Assessment of shallow groundwater on the bank of the ISTN lake through lakebank filtration based on aquifer properties, pH, total dissolved solids (TDS), and microbiological analysis

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Abstract. A lakebank filtration assessment was carried out on the shallow groundwater surrounding the ISTN lake to evaluate of the shallow groundwater resources in the area. The objective of this research is to describe the shallow groundwater characteristics based on aquifer properties, pH, TDS and microbiological analysis. This research was conducted by making boreholes and observation holes at the bank of the ISTN area for 3 points in a single line perpendicular to the Lakebank together with 3 points in a single line perpendicular to the canalbank for doing the experiments and taking samples for pH, TDS, and microbiology analysis. Based on aquifer properties using boring and pumping test results, the aquifer layer with a thikness around 4 m show the normal storage coeficients between 0.00026 and 0.0316. From the pH, TDS, and microbiological analysis for sampling taken from boring 2.1, 2.2., and 2.3 with the distance around 10, 20, 30 m from the lake boundary were found in range of fresh water with zero patogent microbial population but the pH of some samples was lower than the pH of drinking water requirement in which that should be improved by using simple treatment before consumption.

1. Introduction

Lakes are a surface water resource that has a critical function for human life and other living things. Utilization of lake water to support human life, if not accompanied by wise action in its management, will cause damage to the water resources [1]. Lakes have a variety of purposes, such as water reservoirs, as a catchment area, flood control, water availability, a place to keep fish and as a place of recreation [2]. A lake is a body of water over the surface of the soil that is formed naturally and artificially, whose water comes from groundwater and surface water, is relatively small in size, and belongs to the open and dynamic freshwater ecosystem as a potential form of the protected area. The function of the lake can be viewed ecologically based on the water system of the surrounding area, and the

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water catchment area. Under certain conditions, a lake can recharge the water into shallow groundwater, be a power plant, be a deep groundwater basin and sea intrusion defender, be a raw water source, provide irrigation, flood control, and economic functions, and, play a role as recreation, fishery, etc. [3].

As a water reservoir, it has a specific capacity and can change due to natural activity and human activity. A decrease in the quality of water will decrease the usefulness, productivity, and capacity of water resources, which will ultimately reduce the wealth of natural resources. To maintain water quality in its natural condition, it is necessary to manage and control water pollution wisely. For example, river and in-situ pollution can result from high sediment contents derived from erosion, agriculture, mining, construction, land clearing and other activities, organic waste from humans, animals, and plants including the rate of increase of chemical compounds derived from industrial activities that dispose of their waste to the lake waters. These are the impacts of rising human populations, poverty and industrialization [1].

Institut National Science and Technology has a land area of about 12 ha, located on Jl. Moch Kahfi II, Srengseng Sawah, Jagakarsa, South Jakarta City, Special Capital Region of Jakarta. Most of the campus area of the National Institute of Science and Technology (ISTN) consists of open green spaces, so it is very well used as a watershed conservation area, such as an artificial reservoir. The campus of ISTN Jakarta serves as a catchment area in South Jakarta, accommodating rainwater and an abundance of wastewater from the surrounding area, and as a source of biodiversity. Injecting waste or other materials into it can lead to a decrease in water quality, even beyond the limits of water's ability to recover naturally, resulting in water pollution. Decreased water quality will affect the life of the water organisms in it so that it can lower the productivity of these waters [4].

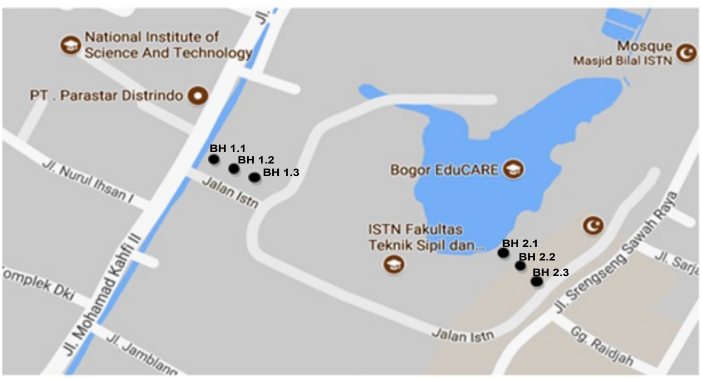
Therefore, the focus of this research paper is the utilization of ISTN situ pillar to be used as a source of clean water, and lakebank filtration a tool used to filter the water. Although 70% of the earth is water, only a small amount of water is fresh water. The main freshwater source is surface water such as rivers, lakes, and sites available for abstraction.

