Assessment of the quality of well water in the spatial terraces of river code in Yogyakarta Indonesia

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Abstract. Many residents live on the banks of the Yogyakarta Code River. Some of them are still there who dispose of liquid waste directly into the river so that it has the potential to pollute the environment. Pollution also occurs in population wells. In general the condition of the riverbank is terraced, so that liquid waste originating from terrace 1 (the top) will flow to terrace 2 (the middle part), then flow to terrace 3 (bottom), and finally enter the river. The purpose of this study was to assess the quality of well water on the banks of the River Code, based on DO parameters, pH, DHL, Temperature, TDS, and E-Coli bacteria and to ascertain whether there was a direct correlation of pollution accumulation from high elevation to low elevation. The methods used include: identification of wells, measurement of the position of the well with GPS, plotting the location of wells to maps, sampling of well water, analyzing the quality of well water in the laboratory, and assessing the spatial water pollution of the well. Based on the results of the study, it can be concluded that there is a decrease in the quality of well water from high elevation to low elevation so that the quality of well water at low elevations is worse than the quality of well water at higher elevations. So that there is a direct correlation of accumulated pollution from well water at high elevations to lower elevations in the terraces of the Code River banks.

1. Introduction

The city of Yogyakarta is passed by the Code River, Winongo River, and Gajahwong River. The most pollution was the Code River because the central part of the Code River drainage area crossed a densely populated urban area. Code River pollution mainly comes from household waste, because around the river is the most densely populated [1].

Urbanization accelerates population growth in Yogyakarta. The more population increases, the land resource needs for settlements increases, one of the locations considered strategic is the riverbank [2]. Some residents still dispose of liquid waste without processing into the river, so that the potential to pollute the environment [3]. Slum settlements around the Code River also trigger environmental health problems, such as garbage accumulation, increased groundwater pollution mainly by Nitrogen and coliform bacteria.

Pollution besides occurring in rivers also occurs in population wells, as a result of poor sanitation systems. These problems are exacerbated by terrace driver conditions. Terrace 1 is at the top of the cross section of the river. Terrace 2 is located below terrace 1, and terrace 3 is located at the bottom. Waste originating from septic tank terrace 1 and terrace 2 will flow downward, and pollute the wells of residents living on terrace 3 as accumulated septic tanks from settlements above them. The purpose of
this study was to assess the condition of the well water quality of residents, based on DO parameters, pH, DHL, Temperature, TDS, and E-Coli bacteria and to ensure there is a direct correlation of accumulated well water pollution at high elevations to low elevations in terraced residential areas Code River banks.

The coordinate for the study area is along the Code river which entered the urban area of Yogyakarta consisting of Gowongan sub-district, Jetis sub-district, Kotabaru sub-district, Gondokusuman sub-district, Tegalpanggung and Suryatmajan sub-districts of Danurejan sub-district.

Coliform bacteria can be a signal to determine whether the water source has been contaminated by pathogens or not [4]. These bacteria are decomposing bacteria that produce various kinds of poisons which can cause disease if the amount is excessive in the body [5]. These bacteria also have a higher resistance than pathogens and are more easily isolated and grown [6].

The characteristics of these bacteria include aerobic or facultative anaerobes, including gram negative bacteria, do not form spores, and can ferment lactose to produce acids and gases at temperatures of 35° C-37° C [7]. The presence of coliform bacteria in food or drinks shows the possibility of the presence of enteropathogenic and/or toxigenic microorganisms that are harmful to health. E coli is a bacterium that comes from animal and human feces [8]. EPA recommendations for household water supply, for treatment, the number of fecal coliform is less than 2000 colonies/100 mL, and for drinking water standards less than 1 colony/100 ml [9], [10].

Oxygen is a very important parameter in water. Most living things in water need oxygen to sustain life, both plants and aquatic animals, depending on dissolved oxygen. Fish are aquatic creatures with the highest oxygen demand, then invertebrates, and the smallest oxygen needs are bacteria [11]. If at one time organic material in water becomes excessive as a result of the entry of human activity waste, causing the growth rate of microorganisms to multiply, which also means increasing oxygen demand, while supply oxygen from the air is fixed. In these conditions, the equilibrium between oxygen entering the water and those used by aquatic biota is not balanced, resulting in a deficit of oxygen dissolved in water. As with aerobic microbes, anaerobic microbes will also utilize carbon from organic matter. From this anaerobic respiration methane gas (CH4) is formed in addition to forming foul-smelling sulfide acid gas (H2S) [12].

pH is an acid base level of a solution measured on a scale of 0 to 14. The high and low pH of the water is strongly influenced by the content of other minerals contained in water. A pH value that is good for health is not smaller than 6.5 and not greater than 9. Larger values can change some chemical compounds into poisons that can interfere with health [11].

