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Water Pollution Index and The Distribution of Waterborne Diseases on The East Flood Canal, Semarang City: An Analysis Spatial

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A B S T R A C T

High environmental health quality status is an environmental condition that needs to be preserved. Poor environmental health quality is closely related to the level of heavy pollution status and the high incidence of waterborne disease. In 2018 there were 25 rivers with heavy pollution status in Indonesia and the condition is worsened in 2019 with as many as 38 rivers in the condition of heavy pollution status. Water pollution can be a factor in the emergence of waterborne diseases such as diarrhea, typhoid and leptospirosis. This study aimed to provide an overview of the water pollution index and the incidence of waterborne disease on the Semarang East Flood Canal with a spatial modelling approach. This research was a spatial analysis approach. The type of data in this study is quantitative with retrieval 6 sampling points on the east bank of The Canal Flood which was then analyzed with spatial-Gis modelling. Parameters for the water pollution index were total coliform, faecal coliform, dissolved oxygen, and anionic detergent. From the results of the calculation of the water pollution index, sample points 1-6 (T1-T6) are categorized with mild pollution status. However, when viewed from each parameter, there are total coliform, faecal coliform, dissolved oxygen parameters that exceed the quality standard. Existing results and interviews obtained, waterborne disease in the work area of the public health centre related to istewater from the Semarang East Flood Kanal. From the existing results, most of the contamination from domestic activities that do not have a istewater treatment plant and in T6 is an industrial area, which allows the contamination to come from industrial activities. Efforts are also needed to make istewater treatment installations either individually, semi-communally or communally to minimize water parameters exceeding quality standards.

Kata kunci:

Indeks Pencemaran Air
Penyakit Melalui Air
Total Coliform
Oksigen Terlarut
Deterjen Anionik

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A B S T R A K

Status kualitas kesehatan lingkungan yang tinggi merupakan kondisi lingkungan yang perlu dilestarikan. Kualitas kesehatan lingkungan yang buruk erat kaitannya dengan tingkat status pencemaran berat dan tingginya insiden penyakit yang ditularkan melalui air. Pada tahun 2018 terdapat 25 sungai dengan status pencemaran berat di Indonesia dan kondisi tersebut diperparah pada tahun 2019 sebanyak 38 sungai dalam kondisi status pencemaran berat. Pencemaran air dapat menjadi faktor munculnya penyakit yang ditularkan melalui air seperti diare, tifus dan leptospirosis. Penelitian ini bertujuan untuk memberikan gambaran indeks pencemaran air dan kejadian penyakit yang ditularkan melalui air pada Banjir Kanal Timur Semarang dengan pendekatan pemodelan spasial. Penelitian ini merupakan penelitian dengan pendekatan analisis spasial.

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Jenis data dalam penelitian ini adalah kuantitatif dengan pengambilan 6 titik sampling di tepi timur Banjir Kanal yang kemudian dianalisis dengan pemodelan spasial-Gis. Parameter indeks pencemaran air adalah total coliform, fecal coliform, oksigen terlarut, dan deterjen anionik. Dari hasil perhitungan indeks pencemaran air, titik sampel 1-6 (T1-T6) dikategorikan dengan status pencemaran ringan. Namun jika dilihat dari masing-masing parameter terdapat parameter total coliform, fecal coliform, oksigen terlarut yang melebihi baku mutu. Hasil eksisting dan wawancara yang diperoleh, waterborne disease di wilayah kerja Puskesmas terkait dengan air limbah dari Kanal Banjir Timur Semarang. Dari hasil yang ada, sebagian besar pencemaran dari kegiatan domestik yang tidak memiliki instalasi pengolahan air limbah dan di T6 merupakan kawasan industri, yang memungkinkan pencemaran berasal dari kegiatan industri. Upaya juga diperlukan untuk membuat instalasi pengolahan air limbah baik secara individual, semi-komunal maupun komunal untuk meminimalkan parameter air yang melebihi baku mutu.

INTRODUCTION

Environmental health status is the state of environmental health aspects which include water, soil, and air as abiotic components and interrelated living things. In this study, the biotic component of the environment that is the topic of research is water. Water is an important component in an ecosystem (Aznar-Sánchez, Velasco-Muñoz, Belmonte-Ureña, & Manzano-Agugliaro, 2019). Water sources can come from rivers, reservoirs, lakes, rainwater, groundwater, etc (Chowdhury & Al-Zahrani, 2015). The quality of water sources can be affected by the presence of pollution from various sources.(Wu, Wang, Chen, Cai, & Deng, 2018)

Assessment of environmental health status can be studied by looking at water pollution and waterborne diseases. River pollution in Indonesia is very severe, in 2019 of about 98 rivers in Indonesia, 54 rivers were mild polluted, 6 rivers were medium polluted, and 38 rivers were hard polluted(Firmansyah, Setiani, & Darundiati, 2021). This condition is worse than in 2018, where there were 97 rivers in Indonesia, 67 rivers with mild polluted status, 5 medium polluted rivers, and 25 hard polluted rivers (Firmansyah et al., 2021). The Semarang East Flood Canal of Semarang City is the object of study in this study and the contamination of the river conditions is not yet known. Poor river water quality is caused by pollution from domestic and industrial activities(Sun, W., Xia, C., Xu, M., Guo, J., & Sun, 2016). Each source of pollution has different characteristics of istewater (Lima, Lombardo, & Magaña, 2018). For example domestic activities, are more dominant on bacterial parameters which then cause waterborne diseases (Blettler et al., 2019). Meanwhile, industrial activities have the characteristics of istewater with more heavy metals (Sun, W., Xia, C., Xu, M., Guo, J., & Sun, 2016).

