Factors influencing adequate sanitation on domestic wastewater management of black water type in Margasari Village

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Abstract. Sanitation on the domestic wastewater management (WWM) component was a severe concern in the slums of Margasari Village, which has two characteristics area, administrative neighborhood above water, and neighborhood on land. The universal access to adequate sanitation was only 35.8%. Therefore, Margasari Village belonged in the priority zone of sanitation risk at a very high level for domestic wastewater problems. The purpose of this research was to identify important factors to increase the adequateness sanitation on the black water domestic WWM in Margasari Village. The questionnaires spread on 345 household samples taken at 32 neighborhoods as the data collection method. Identification factors had done through two stages of analysis. The comparative descriptive analysis used to determine characteristics of the domestic WWM black water type obtained the findings that the neighborhood above water had low users percentage of adequate black water domestic WWM. Second, binary logistic regression analysis was to identify the factors that affect the adequatess domestic WWM of black water type, four significant factors encompassing household income, knowledge level, financing willingness, and ease of technology. Significant factors not only increased adequate sanitation, but also contribute to the development of appropriate environmental and public health policies related to slums settlement.

1. Introduction

According to [1] sanitation is defined as access and provision of facilities and infrastructure for disposal of human waste such as urine and faeces. In contrast, the definition of access to adequate sanitation (healthy latrines) according to [2] a sanitation facility that meets health requirements, among others, is equipped with a pour flush toilet or slope with lids and has a sewage-disposal tank or wastewater management system (WWM). The condition of universal access to adequate sanitation in Balikpapan Municipal is still an urban issue, based on environmental health indicators, the community’s access to adequate sanitation facilities (healthy latrines) occupies the low percentage indicator, which is only 39.6% [3]. In comparison, it is stated in the National Medium-Term Development Plan 2015-2019 that the target of adequate sanitation is 100% [4]. The risk of sanitation is defined as a decrease in the quality of life, health and the environment caused by low access to sanitation services and facilities and poor hygiene and sanitation behavior. The results of Environmental Health Risk Assessment (EHRA) show that the sanitation risk index analysis consists of five (5) components, encompassing clean and healthy living behavior, water sources, inundation, solid waste, and domestic wastewater, where the domestic wastewater component is the largest contributor to the risk index, 57 of the total sanitation risk index.
analysis is 170, while the sanitation risk index of the water source component is 27, sanitation risk index clean and healthy living behavior is 35, sanitation risk index inundation is 20, sanitation risk index of solid waste is 30. These data mean that the problem of domestic wastewater is the most prominent component and priority sanitation risk in Balikpapan Municipal [5].

Margasari Village is one of the slum settlements in the City of Balikpapan with a slum area of 22.06 hectares [6]. Margasari Village is included in the priority zone for sanitation risk areas with a very high level of sanitation risk for domestic wastewater component problems [7]. This is supported by data from the Health Profile of Balikpapan City [3] that the Margasari Slum Settlement is a village with a percentage of universal access to adequate sanitation below the average of Balikpapan Municipal, which is only 35.8%, even this figure is far from the national target of adequate sanitation, that is 100%. Thus, there has been a decrease quality in environmental and public health in Margasari Village, this is proven by the fact that Margasari Village is included in the priority zone of a very high-level sanitation risk area. In the Regulation of the Minister of Environment and Forestry Number 68 of 2016 concerning Domestic Wastewater Quality Standards, wastewater management is a mandatory effort for every business and/or activity that produces wastewater [8]. Thus, because the problem of adequate domestic WWM on sanitation system facilities has a minimal percentage, while there are already regulations that require WWM for every business/activity that produces waste, it is necessary to identify factors that have a significant influence on the adequate sanitation on the domestic WWM of black water type to increase the number of adequate facilities users. Significant factors not only able to increased adequate sanitation but also consequently, contribute to the development of proper environmental and public health policies related to the slums settlement.

2. Methods

2.1. Data collection method

In this study, the data required is primary data with the technique of data collection are household questionnaire and observation at the sample residence. The population of this research are all households in the slum settlements of Margasari Village, is 2517 household. In determining the number of samples was used the proportionate random sampling technique, with the following formula is:

\[ n = \frac{N}{N \cdot d^2 + 1} \]  

(1)

Description :
N = Total population household
n = total households sample
d2 = error value (5%)

Therefore, it is known that the number of household samples is 345 households. Furthermore, the proportional allocation formula is used to determine the number of samples in each neighborhood administrative area.