Water is a resource that is replenished through the process of deposition in the hydrologic cycle, yet water scarcity has become an increasingly alarming issue in recent years due to the acceleration of world population growth that demands large amounts of water for food consumption and production. In this case, the lack of water impacts the lack of cheap supplies, clean water, and drinking water. The world’s population is expected to reach 8.3 billion, which is expected to increase energy and food global demand by 50% and increase demand for fresh drinking water by 30%; resources are already in short supply for one-third of the world population [5]. Water scarcity is further exacerbated by anthropogenic water pollution; an estimated 3,575 million deaths each year are caused by water-related diseases. A drastic increase in exploration of groundwater has also led to the depletion of groundwater in many places such as Asia and Africa due to groundwater aboard the ability to recharge [6]. Thus, the method of lakebank filtration (LBF) is expected to overcome this. LBF, a variant of conventional groundwater retrieval methods, draws water from a shallow aquifer recharged with the help of nearby lake water that creeps through the lake before mixing with shallow aquifer water. LBF is a cheap and sustainable yet efficient process of natural water treatment in mass producing large amounts of treated water. LBF filters out contaminants by natural attenuation processes such as filtration, absorption, acid-base reactions, oxidation, reduction, hydrolysis, biochemical reactions [7].

Dash et al. [8] also found that LBF is efficient in removing turbidity, bacterial coliform bacteria and over 70% of organic substances. LBF water treatment is generally found to be low in contamination compared to standard river water. Compared to pumping directly from river water, LBF is more effective for improving water quality by reducing color, coliform bacteria, UV-absorbance, and organic contaminants as well as halving water treatment time. However, to adequately remove cyanobacteria, the well distances from the lakebank should be sufficient to allow adequate time for biodegradation on account of less proportion of lake water uptake in LBF water mixtures, and thus, a balance of cyanobacteria removal and river absorption is required. As the LBF process depends on natural geographic conditions, there is a need to know the circumstances and settings that are suitable for optimizing LBF applications in different places. Based on the implementation of LBF and RBF by making boreholes perpendicular to the lake and river, it was found that a distance of 20 meters from the bank provides the best water quality from bacteria contamination and the water can be considered as A classification [5]. The objective of the research was to evaluate the water quality from the experiment boreholes to be utilized as a source of clean drinking water.

2 Materials and methods

This study examines the use of lake bank filtration (LBF), which will be applied on the ISTN lake and the ISTN front channel. The research area is located in the Campus Area of the National Institute of Science and Technology Jagakarsa, South Jakarta. The area of ISTN is the largest water reservoir in South Jakarta, which also accommodates rainwater, so the area of South Jakarta is rarely flooded. The location of the site is shown in Fig. 1.



Location of borehole: BH 1.1 = 10 meters from canal, BH 2.1 = 10 meters from the lake, BH 1.2 = 20 meters from canal, BH 2.2 = 20 meters from the lake, BH 1.3 = 30 meters from canal BH 2.3 = 30 meters from the lake.

Fig. 1. Borehole locations for taking samples and the experiments.

3 Research methodology

The research method was done by preparing 6 main holes and 6 observation holes (3 boreholes and 3 observation holes at the lake and 3 boreholes and 3 observation holes at the canal) to define the geological layers of location sites and conduct the pumping test experiments to characterize the aquifer layers. Fig. 1 shows the borehole locations for both sites. Fig. 2 shows the breakdown of each borehole into a main hole and observation hole for both sites.

For water quality evaluation, the water samples were taken from all six main holes and all six observation holes. At both the lake and canal sites, the first borehole was 10 meters from the bank, the second borehole was 20 meters from the bank, and the third borehole was 30 meters from the bank. Each borehole is in a straight line from the bank.

Water samples were taken from each well after the borehole water was drained up to three times of the pipe volume for reducing the error and contamination of water samples. The well was drilled to a depth of more than 9 meters from the ground surface because bacteria Escherichia coli are not present at a depth of more than 9 meters. Cleaning as much as three times the volume of water in the wellbore was carried out each time before sampling to remove any impurities to obtain a representative sample of groundwater. The samples were bottled and sent to the cooling room in the laboratory to store them before being analyzed, except for microbiology analysis samples which were directly sent to the laboratory for analysis. Physicochemical properties were tested using a parameter (pH and TDS) probe during sampling (Hanna HI98130 pH, EC, TDS, Temp). Analysis of water samples was performed using conductivity analysis for TDS and bacterial (E. coli) for the microbiologic test, and the samples were immediately sent to Environmental Laboratory of Indonesia University (UI).

