Assessment of Spring Water Quality Affected by Agricultural and Human Activities in Bali Island

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Abstract. This study aims to determine the water quality of Tirta Sanjiwani Spring at Banjar Gunung Kangin, Bangli Village, Baturiti District, Tabanan Regency, Bali Province, Indonesia based on physical, chemical and bacteriological parameters; and to determine water quality index and its criteria. Results showed that temperature, turbidity, and nitrate concentration were acceptable, according to the Regulation of the Minister of Health of the Republic of Indonesia No. 429 / MENKES / PER / IV / 2010. However, pH was below the limit and fecal coliform exceeded the minimum acceptable level. Total dissolved solid (TDS), dissolved oxygen (DO), and phosphate concentration were also acceptable; however, pH in the source of the spring and reservoir were below the limit. Meanwhile, biochemical oxygen demand (BOD) and fecal coliform of the water from fountain were over the limit according to the Governor of Bali Regulation No. 8 / 2007. Water quality index of Tirta Sanjiwani Spring was between 52.89-55.76 and classified as moderate quality based on NSF-WQI suggested that water treatment was necessary before using it as drinking water.

1. Introduction

Nowadays, the quantity and quality of water becomes the main problem in society. The low water quality will result in a bad environment, which will affect the health and safety of humans and other living things. A decrease in water quality will reduce the utility, yield, productivity, and carrying capacity of water resources which in turn will reduce the wealth of natural resources. Therefore, getting good water quality according to certain standards is currently an expensive item because water has been polluted by various kinds of waste from various human activities. Water as a source of clean water and drinking water must fulfill several aspects including quantity, quality and continuity [1].

The importance of clean water needs, both in quality and quantity, has made the clean water sector a top priority for handling because it involves the lives of many people. Handling the fulfillment of clean water needs can be carried out in various ways, according to existing facilities and infrastructure. The clean water supply system in urban areas is carried out by piping and non-piping systems. In rural areas, water utility services are still limited. Therefore, people usually seek and utilize other water sources to meet their needs. One of them is by utilizing water that comes from springs.

Spring water quality is affected by many factors. In the mount area, spring water did not influence by agricultural and human activities [2]. In a pristine area, water quality was affected by hydro-geological activities underground [3]. In an urban area, recent study emphasized the effect of anthropogenic activities to the spring water quality [4], [5], although the impact was not always
dominant [6]. Therefore, spring water in an urban area should be analyzed before using it as drinking water supply.

In this study, we studied spring water quality located in an urban area to assess its readiness as drinking water supply. The quality included physical, chemical, and biological properties. We also compared the parameters to the allowed values for drinking water and in addition, calculated water quality index.

2. Methodology

We obtained samples from Tirta Sanjiwani spring water, located at Banjar Gunung Kangin, Bangli Village, Baturiti District, Tabanan Regency, Bali Province, Indonesia. The community uses Tirta Sanjiwani spring water as the only water source because municipal water utility cannot reach this area. We collected samples from 4 sampling points: water source, composite from reservoir I and reservoir II, and fountain, around 11:00-13:00 local time.

We used Shimadzu UV 1800 Spectrophotometer, ice box, glass bottle, 1 L water tank, vaporizer cup, waterbath, oven, analytical balance, thermometer, pH meter, turbidimeter, Winkler bottle, incubator, measuring flask, measuring cup, dropper pipette, reagent bottle, test tube, Durham tube, autoclave, spirit lamp, loop needle, and desiccator. As of materials, we used distilled water, sodium chloride, sulfuric acid, brucine-sulfanilic acid, ammonium molybdate, sodium thiosulfate solution, phosphate solution, alkaline iodide solution, potassium nitrate solution, manganese sulfate solution, starch indicator, lactose broth medium, brilliant green lactose bile broth medium, filter paper, cotton, and ice cubes.