Electric conductivity (DHL) in water is a numerical expression that shows the ability of a solution to deliver an electric current. Measurements made based on the ability of cations and anions to deliver the electric current flowing in water samples can be used as an indicator, where the greater the value of electrical conductivity directed at the conductivity meter means the greater the ability of cations and anions to deliver electric current [11].

Total Dissolved Solids (TDS) is a parameter of the amount of minerals dissolved in this material, which can include carbonates, bicarbonates, chlorides, sulfates, phosphates, calcium nitrates, magnesium, sodium, organic ions and other ions. High concentration TDS can also reduce water clarity, provide a significant decrease in photosynthesis, and a combination with toxic compounds and heavy metals can increase the water temperature [11].

The temperature in water also greatly affects water quality, because the temperature can affect the reaction of the performance of microorganisms in water.
2. Methods

2.1. Study Area
The research location is along the Code river which entered the urban area of Yogyakarta consisting of Gowongan sub-district Jetis sub-district, Kotabaru sub-district Gondokusuman sub-district, Tegalpanggung and Suryatmajan sub-districts of Danurejan sub-districts shown in Figure 1. The basis for consideration of the selection of research sites is the surrounding or Code Riverbanks. The urban area is a dense residential area, there are industrial activities, shops, offices, restaurants, hotels, laundry businesses and others.

![Figure 1. Map of research location](image)

2.2. Research Stages
The stages used in this study consist of:
- Survey preparation.
- Identification of population wells in the research location.
- Measuring the position of the population well with GPS.
- Plotting the location of residents'wells into the map of the research location.
- Taking water samples from residents'wells.
- Analysis of the quality of clean water from samples of water from wells in the laboratory.
- Assessment of water quality of community wells in the terraced area of the Code River by using a Geographic Information System (GIS).
3. Results and Discussion

3.1. Results of the study

3.1.1. Measurement of the position of the well and plotting to the map
The well position measurement activity begins with a survey of the number of wells in the research location. Then it is determined the number of well samples to be examined for water quality by considering the terraced area (including the distance) of the existence of the well itself. The position of the well is determined using GPS to determine its X, Y, and Z coordinates.

After measuring the position of the well sample, then the position of the well can be plotted onto the map. Figure 2 shows a plot of well samples into the Rupa Bumi Indonesia (RBI) map.

![Plotting the position of each well](image-url)
3.1.2. Results of examination of well water quality

Quality checks of well water samples were carried out on parameters: DO, pH, DHL, Temperature, TDS, and E-Coli. Table 1 shows the results of research on sampling water quality.

