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Pollution Valuation and Groundwater Preferences: Case Study of Kedungpalang and Sambigembol Lakardowo Village Jetis Sub District, Mojokerto District

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Pollution is a common negative externality in economic activity related to the environment and the use of natural resources. The purpose of this study is to estimate the economic value of total losses due to pollution of groundwater and determine the factors that affect the groundwater usage preferences. The calculation of the total economic value losses is using the replacement cost approach and the cost of illness. Factors that affect the preferences of households in the use of groundwater contaminated are estimated by multinomial logit. The use of groundwater includes cooking and drinking water. The data were collected from primary research that took place in the dusun (hamlets) of Kedungpalang and Sambigambol, Lakardowo village, Mojokerto regency. The estimation results indicated that household income and age of the respondents are proved to affect household preference to the use of contaminated groundwater. It means that the losses to be borne by local residents is more aggravate their weak economic situation as indicated by the significant household income in affecting the preferences of the use of groundwater that has been contaminated.

Key words: *The economic value of the total loss, Pollution of groundwater, Preferences, Replacement cost, Cost of illness, Multinomial log.*

Introduction

The environment has many roles in human life. However, the roles and value of environment have no agreed price market. Such conditions often make excessive use of natural resources and excessive environmentally harmful activities that become triggers to environmental damage. The decreasing quality or the destruction of an environment does not only affect one aspect of life but also, directly and indirectly, affect all aspects of life around the environment (Muryani, 2018). Environmental issues then become important in every decision to use the environment as input economic activity (Muryani, 2018).

Given the importance of the environment to economic activities, it will be crucial to know its monetary value. Through economic valuation, monetary values can be obtained and an overview of the net economic benefits as well as total environmental damage, in addition to the usual economic benefits and costs calculated conventionally. The monetary value obtained is useful for analysis of the condition of the environment.

The economic value of the overall functions and benefits of natural resources and the environment reflects the rationalisation for the management of natural resources and the right and shows that natural resources and the environment have economic value. Knowledge of the economic value of natural resources and the environment must be the basis of consideration for managing natural and environmental resources properly and wisely.

To assess how much influence the damage caused, then the valuation of economic value, environmental damage is needed as a reference in formulating policies in accordance with the circumstances of the situation. For this purpose, this study will calculate the losses of communities due to the contamination of underground water and identify the preferences factors of households who still consume contaminated underground water.

Literature Review

Underground Water Pollution

Pollution can be defined in different ways. According to the government of Indonesia (GOI, 2014), pollution is the entry or inclusion of living things, substances, energy, and/other components into the environment by human activities so as to exceed the established environmental quality standards. Pollution is considered as external cost caused by activity from one party resulting in loss of welfare to other parties, and loss of welfare is not compensated (Pearce and Turner, 1990). Pollution depends on two aspects: the physical (biological and chemical) impact of waste on the environment and human reactions to the impact, anxiety, unpleasantness, and distress indicated by loss of welfare.

Wardhana (1995) defines water pollution as a deviation from a normal state. In other words, groundwater contamination is a state of water that has been deviated from its normal state. The normal state of water still depends on the determinant factor, the water use itself and the origin of the water source. Water pollution happens because of the entry of waste and Hazardous and Toxic Substances into the water. Based on the government of Indonesia definition, Hazardous and Toxic Substances hereinafter abbreviated as B3 are substances, energies, and/or other components due to their nature, concentrations and/or quantities, either directly or indirectly, to pollute and/or damage the environment, and/or harm the environment life, health, and the survival of human beings and other living beings. Waste is the remainder of a business and/or activity (GOI, 2014).

When a negative externality occurs, the private cost or the cost calculated by the manufacturer to pay for all factors of production is too small because it does not take into account the costs of losses suffered by other parties or the public. They do not take into account the impact of waste disposal on production to the perceived environment of other people using groundwater (Mangkoesubroto, 2000). In this case, the company still has not external costs such as health costs and replacement costs of water needs borne by the community due to water that has been polluted.