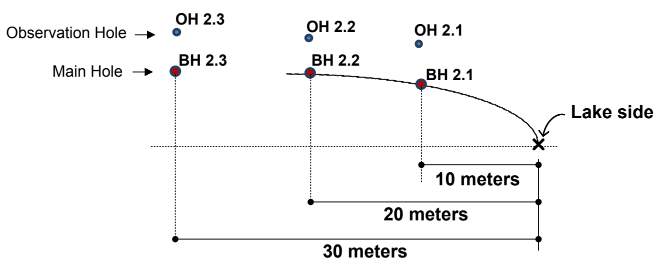


Fig. 2. Boreholes design for the characteristics of shallow aquifer.

To provide information on aquifer characteristics demand for shallow groundwater development, the pumping tests were carried out in different locations. Parameters of the aquifer such as drawdown and recovery transmissivity, specific capacity, aquifer thickness, and storage coefficient derived from pumping tests were evaluated and are described in this paper. This evaluation will provide the necessary hydrogeological information, which will provide an understanding of the aquifer potential so that the potential shallow groundwater zones for development can be located. The pumping test method is usually preferred for shallow groundwater development and determining aquifer characteristics. In this study, pumping tests were carried out at three open wells in the study area, and all the essential aquifer parameters, like conductivity hydraulics and transmissivity (T), were calculated using Cooper-Jacob and Chow methods [9]. The storage coefficient, optimum yield, recovery time, and aquifer thickness were calculated from the drawdown and recovery measurement data, well dimensions, water level, and discharge. Transmissivity can provide an understanding of the shallow groundwater potential for shallow groundwater development.

4 Results and discussion

Twelve points were drilled in this study, three main holes and three observation holes were drilled around the ISTN lake, and three main holes and three observation holes were drilled at the canal site. 4-inch diameter PVC pipes were used at the main holes, and 2 inch diameter PVC pipes were used at the observation holes. The observation holes were located 1 meter from the main hole. The boreholes at both the lake and canal site were located 10 meters from the bank, 20 meters from the bank and 30 meters from the bank. The drilling depth was planned to be around 20 meters or until the drill reached the sand layer, so if at a depth of 20 meters the drill bit had not reached the sand then the drilling would continue until the sand layer was breached.

4. 1 Lithologies of ISTN canal bank

After the drilling process was completed, the lithologies of each main borehole can be seen in Fig. 3 (a)-(f).

