Well Water Contamination Analysis in the Code Riverbank Terrace in Yogyakarta

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Abstract. Urbanization accelerate the growth of population in Yogyakarta. The existence of densely populated settlements directly affect the river environment Code. Some residents still dispose liquid waste into the river that contribute to polluting the environment. Slums also lead to environmental health problems. Pollution is not only happen in the river, but also occurs in wells population. The problem is compounded by the condition of the terraced river border. Waste from septic terrace 1 (top) and terrace 2 (middle) will flow into the patio 3 (bottom) and pollute wells population in the terrace 3 (bottom) as the accumulation of septic tank waste originating from above. The purpose of this study was to determine the condition of the water quality of wells in terraced areas, based on parameters DO, pH, electrical conductivity (DHL), temperature, TDS, and E-Coli bacteria as well as to ascertain whether there is a direct correlation of pollution accumulation from high to lower elevation on a terraced area. Methods being used include: Identification of wells and sanitation, wells positioning measurements with GPS, plotting the location of wells to map, collecting sample from wells, analyzing the quality of well water in the laboratory, and analyzing the well water contamination. Based on the results, it can be concluded that there are decline in water quality, either on the left or on the right side of the river. In other words, there is a direct correlation between contamination accumulation of well water at a high elevation and a lower elevation on the terraced riverbank area code.

1. Introduction

Yogyakarta city passed three main rivers, namely Code, Winongo and Gajahwong River. Of the three rivers, which suffered the worst pollution is the Code River since it is the center of the river drainage areas and traverse through populated urban areas. Code River pollution comes primarily from household waste, because its watersheds is the most densely populated area (Eko, 2008). Urbanization accelerate the growth of population in Yogyakarta. Increasing the number of residents led to the increasing need for settlement and land resources. One of the area that is considered strategic is the periphery (banks) of the river. Code River banks became the main choice of people, who came from the village with very little money, to establish illegal settlements (Laily, 2011).

The existence of densely populated settlements have a major influence on the development of the Code River. Some residents still dispose their wastewater to the river without processing it first and potentially pollute the environment (Astuty, 2008). Slums around the Code River also trigger environmental health issues, such as the accumulation of garbage and the increasing groundwater pollution, especially by the nitrogen elements(NO2, NO3, NH3) and coliform bacteria.
In addition to the river, pollution also occurs in the wells of the residents due to the poor sanitation system. That problem is compounded by the condition of riparian consisting of terraces 1, terrace 2, and 3 terraces arranged vertically. Terrace 1 is located in the top border river. Terrace 2 situated below the terrace 1, and terrace 3 located at the very bottom and into water bodies. Waste from septic tank of terrace 1 and 2 will flow downward, contaminating wells and those living on the terrace 3 as the accumulation of septic tank waste originating from above.

The purpose of this study was to determine the condition of the well water quality based on the parameters DO, pH, electrical conductivity (DHL), temperature, TDS, and E-Coli bacteria as well as to ascertain whether there is a direct correlation of contamination accumulation of well water at high elevation to a lower elevation in a residential area of terraced Code riverbank.

In terms of water quality, pollution will affect the water quality either directly or indirectly. Water quality used for human needs must be uncontaminated or meet the requirements of physical, chemical, and biological parameters.

1. The physical requirements, water quality must meet the physical requirements as follows:
   a. Clear or turbid. Murky water caused by the presence of granules of clay colloids. The more the content of colloidal then the water gets murky.
   b. Colorless. Water for domestic use must be clear. Colored water means it contains other ingredients that are harmful to health.
   c. It felt fresh. According to physics, water can be perceived by the tongue. Water tasted sour, sweet, bitter or salty water is not a good show. Salty taste caused by certain salts are soluble in water, while the sour taste caused by presence of organic acids and inorganic acids.
   d. Odorless. Good water usually odorless, either from far away and from closeby. Foul-smelling water containing organic matter undergoing decomposition by microorganisms of water.
   e. Normal temperature. Water temperature should be cool or heat, especially in order to avoid dilution of existing chemical substances on the duct/pipe, which can endanger the health and inhibit the growth of micro-organisms.
   f. Does not contain solids. Water containing solid substances floating in the water.