2.2. Analysis method

2.2.1. The adequateness characteristics of black water domestic WWM analysis.

In analyzing the characteristics of adequate black water domestic WWM in the study area, it was carried out using comparative descriptive analysis. Descriptive analysis is a method in examining an object. Furthermore, the purpose of the descriptive method is to make a complete picture or to describe what is seen, heard, felt and asked, while the definition of comparative is comparing the existence of one or more variables in two different samples, or at the different time [9]. In this study, the authors compared the terms of adequate domestic wastewater management of black water type with the existing conditions of domestic WWM of black water type at the sample residence.
2.2.2. Analysis of influencing factors of the domestic WWM of black water type.

Analysis of the factors that significantly affect the adequate domestic wastewater of black water type in the slum settlements of Margasari Village uses Binary Logistic Regression (BRL) analysis. BRL is a model for estimating the relationship between a response variable and a set of predictor variables, where the response variable is dichotomous (nominal or ordinal scale) [10]. In cases where the response variable is a qualitative variable which is dichotomous, then binary logistic regression is used, dichotomous variables are variables that have only two possible values, for example, success and failure [11]. In this research, the response variable (the result of the previous analysis) is dichotomous, namely adequate and inadequate black water domestic WWM, then to identify influencing factors of the adequateness black water domestic WWM, BRL is used. Nevertheless, the predictor variables consist of factors encompassing the social, financing, and technology aspects.

Table 1. Analysis process of factors influencing the adequate black water domestic WWM with BRL

| Input | Assessment | Analysis Process |
|-------|------------|------------------|
| **Response Variable (Y) =** | Nominal Scale | 1. Input variables data (X and Y variables data) to SPSS 25.0 Statistics Software |
| Results of previous analysis (the users of the adequate facility and inadequate facility) | 1. Adequate 2. Inadequate | |
| **Predictor Variable (X)** | | 2. Conduct simultaneous test (Omnibus Test) to identify the capability of predictors in the model jointly to predict the response variable [17] |
| Social Aspects | | 3. Conduct Goodness of fit using Hosmer and Lameshow Test [17] |
| 1) The intensity of direct experience in water pollution [12-13] | Ratio Scale | 4. Conduct partial test (Wald Test) to test the significance of each predictor variables. [17] |
| 2) The intensity of household participation in housing or local area activities [13] | Ratio Scale | 5. Identify the effect of each predictor variable using odds ratio output (Exp (B)) |
| 3) Household income [14] | Ratio Scale | |
| 4) Household knowledge level about pollution [13] | Nominal Scale | |
| 1. Good 2. Poor | | |
| 5) Household house ownership status [14] | Nominal Scale | |
| 1. Private house 2. Rent house 3. Others (social or official housing) | | |
| 6) Household education level [14] | Nominal Scale | |
| 1. High (Senior High School and College) 2. Low (not yet school, elementary, junior high school) | | |
| Financing Aspects | | |
| 7) Household Willingness to pay operations [15-16] | Nominal Scale | |
| 1. Willing to pay 2. Not willing to pay | | |
| 8) Household Ability to pay Maintenance [15-16] | Nominal Scale | |
| 1. Able to pay 2. Unable to pay | | |
| Technology Aspect | | |
| 9) Ease of technology (operate and maintain application) [15-16] | Nominal Scale | |
| 1. Easy 2. Difficult | | |

The following are some test to verify the adequacy of the BRL analysis:

a) Simultaneous test was used to know the effect of all exploratory variables simultaneously to the characteristics of the WWM Blackwater type (adequate or Inadequate). The simultaneous significance test parameters were performed using Omnibus [18]. The basic decision-making for this
test is if the p-value of the Omnibus Test less than 0.05, it means entering the predictor variable into the model gives a better effect in explaining the response variable at the 5% level of significance. 

b) Partial test was used to determine the predictor variables that have a significant effect on the response variable. Partial significance test parameters were performed using Wald [18]. The basic decision-making for the test is if the p-value of the Wald Test less than 0.05, it means the predictor variable has a significant effect on the response variable at the 5% level of significance [19].

c) Goodness of fit test model was used to examine the difference between the results obtained from the model and the observed results in the observational data. To check the suitability of the model used Hosmer and Lemeshow test statistics [18]. If the Hosmer and Lemeshow test significance is higher than 0.05 (that is, is non-significant), there is no difference between observed and model-predicted values, implying that the model's estimates fit the data at an acceptable level [17].

d) Odds ratio represents the estimates of how the tendency of predictor variables to the response variable, that is the comparison between two events that fall into success and failure category, the odds ratio output can be seen on \( \exp(B) \) [20].