Economic Valuation of Natural Resources and Environment

The Ministry of Environment (2007) defines the economic valuation of natural resources as an effort to impose monetary value on some or all of the potential of natural resources and environment, in accordance with the purpose of its utilisation. This is in the form of total economic value, the value of recovery of damage pollution, and the value of pollution prevention/damage. Askary (2001) mentions the economic valuation of environmental impacts as a process of quantifying and assigning economic valuations to environmental impacts in monetary form, after identification and impact screening.

Based on the Ministry of Environment (2007), an economic valuation will provide an overview of the economic value of an SDAL. This value reflects the rationalisation of the management of natural resources because natural resources have an economic value. Nevertheless, there are some monetary values that will not be realised because the amount is too large, especially if the functions and benefits of this SDAL disappear.

Economic Value of Total Environmental Damage

The Ministry of Environment (2007) describes the total economic value (NET) is the monetary value of natural resources and environment (SDAL) which is a proxy reflects the value of the functionality of natural resources in an ecosystem. Total economic value divided into two, value on the basis of use (use-value) and value on the basis of non-use (non-use value or passive value). In calculating the total damage to SDAL, there are various methods of valuation. The choice of method used can be determined by looking at impacts such as changes in productivity (quantitative change) or changes in environmental quality. The selection of methods for calculation is tailored to the functions and environmental benefits that are impaired.

Case Study: General Overview of the Case

East Java is one of the provinces in Indonesia where economic activity is very solid. This economic activity, besides giving positive impact, also causes a negative externality. Negative externality often arises the existence of environmental pollution around the economic activity. Rest or discharges from economic activity in the form of waste becomes an important issue. It is considered important because every year, B3 waste (Hazardous and Toxic Material) in East Java reaches 19.4 million tons or about 1.6 million tons per month (detikNews, 2016). The largest B3 waste supplier in East Java comes mainly from companies in industrial areas of Gresik, Surabaya, Sidoarjo, Pasuruan and Mojokerto. East Java itself has a B3 waste processing company located in Mojokerto Regency and the largest B3 waste management company in East Java.

In our study area, PT. Putra Restu Ibu Abadi (PRIA) was established in 2010 located in *Dusun* (Hamlets) *Kedungpalang*, *Desa Lakardowo*, *Kecamatan Jetis*, *Mojokerto Regency*. PT PRIA is a company engaged in transportation services, utilisation of B3 waste, and management of B3 waste. The PT PRIA engaged in utilisation of B3 waste as stipulated in the Government Regulation of the Republic of Indonesia Number. 18 Year 1999 Jo. 85 of 1999 on the Management of Hazardous and Toxic Waste, and Regulation of the Minister of Environment No. 02 of 2008, that the principle of activities includes reuse, recycle, and reduce.

Table 1. Results of Analysis of Well Water and Surface Water Quality in Lakardowo Village in June 2016

Result of Laboratory Analysis of Environment Agency of East Java

Parameter	Quality Standard of Drinking Water		Range of Water Quality Test Result Rona 2011	Range of Water Sample Quality Test Result in PT PRIA area by Laboratory Environment Agency of East Java	Range of Water Sample Quality Test Result in Resident Wells by Laboratory Environment Agency of East Java
	East Java Regulation No 2/2008	Regulation the minister of health No 492/2010			
Fecal coliform	100	0	21-150	<2-170	<2-170
TDS	1000	500	504-688	708-2997	510-2.712
Sulphate	400	250	64.2-154.9	144-955	73.26-1308
Mangan	0.1	0.4	<0.02	0.025-0.942	0.014-0.808
Zinc	0.05	3	<0.01-0.03	<0.016-0.390	<0.016-0.058
Kesadahan CaCO3	-	500	430.1-493.1	245-1568	199.1-1682
KMnO4	-	10	-	1-31.9	0.8-7.5
Result of Laboratory Analysis of PJT					
Parameter	Quality Standard of Drinking Water		Range of Water Quality Test Result Rona 2011	Range of Water Sample Quality Test Result in PT PRIA area by Laboratory PJT I	Range of Water Sample Quality Test Result in Resident Wells by Laboratory PJT I
	East Java Regulation No 2/2008	Regulation the minister of health No 492/2010			
Fecal coliform	100	0	21-150	<3-230	2-120
TDS	1000	500	504-688	580-2480	512-2680
Sulphate	400	250	64.2-154.9	127.2-858.2	49.93-708
Mangan	0.1	0.4	<0.02	Ttd-0.433	TTd
Zinc	0.05	3	<0.01-0.03	0.129-0.536	0.052-0.064
Iron	0.3	5000.3	<0.01	0.196-0.905	0.095-0.141
Baron	1	0.5	-	0.121-1.290	0.034-0.194
H2S	0.002	-	-	Ttd-0.032	Ttd-<0.013
COD	10	-	-	12.82-22.81	6.21-14.86