2. Chemical requirements, for instance:
   a. pH (acidity). pH is important in the purification process. The acidity of water is generally caused by oxide gas that is soluble in water, especially carbon dioxide. For drinking water, pH below 6.5 and above 9 may cause some chemical elements turn into poison that is very detrimental to body health.
   b. Hardness (kesadahan). There are two types, namely temporary hardness and noncarbonated (permanent) hardness. Temporary hardness caused by the presence of calcium and magnesium bicarbonate that are removed by boiling the water or adding lime in the water. Noncarbonated hardness caused by sulfate and carbonate, chloride and nitrates of magnesium and calcium, in addition to iron and aluminum. The concentration of calcium in drinking water lower than 75 mg/liter can cause brittle bone disease, whereas a concentration above 200 mg/liter can cause corrosion in water pipes.
   c. Iron. Water containing a lot of iron will be yellow and cause a metallic taste of iron in water and corrode the material made of metal. Maximum limits contained in the water is 1.0 mg/liter.
   d. Aluminum. The maximum limit contained in the water is 0.2 mg/liter. Water that contains a lot of aluminum causes a bad taste when consumed.
   e. Organic substances. Complex solutions that are consist of organic substances can contains either the nutrient food or other energy source for the flora and fauna that live in the waters.
   f. Sulfate. The sulfate content of the excessive water can result in a hard water scale on the appliance to boil water (pot/kettle) besides resulting in odor and corrosion of pipes.
   g. Nitrates and nitrates. Water pollution from nitrates and nitrites are sourced from plants and soils.
      Nitrate can occur either from NO2 atmosphere and from the fertilizers used and the oxidation of NO2 by bacteria from the group nitrobacter.

3. Microbiological conditions, for instance does not contain the germs of diseases such as dysentery,
typhoid, cholera, and bacterial pathogens that cause disease. Water quality parameters examined in this penelitian consists of:

1.1. **Coliform Bacteria (Burhansyah, 2011)**

Coliform bacteria are a group of microorganisms that are commonly used as an indicator, where bacteria may be a signal to determine the source of the water has been contaminated by pathogenic or not. Coliform bacteria are spoilage bacteria which produce various toxins such as indole and skatol that can cause disease if the amount of excess in the body (Pracoyo, 2006). Coliform bacteria can be used as an indicator because of its density is directly proportional to the level of water pollution. These bacteria can detect pathogens in water such as viruses, protozoa, and parasites. These bacteria also have a higher durability than the pathogen as well as more easily isolated and grown (Doyle, 2006).

Distinctive among other coliform bacteria are aerobic or facultative anaerobes, belonging to the gram-negative bacteria, do not form spores, and can ferment lactose to produce acid and gas at a temperature of 35 °C-37 °C (Hajna, 1943). E coli is a bacteria that is derived from animal or human feces (Nengsih, 2010). Fecal coliform (sometimes faecal coliform or fecal coliform) is a facultative-anaerobic bacteria are rod-shaped, gram-negative, and non-sporulation. Fecal coliform is able to grow and produce acid and gas from lactose in 48 hours at 44 ± 0.5 °C. Fecal coliform, like other bacteria, can be inhibited growth by boiling water or by treating it with chlorine. Recommendations EPA for domestic water supply, for treatment, the amount of fecal coliform less than 2,000 colonies/100 mL, and for the drinking water standard of less than 1 colonies/100 ml (Anonymous, 2010).

1.2. **Dissolved Oxygen (DO)**

Oxygen is a very important parameter in water. Most of the living creatures require oxygen to sustain life. Both plant and aquatic animals, rely on dissolved oxygen. Fish are aquatic creatures with the highest oxygen requirement, followed by invertebrates and the least is a bacterium needs oxygen. The balance of dissolved oxygen (DO) in water are occurred naturally and continuously. Oxygen is used for the decomposition of organic material that will then be replaced by oxygen coming from the air and from other sources. It is quickly depleted into dissolved oxygen to be used by bacteria. Or, in other words, the oxygen taken up by aquatic biota is always in balance with oxygen coming from the air or from the results of photosynthesis water plants.