The Semarang East Flood Canal is categorized into a class 2 river, which functions as water recreation facilities, freshwater fish cultivation, livestock farming, and to irrigate agriculture. Therefore, it is necessary to monitor the status of the river in terms of the water pollution index. The parameters studied in this study were total coliform, fecal coliform, dissolved oxygen, and anionic detergents. Coliform bacteria are categorized into biological parameters which are included in water quality monitoring efforts. Coliform bacteria are agents that cause waterborne diseases such as diarrhea and typhoid(Okafor, 2011). Waterborne diseases is another indicator in efforts to determine environmental health status. Coliform bacteria can be classified into two types, total coliforms which include salmonella bacteria that cause typhoid, and fecal coliform called Escherichia coli agents that cause diarrhea(Indiana, n.d.). In addition, coliform bacteria can produce ethionine toxin which is carcinogeni (Adrianto, 2018). A high concentration of anionic detergent in water will indicate the presence of foam on the surface of the water. The presence of the foam will inhibit sunlight and the availability of oxygen in the water so that it can interfere with the survival of aquatic biota(Rizky Kamiswari, M. Thamrin Hidayat, 2013).

The water pollution index method can be used in an effort to assess water quality against pollution by categorizing(Effendi, Romanto, & Wardiatno, 2015). The water pollution index is also used in determining initial status assessment of water quality (Zhang, Li, Li, Han, & Xiong, 2017). The Eastern Flood Canal is a river that has a flow, so spatial-based segmentation is needed. Spatial analysis can be used to see which river segmentation is still safe, mild, medium, hard polluted (Gazzaz, N.M.; Yusoff, M.K.; Ramli, M.F.; Aris, A.Z.; Juahir, 2012). This study aims to assess the water quality status of the Semarang East Flood Canal which is then spatialized to determine the segmentation of polluted rivers and to describe waterborne diseases (diarrhea, typhoid and leptospirosis) on the banks of the Semarang East Flood Canal.

METHOD

This research is conducted in the Semarang East Flood Canal, Semarang City, in August 2021. This research is quantitative with a spatial approach. Quantitative data were taken from direct measurement of biological parameters (total coliform and fecal coliform) and chemical parameters (dissolved oxygen and anionic detergent) without repeated samples. The test is carried out at the testing and calibration laboratory, center of industrial pollution prevention technology, Semarang City. The test method for each parameter is described in table 1 as follows,

Table 1.
Tested Method on Parameters

Parameter	Unit	Test Method
Coliform total	MPN/100ml	SM 9221-B, 23rd Edition 2017
Coliform fecal	MPN/100ml	SM 9221-E, 23rd Edition 2017
Dissolved oxygen	mg/L	SM 4500-O, C, 23rd Edition 2017
Anionic detergent	mg/L	SM 5540. C, 23rd Edition 2017

Source: primary data

Sampling in the Semarang East Flood Canal is based on a critical point which is then segmented. The segmentation of points in this study amounted to 6, with the coordinate points which can be seen in table 2. The sample is taken by grab sampling. Samples were taken at one time, not raining, not repeated, with sampling at 08.30-11.30 AM.

Table 2.
Sampling Location in East Flood Canal

Name Sampled	Coordinat	Time Sampled
T1 (Diponegoro Education Reservoir)	70 03' 10.0" E = 1100 26' 44.8"	08.48 AM
T2 (Kompol R. Soekanto Street)	70 03' 07.4" E = 1100 27' 53.3"	09.26 AM
T3 (Pekuncen Sendangmulyo Street)	70 02' 26.9" E = 1100 29' 01.3"	09.47 AM
T4 (Amposari Bridge)	70 00' 56.7" E = 1100 28' 00.3"	10.10 AM
T5 (Kimar Street)	60 59' 54.7" E = 1100 26' 19.4"	10.30 AM
T6 (Tanggung Rejo Street)	60 57' 00.0" E = 1100 26' 26.1"	11.00 AM