| No | Location Kekurahan | Coordinate X | Coordinates Y | Coordinates Z | Kod sample | DO (ppm) | pH | DHL (µmhos/cm) | Suhu (OC) | TDS | E-Coli (MPN/100 ml) |
|----|---------------------|--------------|---------------|---------------|------------|---------|----|----------------|-----------|-----|---------------------|
| 1  | Suryatmajan         | 430253       | 9138622       | 130           | 9          | 6.6     | 6.2| 433            | 29        | 194 | 1100                |
| 2  | Suryatmajan         | 430336       | 9138650       | 120           | 7          | 6.3     | 6.4| 458            | 28        | 203 | 2400                |
| 3  | Suryatmajan         | 430366       | 9138627       | 116           | 4          | 5.7     | 6.7| 481            | 29        | 207 | 2400                |
| 4  | Suryatmajan         | 430375       | 9138538       | 124           | 5          | 5.9     | 6.8| 318            | 30        | 144 | 1100                |
| 5  | Suryatmajan         | 430409       | 9138511       | 118           | 14         | 5.1     | 7.4| 418            | 28        | 180 | 2400                |
| 6  | Suryatmajan         | 430363       | 9138493       | 121           | 12         | 7.2     | 7  | 365            | 30        | 160 | 1100                |
| 7  | Suryatmajan         | 430328       | 9138726       | 127           | 5          | 6.2     | 6.9| 601            | 31        | 253 | 2400                |
| 8  | Suryatmajan         | 430347       | 9138695       | 126           | 6          | 6       | 7  | 449            | 30        | 193 | 2400                |
| 9  | Suryatmajan         | 430420       | 9138420       | 108           | 11         | 5.1     | 7  | 370            | 28        | 160 | 75                  |
| 10 | Suryatmajan         | 430430       | 9138418       | 108           | 15         | 5.4     | 6.9| 304            | 28        | 135 | 460                 |
| 11 | Suryatmajan         | 430405       | 9138456       | 111           | 13         | 5.6     | 7.4| 567            | 29        | 240 | 210                 |
| 12 | Suryatmajan         | 430440       | 9138463       | 111           | 8          | 5.7     | 7.4| 384            | 28        | 167 | 2400                |
| 13 | Tegalpanggung       | 430472       | 9138482       | 114           | 23         | 6       | 7  | 383            | 29        | 166 | 2400                |
| 14 | Tegalpanggung       | 430553       | 9138489       | 116           | 24         | 6.1     | 7.2| 448            | 29        | 196 | 1100                |
| 15 | Tegalpanggung       | 430550       | 9138581       | 128           | 25         | 5.3     | 7.3| 426            | 28        | 192 | 2400                |
| 16 | Tegalpanggung       | 430557       | 9138603       | 131           | 26         | 5.3     | 7.1| 360            | 28        | 158 | 75                  |
| 17 | Tegalpanggung       | 430693       | 9138602       | 121           | 28         | 5.4     | 7.3| 371            | 28        | 164 | 1100                |
| 18 | Tegalpanggung       | 430710       | 9138618       | 130           | 29         | 5.2     | 7.5| 333            | 30        | 151 | 240                 |
| 19 | Tegalpanggung       | 430767       | 9138912       | 133           | 30         | 4       | 7.3| 350            | 32        | 155 | 9                   |
| 20 | Tegalpanggung       | 430409       | 9138790       | 121           | 17         | 6       | 7.5| 381            | 30        | 168 | 2400                |
| 21 | Tegalpanggung       | 430394       | 9138764       | 123           | 18         | 3.7     | 7.5| 381            | 30        | 168 | 1100                |
| 22 | Tegalpanggung       | 430408       | 9138664       | 120           | 19         | 7.4     | 6.9| 450            | 28        | 192 | 1100                |
| 23 | Tegalpanggung       | 430418       | 9138653       | 121           | 20         | 5.5     | 7.5| 431            | 29        | 186 | 93                  |
| 24 | Tegalpanggung       | 430395       | 9138610       | 121           | 22         | 5.6     | 7.2| 407            | 28        | 184 | 2400                |
| 25 | Tegalpanggung       | 430448       | 9138619       | 123           | 21         | 4.9     | 7.1| 450            | 29        | 185 | 1100                |
| 26 | Kotabaru            | 430672       | 9139610       | 137           | 16         | 4.3     | 7.5| 381            | 30        | 164 | 1100                |
| 27 | Gowongan            | 430361       | 9139455       | 133           | 2          | 4.2     | 6.9| 366            | 29        | 160 | 1100                |
| 28 | Gowongan            | 430366       | 9139422       | 130           | 3          | 5.3     | 7  | 371            | 29        | 162 | 1100                |
| 29 | Gowongan            | 430384       | 9139476       | 132           | 1          | 6.1     | 7.5| 375            | 29        | 162 | 3                   |
| 30 | Gowongan            | 430300       | 9138978       | 131           | 4          | 5.4     | 7.6| 491            | 30        | 209 | 460                 |
3.2. Well Water Quality Assessment

3.2.1. Results of DO sampling
Dissolved Oxygen (DO) values indicate the amount of oxygen (O\textsubscript{2}) available in water. It appears that DO levels range from 2.93 - 6.67 ppm. High DO values (red) are mostly on the right side of the river in Suryatmajan village, which means that the quality of well water and sanitation is better than in other kelurahan.

While on the left (Kotabaru and Tegalpanggung villages) the DO value is lower, this is possible because in this area it is a more densely populated residential area. Besides that, based on the color gradation of the map it appears that the DO value decreases in quality starting from terrace 1 (highest elevation) to terrace 2 (middle elevation) and lowest DO quality at terrace 3 (lowest elevation).