Table 1. Methods used to analyse each parameter.

| No | Parameter | Unit | Method          |
|----|-----------|------|-----------------|
| 1  | Turbidity | NTU  | Colorimetry     |
| 2  | Temperature | °C   | Expansion       |
| 3  | TDS       | mg/L | Electrometry    |
| 4  | DO        | mg/L | Electrometry    |
| 5  | pH        | -    | Electrometry    |
| 6  | BOD₅      | mg/L | Titrimetry      |
| 7  | Nitrate   | mg/L | Brucine         |
| 8  | Phosphate | mg/L | Ammonium molybdate |
| 9  | Fecal Coliform | mL | MPN/100mL |

Water quality was examined from several parameters, i.e. temperature, total dissolved solid (TDS), turbidity, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), phosphate, nitrate, and fecal coliform using methods in Table 1. The values were then compared to the Regulation of the Minister of Health of the Republic of Indonesia No. 429 / MENKES / PER / IV / 2010 concerning Requirements for Drinking Water Quality and Bali Governor Regulation No. 8 / 2007 concerning Environmental Quality Standards and Class I Environmental Damage Standard Criteria. Water quality index was then analysed using:

\[
WQI = \sum_{i=1}^{n} (W_i \times I_i)
\]

with:

\[
W_i = \text{Weights of parameter i}
\]

\[
i = \text{Sub index parameter}
\]

\[
I_i = \text{Value of the sub-index parameter I (obtained from the sub-index parameter i curve with an index range of 0-100)}
\]

The results of the water quality index were then compared with the water quality criteria according to the National Sanitation Foundation-Water Quality Index (NSF-WQI) [7].
3. Result and Discussion

Results showed that temperature, turbidity, and nitrate did not exceed the allowable values. In addition, the pH value was below the allowable value and fecal coliform exceeded the value permitted by the Regulation of the Minister of Health of the Republic of Indonesia No. 429 / MENKES / PER / IV / 2010 (Table 2). When compared with the Governor of Bali Regulation No. 8 / 2007, TDS, DO, and phosphate did not exceed the allowable values; however, pH of the spring water source and reservoirs was below the limits, BOD, and fecal coliform for the fountain exceeded the allowable limits (Table 2).

Table 2. Analyses of water quality compared to the Regulation of the Minister of Health of the Republic of Indonesia No. 429 / MENKES / PER / IV / 2010 (A) and the Governor of Bali Regulation No. 8 / 2007 (B).

| Parameter        | Result | Max value allowed |
|------------------|--------|-------------------|
|                  | Water source | Reservoir | Fountain | A | B |
| Temperature, °C  | 23.3   | 23.6         | 23.5     | T_air ± 3 | T_air ± 3 |
| TDS, mg/L        | 202    | 197          | 200      | 500 | 1000 |
| Turbidity, NTU   | 0      | 0           | 0        | 5   | -   |
| pH               | 5.82   | 5.86        | 6.59     | 6.8-8.5 | 6-9 |
| DO, mg/L         | 6.68   | 7.39        | 7.04     | -   | min 6 |
| BOD, mg/L        | 7.04   | 3.54        | 3.54     | -   | 2   |
| Phosphate, mg/L  | 0.0687 | 0.0497      | 0.036    | -   | 0.2 |
| Nitrate, mg/L    | 17     | 9           | 4        | 50  | -   |
| Fecal coliform, mL | 4   | 7           | 110      | 0   | 50  |

During sampling, we observed that the spring was surrounded by trees. The leaves debris fell to the spring which then degraded by microbes. This biodegradation resulted the high value of BOD$_5$ at the spring water which exceeded the max allowed value. The degradation needed oxygen to take place; however, DO value still met the standard quality. Beside BOD$_5$ and DO, the debris affected pH because the aerobic decomposition produced carbon dioxide which would lower pH of the water. Out of three sampling points, only the pH of the fountain met the standard quality.