Source: primary data

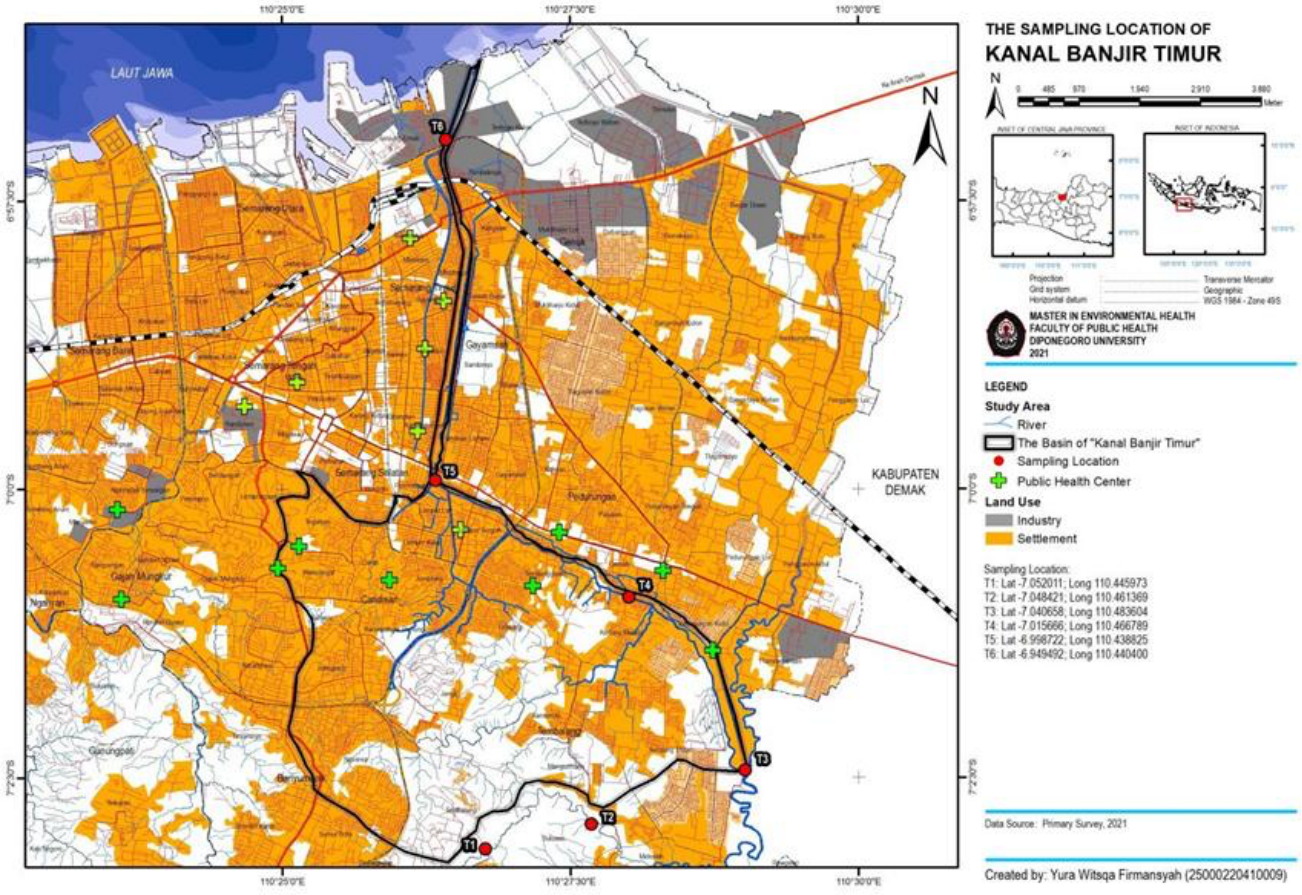

Figure 1. Sampled Map Location

Calculation of water pollution level by the formula in figure 1, determination of water pollution status is based on table 3, then spatialized by the map output. Waterborne disease data (diarrhea, typhoid, and leptospirosis) were obtained from the Semarang City Health Office. Waterborne

diseases data collected by cross section method for 1 year (2020).

$$IP_j = \sqrt{\frac{(\frac{C_i}{L_{ij}})_M^2 + (\frac{C_i}{L_{ij}})_R^2}{2}}$$

Figure 2. Calculation of Water Pollution Level

Descriptioned,
IPj = pollution index for the designation j
Ci = concentration of water quality parameter i
Lij = concentration of water quality parameter i listed in the water designation standard j
M = maximum
R = average

Table 3
Determination of Water Pollution Status

Calculation Score Resulted	Description
Skor 0 ≤ Pij ≤ 1,0	Safe
Skor 1,0 < Pij ≤ 5,0	Mild polluted
Skor 5,0 < Pij ≤ 10	Medium polluted
Skor Pij > 10	Hard polluted

RESULTS AND DISCUSSION

3.1. Parameters Test Results Obtained

The test results obtained for total coliform, fecal coliform, dissolved oxygen, and anionic detergent parameters in table 4. Testing carried out by The Testing and Calibration Laboratory, Center of Industrial Pollution Prevention Technology, Semarang City. The sample is taken from the Semarang East Flood Canal with a river length of 25,21 km and each distance between sampling locations T1-T2 3,28 km; T2-T3 7,33 km; T3-T4 3,78 km; T5-T6 5,58 km; and T6-downstream 1,4 km.

Tabel 4. Test Resulted Parameters

Parameters	Test Resulted						Quality Standart	Unit
	T1	T2	T3	T4	T5	T6		
Coliform total	4900	1400	35000	5400	4500	13000	5000	MPN/100 ml
Coliform total	3300	1100	17000	3900	2600	2700	1000	MPN/100 ml
Dissolved Oxygen	4,74	7,47	4,07	0,95	1,07	5,69	4	mg/l
Anionic deterjent	<0,01	<0,01	<0,01	0,167	0,027	0,025	0,2	mg/l

Source: primary data

The measurement results obtained for sample 1 (T1 Diponegoro Education Reservoir), the parameters that have exceeded the quality standard are fecal coliform. In sample 2 (T2 Kompol R. Soekanto Street), the parameters that have exceeded the quality standard are fecal coliform. Total coliform and fecal coliform are parameters that exceed the quality standard in sample 3 (T3 Pekuncen Sendangmulyo Street). Tests on sample 4 (T4 Amposari Bridge) obtained results, the total coliform, fecal coliform, and dissolved oxygen parameters have exceeded the quality standard. In sample 5 (T5 Khimar Street) the parameter that exceeds the quality standard is fecal coliform and dissolved oxygen. And in the last sample (T6 Tanggung Rejo), the total coliform and fecal coliform parameters have exceeded the specified quality standard.