If at any time the organic material in the water is exceeded as a result of the inclusion of waste of human activities (such as organic waste from industry), which means that the supply of carbon (C) is abundant, so the rate of growth of microorganisms will be doubled, which means also the growing need for oxygen, while the supply fixed amounts of oxygen from air. In this condition, the equilibrium between oxygen into the water with the water used by the biota is not in balance, resulting in a deficit of dissolved oxygen in the water. When the dissolved oxygen reduction continues until it reaches zero, the water biota that require oxygen (aerobic) will die, and are replaced with the growth of microbes that do not require oxygen or anaerobic microbes. Similarly, aerobic microbes, anaerobic microbes will also take advantage of the carbon from organic material. This anaerobic respiration formed from methane (CH4) as well as acid gas formed sulfide (H2S), which stank (Anonymous, 2011).

1.3. **pH**

pH is acid-base level of a solution is measured by a scale of 0 to 14. The level of the water's pH is strongly influenced by the content of other minerals contained in the water. The pH value is good for the health of not less than 6.5 and not greater than 9. A higher value can change some chemical compounds into toxins that can damage the health.

1.4. **Electrical Conductivity (daya hantar listrik/DHL)**

DHL in water is a numerical expression which indicates the ability of a solution to conduct electricity. Therefore, the more dissolved salts are ionized, the higher the value of DHL. The value of DHL depends
on the presence of inorganic ions, valence, as well as the temperature and relative and total concentration. The use of DHL as water quality parameters aimed to measure the ability of ions in the water to conduct electricity as well as predicting the mineral content in the water. Measurements were carried out based on the ability of cations and anions to conduct electric current flow in the water sample. It can be an indicator, where the greater value of electrical conductivity aimed at conductivity meter, means the greater the ability of cations and anions to conduct electricity. This indicates that more and more minerals contained in the water.

1.5. **TDS (Total Dissolved Solids)**

TDS is a measure of the amount of dissolved mineral material, may include carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate calcium, magnesium, sodium, organic ions and other ions. Changes in the concentration of TDS can be dangerous because of the density (densities) of water determines the flow of water into and out of the cells of organisms. However, if the TDS concentration is too high or too low, death can occur. TDS high concentrations can also reduce the clarity of the water, providing a significant reduction in the process of photosynthesis, and combined with the toxic compounds and heavy metals can increase the temperature of the water.

1.6. **Temperature**

The temperature in the water significantly affects the quality of water, because the reaction temperature can affect the performance of microorganisms in the water.

2. **Methodology**

2.1. **Locations**

Administratively, upstream Code are in the northern region of Yogyakarta, which is in the district of Sleman, flowing southward through dense urban areas settlements on the banks of the Code River that are in Yogyakarta, and empties into the right side of the Opak River is downstream from the bridge Sindet Kembang Songo village of Bantul. The research location is along the river Code that entered the urban area of Yogyakarta as shown in Figure 1.

The layout of the sample wells were also divided into two parts, namely the sample wells on the left and on the right side of the river.

![Figure 1. Map showing the research location](image-url)
2.2. Stages of Research

Stages used in this study consisted of:
- Preparation of a student surveyor Civil Engineering, Faculty of Engineering, University of Janabadra.
- Identification of community wells and sanitation systems at the sites.
- Measurement with GPS positioning community wells.
- Plotting the location of wells to map the location of the study population.
- Sampling of water from community wells.
- Analysis of water quality of well water samples in the laboratory population of Environment and Hydraulics, Civil Engineering Department, Faculty of Engineering, University of Janabadra.
- Analysis of the well contamination level of the population against the sanitary conditions in the terraced riverbank Code.

3. Results and Discussion

3.1. Identification Data Wells and Sanitation

Before carrying out the identification data of wells and sanitation, preceded by obtaining a license for research activities to the Provincial Government of DIY, surveyors preparation and collection of secondary data such as: the number of households, wells, PAM, and WC.

3.2. Position Measurement Wells and Sanitation

Position measurement activities wells and sanitation begins with a survey of the number of wells and sanitation are in the research area. Then a predetermined number of sample wells that will be examined by the water quality mampirmah teraced area (including also the distance) of the existence of the well itself. The number of samples was set at 30 pieces wells, 15 wells located on the left bank and 15 wells Brada to the right of the river. Well position is determined using GPS to set coordinates X, Y, and Z.

3.3. Plotting Wells and Sanitation to Map

After the measurement sample positions wells and sanitation is done, then the next to find out the coordinates X, Y, and Znya, wells and sanitary position can be plotted on the map. Figure 2 shows a sample plotting wells and sanitation into RBI maps Indonesia (RBI).