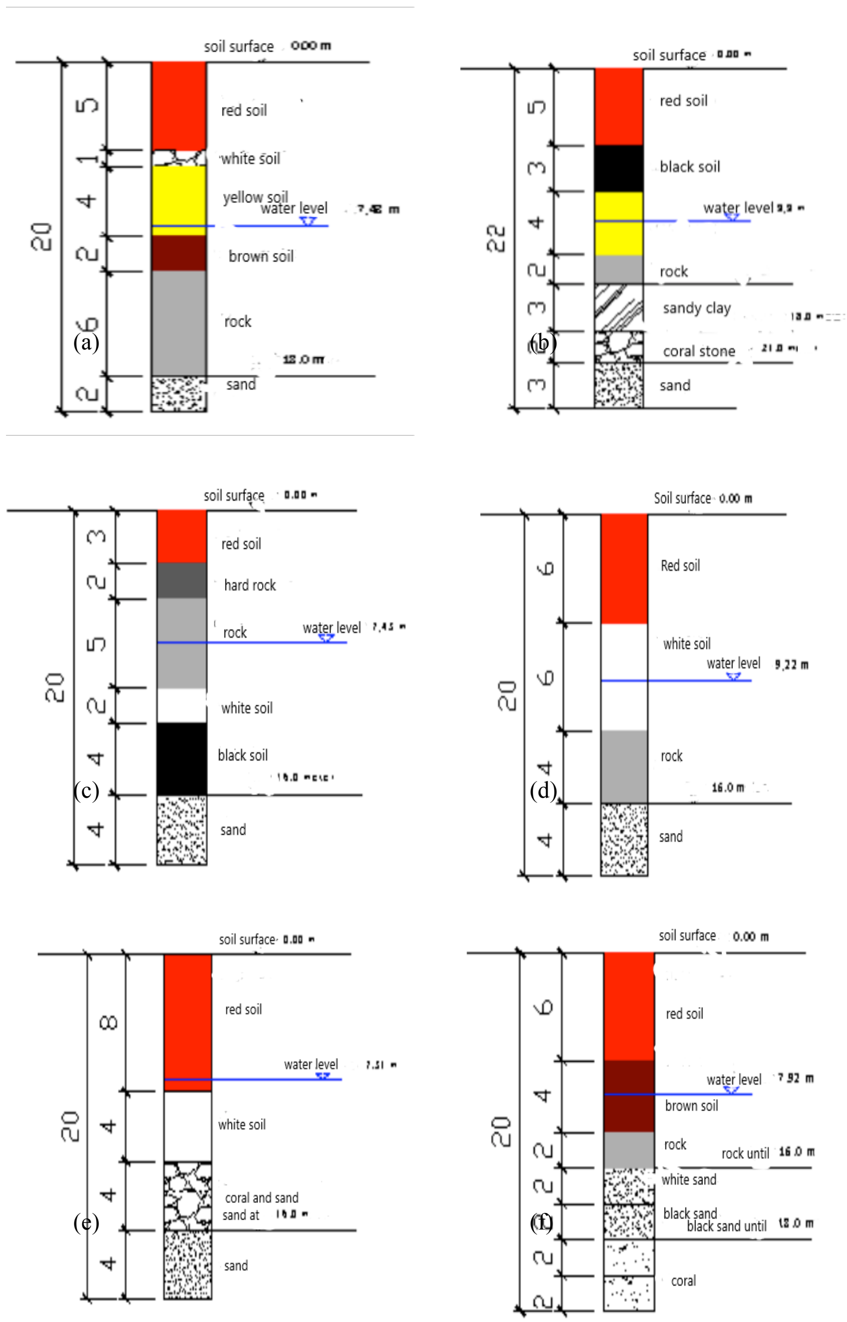


Fig. 3. Lithologies of each borehole (a) BH 1.1, (b) BH 1.2, (c) BH 1.3, (d) BH 2.1, (e) BH 2.2, (f) BH 2.3.

4.2 Transmissivity and Hydraulic conductivity

Transmissivity and hydraulic conductivity are among the most critical hydrogeological data needed for managing groundwater resources. Transmissivity describes the general ability of an aquifer to transmit water over the entire saturated thickness, while hydraulic conductivity measures this ability by unit area. The hydrogeological conditions of the area were evaluated based on the pumping test results. Information about transmissivity and hydraulic conductivity (K) in the present study area aquifer are presented in Table 1.

Tabel 1. The results of hydraulic conductivity, K and transmissivity, T.

Pumping test	T (m^2/day)	S	K (m/day)
BH 2.1	20.32	0.00026	5.08
BH 2.2	24.63	0.0090	6.16
BH 2.3	90.02	0.0318	22.51

Table 2. Results of TDS, pH and E coli analysis.

No	Kode Sampel	TDS (mg/L)	pH	Results E. Coli/100ml
1	BH 1.1	90	5.7	0
2	BH 1.2	81	4.71	0
3	BH 1.3	55	4.64	0
4	BH 2.1	104	5.14	0
5	BH 2.2	105	4.87	0
6	BH 2.3	187	4.82	0
7	ISTN Lake	70.5	6.74	1650
8	ISTN Lake	70.5	6.74	850
9	ISTN Channel	99	7.38	2600
PerMenKes No. 492, 2010 [11]	Maximum permissible concentration	1000	6.5-8.5	0

Todd [9] defined the storage coefficient (S) as the volume of water that an aquifer releases or takes into storage per unit surface area of the aquifer per unit component of the head normal to that surface. In an unconfined aquifer, the storage coefficient corresponds to its specific yield. For unconfined aquifers, this merely is expressed by the product of the volume of the aquifer lying between the water table at the beginning and the end of a specified period and the average storage coefficient of the formation. Besides, storativity usually varies directly with aquifer thickness and depends on grain size, shape, and distribution of pores, compaction of the stratum, and time of discharge. In the study area, results show that the storage coefficient varied from values 0.00026 to 0.0316, with the normal range between 0.01 until 0.35 [10]. Transmissivity is defined as the rate at which water of a specific prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient [9]. The transmissivity of a soil or rock also depends on a variety of physical factors, including porosity, particle size, and the distribution and arrangement of particles.

4.3 Microbiology, pH and Total Dissolved Solids, TDS Analysis

Based on the analysis of microbiology, Escherichia coli and TDS for sampling taken from boring 2.1, 2.2, 2.3 with the distance around 10 meters, 20 meters, 30 meters from the lake boundary had TDS in the range of freshwater with zero pathogens microbial population. The sample fall under class a category. From Escherichia coli test, the water can be consumed without treatment. The effects were related to the results from the investigations of shallow groundwater potential through riverbank filtration for water resources development [5]. The TDS results show that the water moves from the lake to the surrounding bank which is shown by increasing TDS from borehole 2.1 to 2.3 and borehole 1.3 to 1.1 respectively (Table 2) and from TDS results obtained in the range of freshwater based on the standard of water quality from Indonesian Ministry of Health [11].

5 Conclusions

Well boring is an effective method for LBF to predict aquifer layer. The general movement of shallow groundwater shows from the ISTN lake to the surrounding area of the bank based on the TDS analysis. Results show that the microbiology and TDS indicated of the shallow groundwater could be classified accepted, excet for the pH should be reduced before consumptions.

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