3.2. Spatial Analysis of Water Pollution Indeks

After getting the results of the concentration of parameters, then the parameters are calculated the level of pollution and then the pollution index is determined and analyzed spatially. The map legend shows the location of the Semarang East Flood Canal of Semarang City samples, watersheds, the buffer from the river, residential and industrial land uses, water pollution index, sample coordinates, and public health center. Spatial analysis of water pollution index is presented in figure 2 as follows,

From the results of the calculation, the flow water pollution index from T1-T2, it is categorized as mild pollution status with an IPj value of 2.72. The flow of T2-T3 is categorized in a safe level of pollution, based on the calculation of the water pollution index with an IPj value of 0.89. Categorized the level of mild pollution at sample locations T3-T4 from the results of the calculation of the water pollution index, with an IPj value of 5.7. The water flow in samples T4-T5 is categorized at the level of mild pollution, from the results of the calculation of the water pollution index, the IPj value is 3.13. From the results of the calculation of the water pollution index, the flow of T5-T6 is categorized into a mild pollution level with an IPj value of 2.42. The water flow at T6 to the downstream is categorized with a mild pollution level, from the results of the calculation of the water pollution index, the IPj value is 2.54.

Sample point 1 (T1) based on the existing one, is the Diponegoro reservoir area which is the middle part of the

Semarang East Flood Canal that receives water discharge from the upstream. Sample point 1 categorized mild polluted, caused does not have iste water management or treatment, so the water is only deposited. Settlements in the district of Tembalang, drainage channels and gray water use one place (Secioputri, 2014). This allows for drainage contamination from residential gray water, such as total coliform bacteria and fecal coliform (E.coli). In terms of water quality parameters, fecal coliform exceed the specified quality standards. This condition occurred because sample point 1 (T1) is polluted from water runoff from upstream. The result is in accordance with(Putranto & Susanto, 2019), the upstream area is dominated by agricultural, residential and livestock areas, so that contamination comes from human and animal feces which causes fecal coliforms to exceed the quality standard.