Total Dissolved Solid (TDS) is dissolved materials and colloids in the form of chemical compounds and other materials, which are not filtered on paper filter with a diameter of 0.45 µm [8]. The TDS at the spring, reservoir, and fountain were 202 mg/L, 197 mg/L, and 200 mg/L, respectively. These results did not exceed the water quality standard. The TDS affected by organic waste from leaves debris around the spring, but the value was considerably low and did not affect turbidity of all three sampling points. It indicated that the water was clear, thus light could penetrate the water.

Nitrate is the main form of nitrogen in natural waters and is the main nutrient for plant and algae growth. Nitrate nitrogen is soluble in water and stable [8]. The nitrate of the spring, reservoir, and fountain were 17.374 mg/L, 8.510 mg/L, and 4.301 mg/L, respectively. According to the Regulation of the Minister of Health of the Republic of Indonesia No. 429 / MENKES / PER / IV / 2010 these values did not exceed the allowed concentration. The low nitrate of the spring suggested that agricultural activities around the spring did not influence the water quality.

Phosphate is a form of phosphorus that can form complexes with iron and calcium ions under anaerobic conditions, insoluble, and deposited in sediments; therefore, it cannot be utilized by aquatic algae [8]. The phosphate concentration of the spring, reservoir, and fountain were 0.0687 mg/L, 0.0497 mg/L, and 0.0360 mg/L, respectively. The values met the water quality standard which indicated that the agricultural activities around the spring did not influence the water quality.

Beside chemical and physical parameters, we also obtained fecal coliform. Results showed that fecal coliform of the spring, reservoir, and fountain were 4/100 mL, 7/100 mL, and 110/100 mL, respectively. According to the Regulation of the Minister of Health of the Republic of Indonesia No. 429 / MENKES / PER / IV / 2010 all values exceeded the minimum value for drinking water. And
according to the Governor of Bali Regulation No. 8 / 2007, only the fountain did not meet the drinking water quality. The high value of fecal coliform suggested that the spring water contaminated by human feces around this area.

Based of those parameters, we calculated the water quality index of spring, reservoir, and fountain were 52.89, 55.76, and 54.62, respectively (Table 3). Compared with National Sanitation Foundation-Water Quality Index (NSF-WQI), the water quality was on average. Therefore, it was necessary to process the water to increase its quality. Table 3 showed the low index of temperature and pH for spring and reservoir, and DO, BOD, nitrate, and fecal coliform for fountain. To increase the water quality, it is advisable to close the spring which will lower temperature and increase DO. Closing the spring will also reduce organic waste in the water which will decrease BOD and increase DO. Alternatively, farmers should optimize fertilization. And, of course, boiling the water for drinking is necessary.

**Table 3. Water quality index calculation**

| No | Parameter      | Weight of parameter | Spring  | Reservoir | Fountain |
|----|----------------|---------------------|---------|-----------|----------|
| 1  | Temperature   | 0.10                | 17.0    | 17.0      | 17.0     |
| 2  | TDS           | 0.07                | 72.0    | 73.0      | 73.0     |
| 3  | Turbidity     | 0.08                | 99.0    | 99.0      | 99.0     |
| 4  | pH            | 0.11                | 50.0    | 51.0      | 75.0     |
| 5  | DO            | 0.17                | 5.0     | 6.0       | 6.0      |
| 6  | BOD           | 0.11                | 46.0    | 64.0      | 64.0     |
| 7  | Phosphate     | 0.10                | 97.0    | 98.0      | 99.0     |
| 8  | Nitrate       | 0.10                | 40.0    | 54.0      | 68.0     |
| 9  | Fecal coliform| 0.16                | 82.0    | 76.0      | 43.0     |

Water quality index: 52.89, 55.76, 54.62

4. Conclusion

Tirta Sanjiwani spring water has been used as drinking water by people at Banjar Gunung Kangin, Bangli Village, Baturiti District, Tabanan Regency, Bali Province, Indonesia. However, the water quality is still below the standard for drinking water. Therefore, water treatment is substantial.

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