3. Results and Discussions

Margasari Village is one of the slum settlements in Balikpapan City. This area has 32 administrative neighborhoods and has two regional characteristics; administrative neighborhood above the water areas and on the land area can be seen on the map in Figure 1.

![Figure 1. Photo Mapping of Study Area](image)

Based on the map in Figure 1, in the west area, housing activities dominate while in the east area is dominated by trade activities. There are two WWM systems in this area, namely the onsite and offsite systems. 43% of the residences of the sample households are connected in the offsite system or registered as Wastewater Treatment Plant (WWTP) customers, and the other 57% are the users of the onsite system (independent waste treatment on private land or non-users of WWTP).

3.1. Overview of black water domestic WWM facility

This following subsubchapter discusses the conditions related to each of the provisions or indicators of the adequate black water domestic WWM.
3.1.1. Black water collection and treatment facility.
Based on the literature review sourced from [21-22], the adequate facility for collection and treatment of black water domestic wastewater in the onsite system is a septic tank. 32% of sample households are the users of the onsite system providing septic tanks. In the offsite system, the black water is flowed through a sewer pipe and then collected and treated centrally at the WWTP. According to [21-22], the adequate management of black water domestic wastewater in the offsite system is that there are sewer pipes from residents to communal WWTPs. Based on the primary survey results, 34% of sample households are the WWTP users with good physical sewer pipe conditions (the sewer pipe in the sample residence can drain waste from the residence to the WWTP). On the other hand, some households do not have adequate wastewater collection and treatment facilities in the onsite and offsite system. They are households with the onsite system but do not provide septic tanks and households that are the users of WWTP, but there is damage on the sewer pipe so that the black water cannot flow from the residence to the WWTP. There are 34% of respondents who live in these two conditions. Based on the map in Figure 2, it is known that the administrative neighborhood of land area tends to have collection and treatment facilities in the form of septic tanks. On the contrary, the administrative neighborhood above the water area is dominated by red and yellow color diagrams, which means that most of the respondents' residences do not have black water treatment and collection facilities, or the facilities are damaged. The yellow color diagram shows some are the users of the offsite system with good sewer pipes' physical condition.

3.1.2. Ownership of pour flush toilet.
One of the indicators or provisions for adequate black water domestic WWM is to have a pour flush toilet [22-23]. Based on data collection, it's known that 95% of respondents have a pour flush toilet, while 5% do not have a pour flush toilet. The map of the percentage of toilet ownership in Figure 2 shows that in the administrative neighborhood of the water area, there are still some households that do not have pour flush toilets. In contrast, on land area, almost all sample households have a pour flush toilet.

3.1.3. Open defecation practice.
The open defecation practice is the discharge of black water domestic wastewater in any place, namely disposal in environmental drainage for households who live in the land area and disposal in Balikpapan Bay to households that live above the water area. According to [1,21,24] an adequate black water wastewater management system can be demonstrated by none of the defecation practices in households. 117 households do open defecation practice. In the Open Defecation Percentage Map (Figure 2), it is known that the neighborhood administrations above water area tend to have a high percentage of open defecation practice, so it can be seen that in that area, most of the sample households disposing black water domestic wastewater into the Balikpapan Bay.
3.2. Overview condition of social, financing, and technology aspects

3.2.1 The Intensity of Household Participation in Housing Activities.

The participation factor is data related to community involvement in social activities carried out in a residential area within a period of one month. It is known that environmental activities that involve the presence/participation of residents in a period of one month are carried out on average 1 to 3 times. Most of the sample households answer that they participate in social housing activities once a month. The map of the average number of community attendances in social housing activities in each neighborhood area can be seen in Figure 3. Based on the map in Figure 3, it is known that the characteristics of the neighborhood administration area (both land and above water area of the administrative neighborhood) do not affect the number of community participation in residential activities.