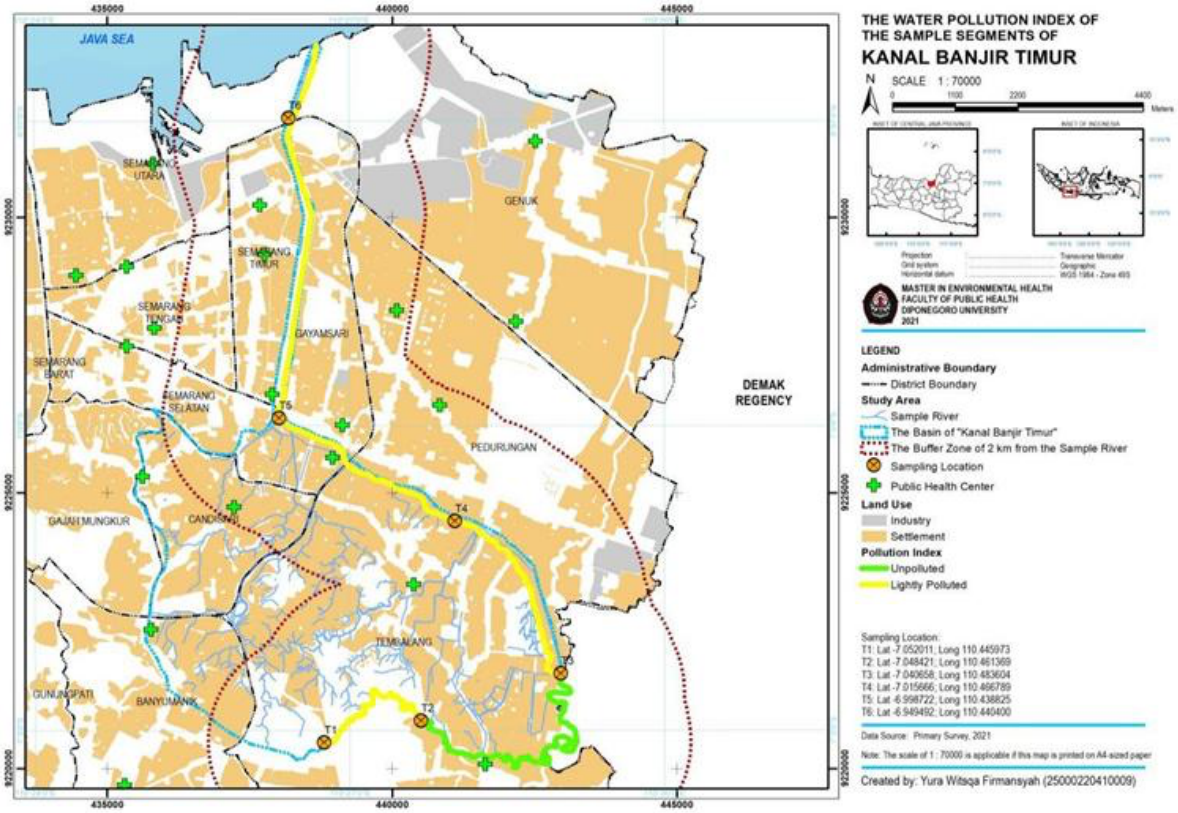

Figure 3. Spatial analysis of water pollution index

Sample point 2 (T2) is categorized with a safe level of pollution. Existing condition Sample point 2 (T2) there is garbage in the water flow, the volume of water is small, there is no domestic activity found at point 2 flow so that pollution is classified as safe. In terms of each parameter studied, only faecal coliform exceeds the quality standard at sample point 2 (T2). This fact is reversed by the research studies conducted (Cobo, J. R., Lock, K., Van Butsel, J., Pauta, G., Cisneros, F., Nopens, I., & Goethals, 2018; Mukate et al., 2018; Wu et al., 2018; Xue et al., 2018), the parameters of dissolved oxygen and total coliforms were higher when conditions were dry than rainy conditions. Total coliforms and fecal coliforms are categorized as bacteria that are often found in aquatic environments because of contamination from feces, both human, animal and domestic iste (Frena et al., 2019). When there is no domestic activity in the flow of The Semarang East Flood Canal, the parameters of total coliform concentration, fecal coliform are below the quality standard(Frena et al., 2019).

Sample point 3 (T3) is categorized as mild polluted, it is found that the existing condition is that there is a source of contamination from residential activities, small-scale livestock, in the buffer 2 km from the canal is an industrial area which is also adjacent to the District of Demak so that the source of contamination is possible from the District of Demak. In terms of parameters, the concentration of total coliform and fecal coliform exceeded the quality standard at sample point 3 (T3). In a research studied(Whitehead, P., Bussi, G., Hossain, M. A., Dolk, M., Das, P., Comber, S., & Hossain, 2020), the presence of total coliforms and fecal coliforms in aquatic environments is due to contamination of iste in the form of human or animal feces and domestic iste.

Amposari Bridge is sample point 4 (T4) with mild pollution category. Similar to other sample points, the source of contamination comes from domestic activities (ished clothes, cooked utensils, and disposing of used cooking water in the flow of sample point 4) which empties into small rivers from the Tembalang sub-district. In terms of parameters, sample point 4 (T4) parameters that exceed the quality standard are total coliform and fecal coliform, while dissolved oxygen is below the quality standard. If dissolved oxygen is below the quality standard value, the availability of oxygen in the water decrease(Setyobudiarso & Yuwono, 2017). If the amount of dissolved oxygen in the water decreases, the microorganisms in the water should decrease because of the process of death due to lack of oxygen. However, the total coliform parameter concentration exceeded the quality standard with a concentration value of 5,400 MPN/100ml and fecal coliform 3,900 MPN/100ml. This condition is in line with research conducted by(Tanjung,

Hamuna, & Alianto, 2019), the concentration of total coliform and fecal coliform parameters exceeds the quality standard, followed by the dissolved oxygen concentration below the quality standard.

Sample point 5 (T5), categorized into mild pollution. Sources of pollution at sample point 5 (T5) are caused by contamination from domestic activities, combined iste from gray water such as iste from bathrooms and kitchens. Meanwhile, black water is iste from the toilet included feces and urine. In terms of parameters, fecal coliform and dissolved oxygen have exceeded the quality standard. Fecal coliforms (E.coli) can live with dissolved oxygen concentrations reaching 1,07 mg/l compared to other bacteria that are classified as total coliforms. According to research conducted by (Abe, 2016), fecal coliforms can survive with the most oxygen levels at a concentration of 1-2 mg/l.

Tanggung Rejo street is a sample point 6 (T6) with a light pollution category. The existing condition of the sample point area 6 (T6), is a residential area, industry, livestock, so that the contamination comes from domestic, industry, and livestock. Parameters that exceed the quality standard are faecal coliform and total coliform. Sources of pollution from domestic activities that do not have istewater treatment plants either privately or communally. Pollution from industry is also possible, there is no istewater treatment plant for domestic activities. Research is in line with (Safitri, L, F., Widyorini, N., dan Jati, O, 2016), domestic iste (settlements) is the largest contribution to fecal coliform and total coliform bacterial contamination.

3.3. Spatial Analysis of Water Pollution Index and Prevalence Rate of Diarrhea

Spatial analysis of water pollution indices presented in the map along with the prevalence rate of waterborne disease diarrhea. The map legend shows the location of the Semarang East Flood Canal of Semarang City samples, watersheds, the buffer from the river, water pollution index, sample coordinates, and public health center include the work area. Spatial analysis of water pollution index is presented in figure 3 as follows,