[Image: Figure 2. Plotting the position of the sample wells and sanitation into the map]
3.4. Sampling Water Well
After the determination of the amount of sample wells are established, the next step is sampling well water for the water quality tested in the laboratory. Figure 3 shows taking several samples of well water.

![Figure 3. Taking multiple samples of well water](image)

3.5. Quality Inspection Water Well
Examination of the quality of well water samples do to parameters: DO, pH, DHL, temperature, TDS, and E-Coli. It also carried out the data collection wells distance to: sewage, waste disposal, and TPS). Figure 4 shows the process of examination of well water samples in the lab. Table 1 shows the results of water quality testing wells.

![Figure 4. The inspection process well water samples in the lab](image)

3.6. Analysis of Well Water Contamination
The objective of the well water contamination analysis are:
- To determine the condition of well water quality, particularly the E-Coli bacteria.
- To determine whether there is a direct correlation accumulated pollution E-Coli bacteria from the well at high elevation to a lower elevation in the area of terraced housing.

In order to know how much influence the terraced area along the river against pollution of water wells do the steps as follows.
- Make a map of the area contour position all the sample wells so it can be high or low position well with each other, or more precisely the coordinates X, Y, and Z from each well. It also created the look cross the river so that it can describe the position of each well in the terraced area along the river. Figure 5 shows a map plotting contour along their respective positions her well.
Then we look at water quality laboratory results on each of the wells, particularly bacteria E-Colinya as shown in Table 1. We then will be able to know whether there is a direct correlation accumulation of E-coli bacteria contamination of wells in low elevation to a high elevation in the area of terraced riverbank Code. If the quality of well water in the patio area 2 worse than the quality of well water in the patio area 1 and the quality of well water in the patio area 3 worse than the quality of well water in the patio area 2, it is evident that there is an accumulation of pollution of water wells in the area of terraced riverbank code.