3.2.2 The Intensity of direct experience in water pollution.

This factor discusses data regarding the number and average incidence of family members exposed by skin diseases due to polluted water conditions in the local environment. It is known that out of 345 sample households, there are 13 households state that skin diseases had exposed their family member due to contaminated water conditions. The 13 respondents were from 8 neighborhood areas. In Figure 3, it is known that the percentage in the high category, the number of incidents of being exposed by disease due to environmental conditions tends to be the respondent of the neighborhood administration in the water area. Meanwhile, in the administrative neighborhood of the land area, most of them have a percentage of 0% (none sample households exposed by the disease due to direct contact with the water pollution).
3.2.3. **Household Income.**

The income factor is data related to the amount of household monthly income [25]. Administrative neighborhoods that have the lowest average income are found in neighborhood 6 and 7, with an income of around Rp. 1,600,000.00 while the highest average income of sample households is at neighborhood 22, amounting to Rp. 5,142,857.00. Based on the map in Figure 4, the administrative neighborhoods with the average income in the highest category is neighborhood 17, 19, 20, 22, 28, and 31, which are the land areas. Meanwhile, the administrative neighborhoods with the average income in the lowest category are administrative neighborhood 5, 6, 7, 11, and 29, which are the administrative neighborhoods above the water areas, and neighborhood 12 which is the administrative neighborhood on the land area.

3.2.4. **Household knowledge level.**

The knowledge level factor is data related to knowledge (good knowledge and poor knowledge) [26] of respondents about environmental pollution caused by domestic or household activities. Respondents who have good knowledge are sample households who have basic knowledge and understanding of environmental pollution and apply measures to minimize environmental pollution. On the map in Figure 4, it can be seen that respondents in the administrative neighborhood of the land area are dominated by blue diagrams so that in this area, they tend to have a good level of knowledge regarding environmental pollution and the opposite conditions occurring in the administrative Neighboord above the water area.

![Figure 3](image1.png)

**Figure 3.** The average number of community attendances in social housing activities map and the average intensity of disease caused by water pollution map

![Figure 4](image2.png)

**Figure 4.** The average household income map and comparison percentage diagram map of household knowledge level

3.2.5. **Household house ownership status.**

The house ownership status factor is data related to the percentage of the respondents’ house ownership status consisting of rent, private, and other (official, social or cultural houses)[27]. The diagram map of
the percentage of household house ownership status can be seen in Figure 5. It is known that private house ownership is the dominating house ownership in neighborhoods of the water and the land areas. Meanwhile, there is only one respondent in “the other (social house)” category house ownership status that is in neighborhood 32 of the water area.

3.2.6. Household willingness to pay operations.
The willingness to pay operations is the respondents’ perception data related to the respondents’ willingness to pay the cost of building an adequate black water domestic WWM facility at the respondents’ residence. Willingness to pay is categorical data consisting willing to pay and not willing to pay [28]. From the diagram map comparison of the percentage of willingness to pay operations, which can be seen in Figure 5, respondents from the administrative neighborhood of the land areas are dominated by a light blue diagram; this shows that respondents in these areas tend to choose to be willing to pay the operations of black water domestic WWM facilities. Meanwhile, respondents who tend to choose not to be willing to pay operations are dominated by a dark blue diagram, they are respondents who live in the administrative neighborhood above the water area.

![Figure 5. Comparison percentage diagram map of household house ownership status and willingness to pay operational facility](image)

3.2.7. Household ability to pay maintenance.
The ability to pay maintenance is a perception related to the ability of the respondent to pay the maintenance of black water domestic WWM facilities routinely. It can be in the form of desludging costs for the onsite system and maintenance costs in the form of retribution fees from WWTP for the offsite system. On the comparison diagram map of the percentage of the ability to pay maintenance in Figure 6, it can be seen that the yellow diagram dominates in the administrative neighborhood of the land areas; this indicates that respondents in these areas tend to answer that they are able to pay the maintenance of black water domestic WWM facilities. Meanwhile, respondents who answer that they are unable to pay maintenance (dominated by the dark blue diagram) are respondents who mostly reside in the administrative neighborhood above the water areas.