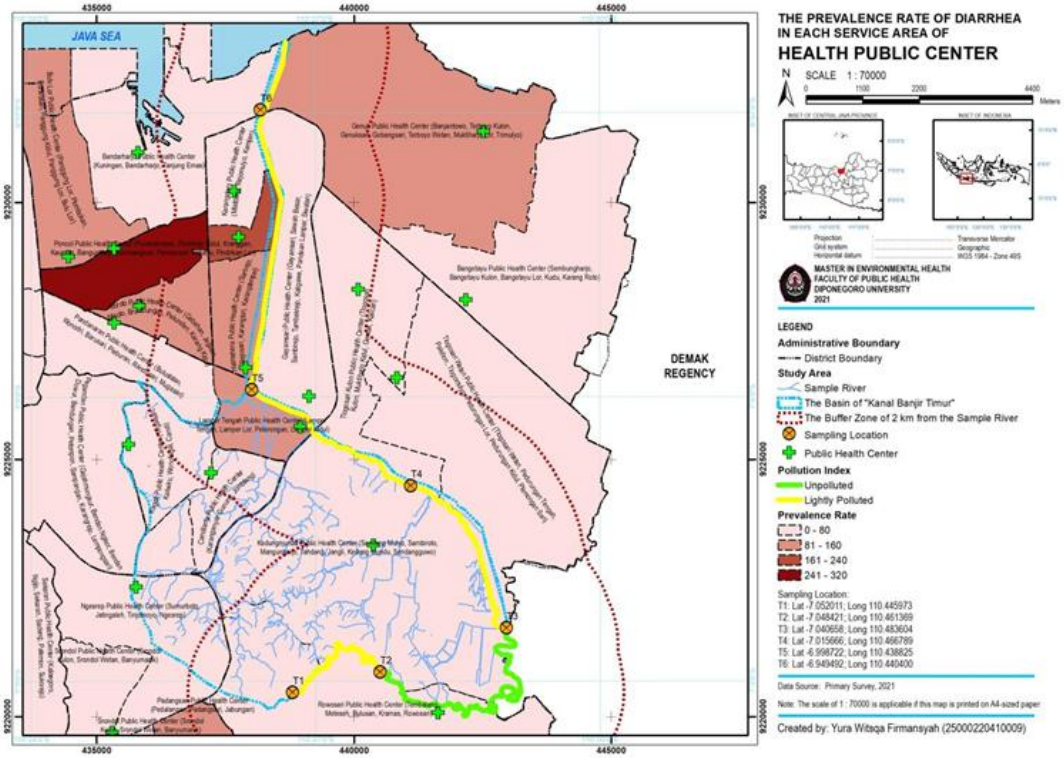

Figure 4.
Spatial analysis of water pollution index and prevalence rate of diarrhea

Spatial analysis of diarrhea prevalence rate is categorized into 4 levels, level 1 with prevalence rate 0-80; level 2 81-160; level 3 161-240; level 4 241-320. The public health centers with level 1 categories with a buffer distance of 2 km include the public health centers Rowosari, Kedungmundu, Ngesrep, Candilama, Kagok, Pandanaran, Tlogosari Wetan, Tlogosari Kulon, Gayamsari, Kandangdoro, and Bandarharjo. The public health centers Padangsari, Lamper Tengah, Halmahera, and Miroto are categorized into level 2 with a prevalence rate of 81-160. Public health center areas with a level 3 prevalence rate category are Genuk and Bugangan. The public health centers Poncol is categorized into level 4 with a prevalence rate of 241-320.

Case is reported as many as 969 cases of diarrhea in children under five, with a prevalence rate of 162 children under five suffering from diarrhea per 1,000 population at the Bugangan public health center with a level 3 category in spatial analysis. The working areas of the Bugangan public health center include Bugangan, Mlatiharjo, and Kebon Agung villages. The results of a brief interview with a public health center officer showed that some local people use the Semarang East Flood Canal water for their daily activities,

people use canal water when the supply of clean water at home is not smooth. The working area of the Bugangan public health center is very close to the buffer 1 km from the canal. The concentration of fecal coliform parameters in the Bugangan public health center flow exceeded the quality standard. Thus, when local people use the water, it is possible that it will be contaminated with fecal coliform (E. coli) which causes diarrhea. A similar study is also conducted by with a cohort and case control study design that found a positive association between istewater and diarrheal disease.(Pham-Duc P et al., 2014) The work area at the Public Health Center is categorized as green open space in East Semarang, which means there is a large agricultural area. People irrigate the rice fields using water from The Semarang East Flood Canal. Canal water with high concentrations of fecal coliform (E. coli) can contaminate agricultural products because it is used in the irrigating process. A similar study is conducted by (Deshpande et al., 2020), untreated istewater used to irrigate agriculture is a source of contamination of the Escherichia coli subtype in children.

Karangtempel, Karangturi, Sarirejo and Rejosari are villages within the Halmahera public health center. The working area of the Halmahera public health center is categorized as a level 2 diarrheal incident rate. A total of 270 cases of diarrhea in children under five were reported from the Halmahera public health center, with an incidence of 159 cases of diarrhea in children under five per 1,000 children. The existing results showed that the local community carried out domestic activities at the Semarang East Flood Canal during the clean water crisis. The concentration of faecal coliforms in T5 that exceeds the quality standard can be a cause of diarrhea in toddlers through food utensils that are still wet and not completely dried, the mother's limbs are not completely dry after ished in canals, which then contact with toddlers is not ished. hands ish with soap and water. In line with research conducted (Kouamé et al., 2014), transmission of E. coli bacteria can occur through unhygienic skin contact (not ished hands with soap and running water).

From the existing conditions, the working area of the Central Lamper public health center is often flooded due to the overflow of the Semarang East Flood Canal which is no longer able to accommodate. The total concentration of coliform is 5,400 MPN/100ml and fecal coliform 3,900 MPN/100ml, which means that it has exceeded the quality standard, so when a flood occurs, it is possible that the Semarang East Flood Canal will overflow with contamination from total coliform and fecal coliform. Similar research is also conducted by(Paterson, Wright, & Harris, 2018), diarrheal diseases increased during a flood disaster. In another research study (Wu et al., 2018), areas that frequently experience flooding have more cases of diarrhea than areas that do not flood.