### Table 1. The results of well water quality

| No. | Status | Kelurahan | RT | RW | RT | Sample Code | X | Y | Z | Coordinate | Depth of the well | DO (ppm) | pH | EC (µmhos/cm) | TDS | EC (MPN/10⁰ ml) | Garbage dump | Temp. (°C) | Sample Code | Distance the well from septictank | Water quality | The waste | Starting a dump |
|-----|--------|------------|----|----|----|-------------|---|---|---|------------|-----------------|---------|----|----------------|-----|----------------|------------|----------|------------|-----------------|-------------|---------|----------------|
| 1   | 3      | Suryatmajan| 23 | 1  | 2  | 430253     | 9  | 12 | 6.4| 0.8 | 433 | 29 | 198 | 1100 | Saluran Limbah | 10 m |
| 2   | 9      | Suryatmajan| 23 | 1  | 2  | 430356     | 9  | 12 | 6.4| 0.8 | 433 | 29 | 202 | 2400 | Langsung Sungai | 10 m |
| 3   | 10     | Suryatmajan| 23 | 1  | 2  | 430360     | 4  | 12 | 5.9| 0.9 | 430 | 25 | 207 | 2400 | Langsung Sungai | 10 m |
| 4   | 11     | Suryatmajan| 23 | 1  | 2  | 430575     | 10 | 12 | 5.9| 0.9 | 318 | 30 | 144 | 1100 | Saluran Limbah | 10 m |
| 5   | 23     | Suryatmajan| 23 | 1  | 2  | 430499     | 14 | 12 | 5.1| 0.9 | 419 | 29 | 198 | 2400 | Komunal Biofill | 10 m |
| 6   | 20     | Suryatmajan| 23 | 1  | 2  | 430363     | 12 | 12 | 7.2| 0.9 | 365 | 30 | 144 | 1100 | Komunal Biofill | 10 m |
| 7   | 6      | Suryatmajan| 23 | 1  | 2  | 430528     | 12 | 15 | 6.2| 0.9 | 461 | 31 | 253 | 2400 | Langsung Sungai | 10 m |
| 8   | 6      | Suryatmajan| 23 | 1  | 2  | 430547     | 12 | 6  | 6  | 0.7 | 449 | 30 | 193 | 2400 | Langsung Sungai | 10 m |
| 9   | 25     | Suryatmajan| 23 | 1  | 2  | 430420     | 10 | 6  | 5.1| 0.9 | 350 | 30 | 144 | 750  | Komunal Biofill | 10 m |
| 10  | 26     | Suryatmajan| 23 | 1  | 2  | 430430     | 10 | 14 | 5.4| 0.9 | 304 | 28 | 135 | 460  | Komunal Biofill | 10 m |
| 11  | 23     | Suryatmajan| 23 | 1  | 2  | 430409     | 11 | 16 | 5.6| 0.9 | 567 | 29 | 204 | 210  | Komunal Biofill | 10 m |
| 12  | 24     | Suryatmajan| 23 | 1  | 2  | 430440     | 11 | 12 | 6  | 0.9 | 460 | 29 | 192 | 2400 | Langsung Sungai | 10 m |
| 13  | 18     | Suryatmajan| 23 | 1  | 2  | 430472     | 11 | 14 | 6  | 0.9 | 346 | 29 | 192 | 2400 | Langsung Sungai | 10 m |
| 14  | 22     | Suryatmajan| 23 | 1  | 2  | 430553     | 11 | 16 | 6  | 0.9 | 448 | 29 | 192 | 2400 | Langsung Sungai | 10 m |
| 15  | 16     | Suryatmajan| 23 | 1  | 2  | 430560     | 11 | 14 | 6  | 0.9 | 450 | 29 | 192 | 2400 | Langsung Sungai | 10 m |
| 16  | 18     | Suryatmajan| 23 | 1  | 2  | 430557     | 11 | 30 | 15 | 7.1 | 360 | 28 | 158 | 75   | Langsung Sungai | 10 m |
| 17  | 23     | Suryatmajan| 23 | 1  | 2  | 430693     | 12 | 12 | 6  | 0.9 | 371 | 28 | 154 | 90   | Komunal Biofill | 10 m |
| 18  | 26     | Suryatmajan| 23 | 1  | 2  | 430710     | 12 | 12 | 6  | 0.9 | 341 | 30 | 151 | 2400 | Langsung Sungai | 10 m |
| 19  | 31     | Suryatmajan| 23 | 1  | 2  | 430767     | 13 | 12 | 4  | 0.7 | 338 | 32 | 154 | 90   | Komunal Biofill | 10 m |
| 20  | 36     | Suryatmajan| 23 | 1  | 2  | 430361     | 12 | 15 | 6  | 0.9 | 366 | 29 | 160 | 1100 | Saluran Limbah | 10 m |
| 21  | 37     | Suryatmajan| 23 | 1  | 2  | 430366     | 12 | 15 | 6  | 0.9 | 371 | 29 | 162 | 1100 | Saluran Limbah | 10 m |

Figure 5. Map contour along their respective positions her well
From Table 1 and Figure 5, it appears that the parameters of the quality of well water in general deteriorate, or in other words the quality of well water in the patio area 2 worse than the quality of well water in the patio area 1 and the quality of well water in the patio area 3 more worse than the quality of well water in the patio area 2, for example, for levels of E-coli for example, more will be explained as follows.

Figure 6. Levels of E-Coli in the left side of Code River

It appears that in the left side of Code River, E-Coli bacteria levels on average in terrace 2 is worse than those in terrace 1, and E-Coli bacteria level in terrace 3 is worse than those in the terrace 2. Thus, there is a direct correlation of accumulated proven E-Coli bacterial contamination from wells at low elevation to a high elevation in the terraced Code riverbank.

Figure 7. Levels of E-Coli in the right side of Code River

It appears that the right side of the Code River, E-Coli bacteria levels on average in terrace 2 is worse than those in terrace 1, and E-Coli bacteria levels in terrace 3 is worse than those in terrace 2. Thus there is a direct correlation of accumulated proven bacterial contamination E-Coli from wells at low elevation to a high elevation in the terraced Coderiverbank.

4. Conclusion
Based on research data as shown in Table 1, Figure 5, Figure 6, and Figure 7, it can be concluded that there has been a decline in the quality of well water in the terrace area 2 worse than in the terrace 1 and in the terrace 3 worse than in the terrace 2, either on the left or on the right side of the river. In other words, there is a direct correlation of pollution accumulation from wells at low elevation to a high elevation in the terraced area of Code riverbank.
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