The smaller the discharge issued, the better the quality of water produced. The expansion of the system allows developers and industrial owners to know about leaks and minor damage to water pipes. Further development is expected to be able to prevent damage to the piping system.
5. Conclusion

From the results of these studies it can be concluded that the bio-sand filter technology is able to reduce water hardness by 78.67% with a flow rate of 0.5 l per minute. In addition, bio-sand filters can improve water quality by reducing the dissolved solids and pathogens contained in water. On the other hand, the use of bio-sand filters requires a long stay and cannot continue to maximize the results.

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