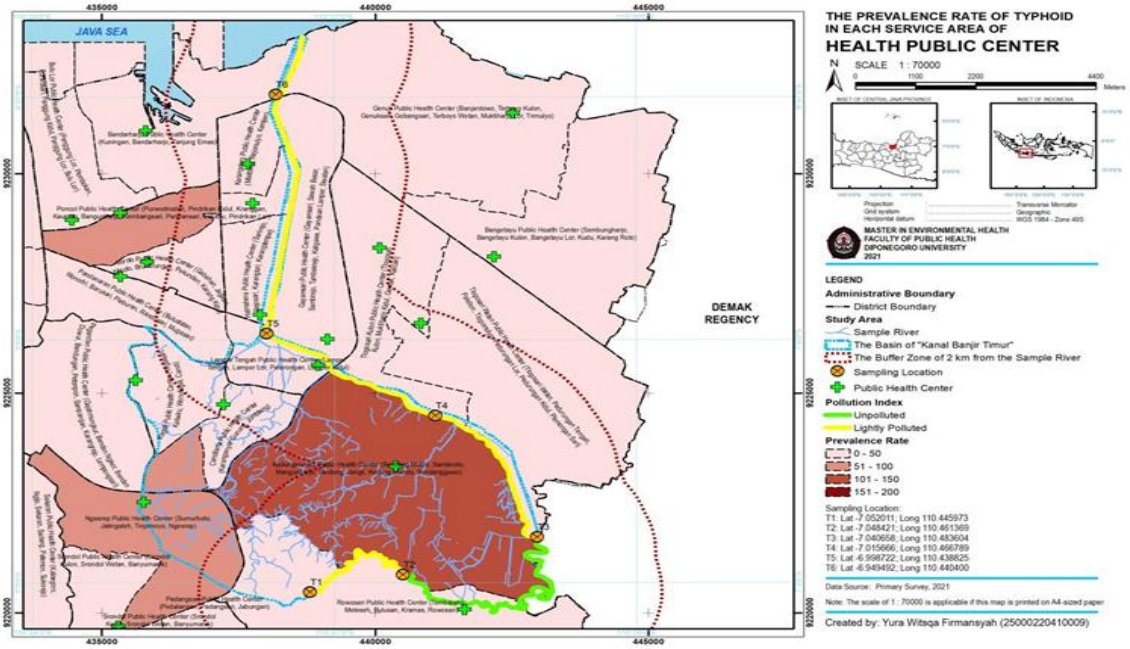

Figure 5.
Spatial analysis of water pollution index and prevalence rate of typhoid

3.4. Spatial Analysis of Water Pollution Index and Prevalence Rate of Thypoid

Spatial analysis of water pollution indices presented in the map along with the prevalence rate of waterborne disease typhoid. The map legend shows the location of the Semarang East Flood Canal of Semarang City samples, watersheds, the buffer from the river, water pollution index, sample coordinates, and public health center include the work area. Spatial analysis of water pollution index is presented in figure 4 as follows,

Spatial analysis of typhoid prevalence rate is categorized into 4 levels, level 1 with prevalence rate 0-50; level 2 51-100; level 3 101-150; level 4 151-200. The public health centers with level 1 categories with a buffer distance of 2 km include the public health centers Rowosari, Padangsari, Candilama, Kagok, Lamper Tengah, Pandanaran, Halmahera, Miroto, Bugangan, Kandangdoro, Bandarharjo, Tlogosari Wetan, Tlogosari Kulon, Gayamsari and Genuk. The public health centers Ngesrep and Poncol are categorized into level 2 with a prevalence rate of 51-150. Public health center areas with a level 3 prevalence rate category isKedungmundu. The public health center for typhoid incidence at level 4 does not exist.

Under the existing conditions, the working area of the Kedungmundu public health center includes the villages of

Sendang Mulyo, Sambiroto, Mangunharjo, Tandang, Jangli, Kedungmundu, and Sendangguwo. The community in the working area of the Kedungmundu public health center uses water from the Semarang East Flood Canal for irrigation of rice fields. This can trigger the transmission of total coliforms (Salmonella sp.) that exceeds the quality standard at T3 the Semarang East Flood Canal in agricultural products. In line with research conducted by (Deshpande et al., 2020), that the use of water contaminated with Salmonella spp can contaminate agricultural products. Another similar study from (Agnès, Isabelle, Anne-Marie, Adam, & Philippe, 2014), water from rice field irrigation is a source of Salmonella spp contamination and plants can be contaminated. The next finding is that in the existing condition, people in the Jangli sub-district often use canal water when there is a water crisis. Jangli Village often experiences a clean water crisis, so the Semarang East Flood Canal water is often consumed by people with low economic income. Consumption of canal water that is not treated properly can transmit Salmonella spp. Research from(Levantesi, C., Bonadonna, L., Briancesco, R., Grohmann, E., Toze, S., Tandoi, 2012) revealed that drinking water that is not disinfected and boiled below 48°C (Fatica, M.K., Schneider, 2011) still contained Salmonella spp.

3.5. Spatial Analysis of Water Pollution Index and Prevalence Rate of Incident Rate of Leptospirosis

Spatial analysis of water pollution indices presented in the map along with the prevalence rate of waterborne disease leptospirosis. The map legend shows the location of the Semarang East Flood Canal of Semarang City samples, watersheds, the buffer from the river, water pollution index, sample coordinates, and public health center include the work area. Spatial analysis of water pollution index is presented in figure 5.