3.2.8. Ease of technology (operation and maintenance application).
Ease of technology is categorical data consisting of technology that is easy to apply and technology that is difficult to apply (difficult to find tools, high costs, and requires special maintenance). On the comparison diagram map of the percentage of technological ease on maintenance in Figure 6, it is known that there are quite a lot of Neighborhoods of the water area with a green diagram; this shows that most respondents answer that adequate technology of black water domestic wastewater management facilities is challenging in terms of supply (operational) and maintenance, above the water areas. The answer “difficult” is because the respondents are unable to repair the damaged pipe, the condition of the stolen pipe, or the use of a lot of water in the offsite system, while the opposite condition is occurring in the administrative neighborhood of the land area.
3.2.9. Household education level.

The household education level factor is the data on the last education level of the head of the family consisting of low education (not attending school, Elementary School, and Junior High School) and higher education (Senior High School and Tertiary Education) [29]. On Figure 6, it can be seen that respondents in the administrative neighborhood of the land areas are dominated by the gray diagram so that in this area, they tend to have a high level of education while in the administrative neighborhood above water areas, it is dominated by the yellow diagram (low education level).

![Figure 6. Comparison percentage diagram map of ability to pay maintenance facility, ease of technology, and household educational level](image)

3.3 Analysis Results

3.3.1 Analysis results of adequateness characteristics of black water domestic WWM In Margasari.

This analysis uses a comparative descriptive analysis method by comparing the conditions of black water domestic wastewater treatment in the respondents’ residence with indicators of adequate black water domestic wastewater treatment. Based on the results of the literature review, it is known that the provisions of adequate black water domestic WWM must meet all of the following variables:

a. None of the open defecation practice on the household [1, 21, 24]

b. Ownership of goose-neck type toilets (pour flush toilet) [22-23]

c. Having black water collection and treatment facility, a septic tank for the onsite system or connect with a good physical sewer pipe (without leak) condition for the offsite system [21-22]

After identifying the adequateness of black water domestic wastewater treatment at the residence of the sample household based on the provisions/indicators, then the calculation of the percentage of adequateness is carried out by comparing the number of households that have adequate facilities with the total sample. It is known that the overall adequateness level of black water domestic wastewater treatment in Margasari Village is 66.08%, where 228 household samples from a total of 345 respondents have adequate black water domestic wastewater treatment. The following is the data regarding the
percentage of respondents who meet the indicators of adequate and inadequate black water domestic wastewater treatment in each neighborhood:

![Figure 7. The Percentage Chart Of Adequate Black Water Domestic WWM User](image)

According to the diagram, it is known that 13 administrative neighborhoods that have a 100% adequateness level. On the other hand, three neighborhood areas that have the lowest adequateness level percentage of 0% or it can be stated that there are no respondents who have adequate black water WWM in those three neighborhoods. Based on Figure 7, the percentage of adequateness category is 80.01%-100% consisting of 15 administrative neighborhood areas, dominated by the East Area or administrative neighborhood of land areas. In the West Area or administrative neighborhoods of the water area, the percentage value of the adequateness level tends to the low. The lowest percentage category, namely the adequateness of 0%, is found in the water area consisting of administrative neighborhoods 11, 29, and 30. Thus, it can be concluded that respondents who live in the administrative neighborhood of the water area tend not to have adequate black water domestic WWM.

![Figure 8. The map of the percentage of users of adequate black water domestic wastewater management in each Neighborhood in Margasari Village](image)

3.3.2 Analysis results of Factors Influencing the Adequate Black Water Domestic WWM in Margasari. Data related to the percentage and number of users who have adequate and inadequate of black water domestic WWM will be input to the BRL analysis as the dependent variable, while the X variable or the factors that influence the adequateness level is the condition data of social, financing, and technology aspects. After inputting the response variable (Y) and the predictor variable (X) data in the SPSS 25.0
Statistics Software, then several tests that must be performed in the binary logistic regression analysis. The tests consist of:

**Table 2. Results of Binary Logistic Regression Analysis**

| Test                      | Conditions          | Analysis Results | Assumption                  | Remarks                                      |
|---------------------------|---------------------|------------------|-----------------------------|----------------------------------------------|
| Hosmer and Lemeshow       | p-value > 0.05      | 0.906            | Accepting $H_0$ and rejecting $H_1$ | The model fits the data                      |
| Omnibus                   | p-value < 0.05      | 0                | Rejecting $H_0$ and accepting $H_1$ | There is at least one independent variable which has a significant effect on the dependent variable |
| Wald                      | The factor has p-value < 0.05 | | Rejecting $H_0$ and accepting $H_1$ | There is an influence between each predictor variable on the dependent variable. Based on the Wald test results, it is known that there are four factors that have a $p$-value $<$0.05, encompassing Household Income, knowledge level, willingness to pay maintenance, and the ease of technology. |
| a. Sig. Intensity of direct experience in water pollution = 0.149 | | | | |
| b. Sig. Participation = 0.875 | | | | |
| c. Sig. Income = 0.005 | | | | |
| d. Sig. Knowledge Level = 0.001 | | | | |
| e. Sig. House Ownership = 0.985 | | | | |
| f. Sig. Willingness to Pay = 0 | | | | |
| g. Sig. Ability to Pay = 0.075 | | | | |
| h. Sig. Technological Ease = 0 | | | | |
| i. Sig. Education Level = 0.518 | | | | |

The following is the output used to interpret the effect of each predictor variables in binary logistic regression model for the adequateness of black water wastewater management:

**Tabel 3. Output Variable In The Equation**

| Factors                              | B   | S.E  | Wald  | df  | Sig.     | Exp (B) |
|--------------------------------------|-----|------|-------|-----|----------|---------|
| Household income (X3)                | 0.00| 0.00 | 1.00  | 1.00| 0.00     | 1.00    |
| Household knowledge level (X4)       | -2.94| 0.87 | 1.00  | 1.00| 0.00     | 0.05    |
| Household willingness to pay operation WWM (X6) | -4.78| 0.97 | 1.00  | 1.00| 0.00     | 0.01    |
| Ease of technology (X8)              | -4.09| 0.90 | 1.00  | 1.00| 0.00     | 0.02    |
| Constant                             | 10.52| 2.15 | 1.00  | 1.00| 0.00     | 37224   |

To Identify the effect of each predictor variables should use the odds ratio (Exp (B)). Here are the influences model based on the odds ratio the Exp (B) column:

a. Household Income
   The greater or the more increasing household income in Margasari Village, the greater the opportunity to have an adequate black water domestic wastewater management facility of 1 (one) time when compared to households with low income.

b. Household Knowledge Level
   Households with good knowledge level related to environmental pollution have a greater chance of having adequate black water domestic wastewater management by 0.05 times when compared to households with a poor knowledge.

c. Willingness to Pay
Households that are willing to pay operations for black water domestic WWM have a greater chance of having an adequate black water WWM facility of 0.01 times when compared to households that are not willing to pay operations for black water domestic WWM.

d. Ease of technology
Households that consider adequate black water domestic WWM to be easy in terms of use, operation, and maintenance have a greater chance of having an adequate black water domestic WWM facility by 0.02 times when compared to households that consider adequate black water domestic WWM is difficult in terms of use, operation, and maintenance.

4. Conclusions and Recommendations

4.1. Conclusions
It has been identified that the characteristics of black water WWM in Margasari Village have an adequateness level of 60.08%. Meanwhile, the inadequate black water domestic WWM is dominated by sample households in the administrative neighborhood of water area, even in this area, the lowest adequateness condition is found 0% in neighborhood 11, 29 and 30.

Factors that influence the adequateness of black water domestic WWM in Margasari Village are (1) household income factor, (2) household knowledge level related to environmental pollution, (3) household willingness to pay operations WWM and (4) ease of technology.

4.2 Recommendations
It is known that the administrative neighborhood of water area has a low percentage of adequateness for black water domestic WWM. This finding can be taken into consideration by the government of Balikpapan in the preparation of a sanitation program in Margasari Village by prioritizing to increase access to adequate sanitation and by improving the infrastructure of black water domestic WWM in the administrative neighborhoods of the water area.

The government of Balikpapan City needs to limit the construction of houses in the administrative neighborhood above water area because the quality and services of infrastructure, especially domestic WWM are still not optimal and still need improvement. The government needs to encourage socialization activities and educational campaigns related to environmental awareness and clean and healthy living behavior in residential communities above water area in Margasari Village. The socialization and campaign will improve the condition of the factors that influence the black water domestic WWM, namely the public knowledge level and the willingness to pay operations of adequate black water WWM.

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