3.2.2. Results of DHL sampling
DHL (Electrical Conductivity) in water shows the ability of a solution to deliver an electric current. The greater the value of DHL indicates that more minerals are contained in water.

It appears that the value of DHL ranges from 340 – 473 µmhos/cm. The high DHL value (red) is mostly on the right side of the river in Suryatmajan sub-district and on the left in Tegalpanggung sub-district, which is a residential area with a denser population.

In addition, based on the color gradation of the map it appears that the value of DHL increases in content starting from terrace 1 (highest elevation) to terrace 2 (middle elevation) and the highest DO content is on terrace 3 (lowest elevation).

![Figure 3. Results of DO sampling](image1.png) ![Figure 4. Results of DHL sampling](image2.png)
3.2.3. Results of E-Coli Sampling

Coliform bacteria (E Coli) is a group of microorganisms commonly used as indicators, to determine whether or not the water source has been contaminated by pathogens. It appears that E Coli levels range from 17.96 - 2,203.9 MPN/100 ml.

High levels of E Coli (red) are mostly on the right side of the river in the village of Gowongan and the Suryatmajan village and on the left side of the river in the Tegalpanggung village which is a more densely populated residential area.

Besides that, based on the color gradation of the map it appears that the value of E-Coli increases its content starting from terrace 1 (highest elevation) to terrace 2 (middle elevation) and the highest E-Coli content is on terrace 3 (lowest elevation).

3.2.4. Results of pH Sampling

pH is an acid-base level of a solution that is measured on a scale of 0 to 14. A pH value that is good for health is not < 6.5 and > 9.

It appears that the pH value ranges from 6.37 - 7.62 which is evenly distributed on the right and left side of the river.

The high pH value (red color) is mostly on the right side of the river in the village of Gowongan and on the left side of the river in the Kotabaru village and in the Suryatmajan village.

Besides that, based on the color gradation of the map it appears that the pH value is getting acidic starting from terrace 1 (highest elevation) to terrace 2 (middle elevation) and most acidic is on terrace 3 (lowest elevation).
3.2.5. Temperature Sampling Results
The temperature in water greatly affects the quality of water, because the temperature can affect the reaction of the performance of microorganisms in water.

It appears that temperatures range from 27.9 - 32.06°C, which are evenly distributed across all villages, both in the Gowongan village, Kotabaru village, Suryatmajan village, and Tegalpanggung village.

In addition, based on the color gradation of the map, it appears that the temperature values increase from terrace 1 (highest elevation) to terrace 2 (middle elevation) and the highest temperature is on terrace 3 (lowest elevation).

3.2.6. TDS Sampling Results
TDS (Total Dissolved Solids) is a parameter of the amount of minerals dissolved in this material, which can include carbonates, bicarbonates, chlorides, sulfates, phosphates, calcium nitrates, magnesium, sodium, organic ions and other ions. It appears that the TDS values ranged from 152 - 204 which are evenly distributed in all villages, both in the Gowongan village, Kotabaru village, Suryatmajan village, and Tegalpanggung village. Besides that, based on the color gradation of the map it appears that the TDS value increases from terrace 1 (highest elevation) to terrace 2 (middle elevation) and the highest temperature is on terrace 3 (lowest elevation).

Figure 7. Temperature sampling results  
Figure 8. TDS sampling results
4. Conclusion

- Based on the data from the research results mapping the well water quality sampling consisting of parameters: Dissolved Oxygen (DO), DHL (Electrical Conductivity), Coliform Bacteria (EColi), pH, Temperature, and TDS (Total Dissolved Solids) as shown in Fig. 3, 4, 5, 6, 7, and 8 can be seen that there is a decrease in the quality of well water from high elevation to low elevation so that the quality of well water at low elevations is worse than the quality of well water at higher elevations, both in the Gowongan village, Kotabaru village, Suryatmajan village, and Tegalpanggung village. So that it can be concluded that there is a direct correlation of the accumulation of well water pollution at high elevations to low elevations in the residential area terraced by the Code River.
- The decrease in the quality of well water occurs because of waste originating from septic tank terrace 1 and terrace 2 will flow downward, and pollute the wells of residents living on terrace 3 as accumulated septic tanks from settlements above them.
- In more densely populated residential areas the quality of well water is getting worse compared to other regions. So it can be concluded also that there is also a decline in the quality of well water in densely populated residential areas.

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