The Kedungmundu public health center is categorized into level 2, with the working areas of Sendang Mulyo, Sambiroto, Mangunharjo, Tandang, Jangli, Kedung Mundu, Sendangguwo. There were 6 reported cases of leptospirosis at the public health center, with 1 death case. The incidence rate of the Kedung Mundu public health center is 5 patients per 100,000 population. The public health center of Lamper Tengah is also categorized into level 2, with the working area of Lamper Tengah; Lamper Lor; South Lamper; and Peterongan. Reported 2 cases, with 1 dead case 1. Incidence rate at the Lamper Tengah public health center, as many as 7 patients per 100,000 population.

The Lamper Tengah public health center has a working area covering the sub-districts of Lamper Tengah, Lamper Lor, Lamper Kidul, and Peterongan which are categorized into level 2 leptospirosis incident rates. It is reported that there were 2 leptospirosis cases with 1 death case, so for the incidence rate there were 7 leptospirosis sufferers per 100,000 population. From the existing conditions, the Lamper area is prone to flooding, the flood overflow occured from the flow of the Semarang East Flood Canal. The overflow of water can also be obtained from field water which is a habitat for leptospira bacteria because it cannot accommodate the overflow of water from the Semarang East Flood Canal. Another similar research study conducted by (Agampodi, Nugegoda, Thevanesam, & Vinetz, 2015), outbreaks of leptospirosis in Sri Lanka occurred during the rainy season or floods in countries with tropical climates.

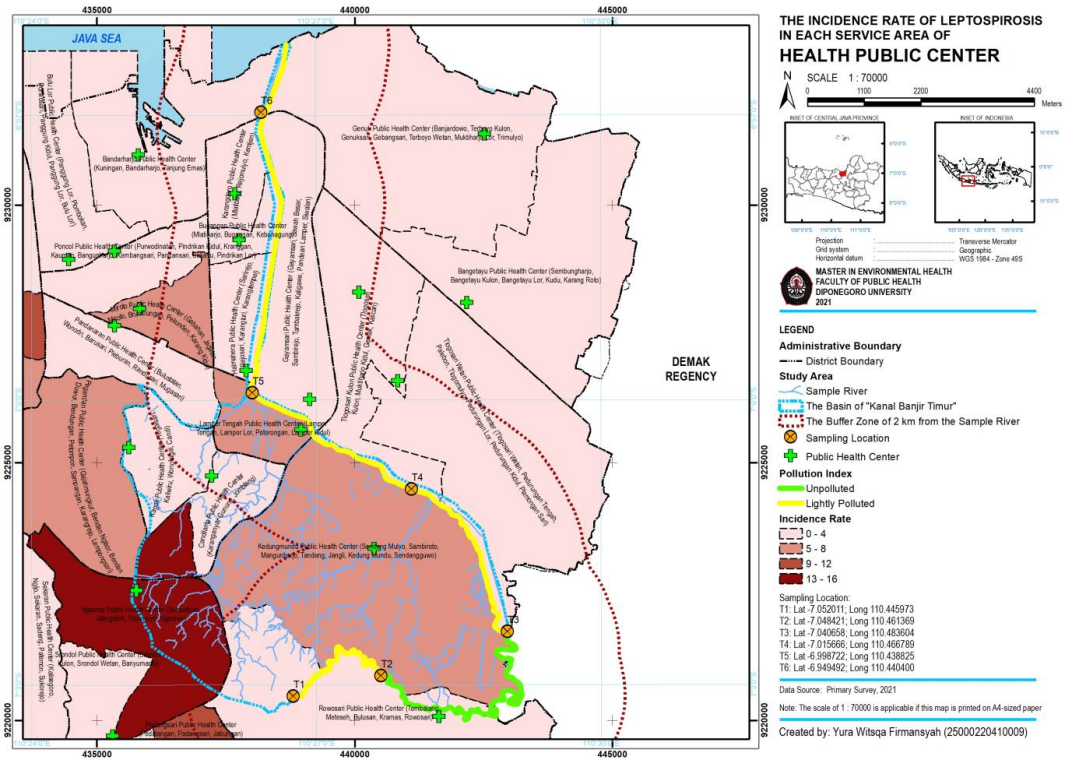

Figure 5.
Spatial Analysis of Water Pollution Index and Incident Rate of Leptospirosis

Another public health center with a 1 km buffer from the Semarang East Flood Canal is the Kedungmundu public health center with an incident rate of leptospirosis at level 2. There were 6 reported cases of leptospirosis, with 1 case

dying from leptospirosis. From the results of interviews with Kedungmundu public health center officers, Jangli sub-district with poor access to sanitation. Jangli Village often has clean water crisis, so people use canal water for their livelihood. There is a suspicion that the canal water in T3 contains leptospira bacteria which need to be measured for leptospira bacteria parameters in water. In line with research (Sato et al., 2019), leptospira bacteria were identified in rivers after there were positive community reports of leptospirosis

CONCLUSIONS AND SUGGESTION

From the results and discussion of the research, it is found that the middle segmentation (T1, T2, T3, and T4) and downstream segmentation (T5 and T6) on the Semarang East Flood Canal were in a state of mild pollution. There are total coliform and faecal coliform parameters that exceed the quality standard at several points. This can cause waterborne diseases such as diarrhea, typhoid and leptospirosis. Measurements are needed for further research on biological parameters (leptospira bacteria) in water in relation to the incidence of leptospirosis. Efforts are also needed to make istewater treatment installations either individually, semi-communally or communally to minimize water parameters exceeding quality standards.

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