Based on the results of laboratory tests of BLH East Java (Table 1), the level of pollution exceeds the quality standard and is higher than the baseline data, especially in monitoring wells and surface water in the area of PT PRIA and some residents' wells have been polluted. The analysis results of water quality wells and surface water in Lakardowo Village by BLH (Environment Agency) East Java and PJT (Perum Jasa Tirta) get almost the same in which there are parameters that exceed the quality standard.

Data Source

This research was conducted in *Dusun Kedungpalang* and *Sambigembol*, *Desa Lakardowo* (Lakardowo Village)*, Kecamatan Jetis*, *Kabupaten Mojokerto*. Both *dusun* were chosen based on consideration of research results of Geophysics Engineering Research Team of ITS (2016) stating that Dusun Kedungpalang and Sambigembol are very susceptible to pollution impact. Dusun Kedungpalang and Sambigembol are each inhabited by 300 and 370 families, so the total population is equal to 670 KK. Based on the Slovin formula (Arikunto, 2011), this research estimated a sample of 87 respondents.

Data used in this study is primary data and secondary data. The primary data needed include household characteristics, the views of households on underground water pollution in their locations, the costs incurred to buy other water sources instead of polluted underground water, the medical expenses borne due to the impact of lower water pollution land and willingness to compensate. Secondary data in this study include data related to the results of testing underground water quality, population data and other data needed in this study. Secondary data was obtained from ECOTON, local government offices, the Central Bureau of Statistics, and agencies or institutions related to research.

Data collection was carried out by random sampling in each hamlet using survey techniques equipped with research questionnaires. The data obtained from the research questionnaire were then tabulated using Microsoft Excel 15. The tabulated data were then tested using Stata 13 using the multinomial logit method.

Model Analysis

Mathematical Model

Mathematical models were used to estimate the economic value of losses. The total economic loss value of environmental damage from contamination of underground water was calculated by summing up all in this case, the cost of buying refilled water and mineral water as a substitute for contaminated underground water, the cost of illness or medical cost suffered by the community and other costs associated with the effects of groundwater pollution. The model can be systematically written with the following equation:

NET = RC + CI

Definition of Variables

NET : Total Economic Value of Losses,
RC : Replacement Cost
CI : Cost of Illness

Statistical Model

The statistical model was used to estimate the probability of households who are consuming underground water. The statistical model used is random utility model (RUM). This model will be estimated using multinomial logit method which is an extension of logistic regression. The RUM model is a regression model with its dependent variable in the form of a qualitative variable. The use of multinomial logit method has more than two qualitative dependent variables and some independent variables. The model can be systematically written in the following equation:

PATi = β0 + β1Incomei + β2Agei + β3Deducationi + β4Distancei + β5Hhsizei + β6LStay + ei

Definition of variables

PATI : Probability of households who are still consuming contaminated underground water to meet their needs.
Income : Household income in one month
Age : Age of respondents
Deducation : The level of education of respondents
Distance : Distance from home to PT PRIA
Hhsize : Household size
LStay : The length of the household lives in the present location
Ei : error term

Research Method

This research uses deterministic quantitative and stochastic quantitative methods. Deterministic quantitative methods are used to calculate the economic value of total losses due to contamination of underground water. The stochastic quantitative approach is used by using a multinomial logit model. The type of data used in this study is primary data and secondary data. Primary data required include household characteristics, household views on contamination of underground water at their site of residence, the number of costs incurred to purchase other water sources in exchange for contaminated underground water, the cost of medical treatment underwent due to the impact of water pollution under land and willingness to receive compensation.

Analysis Technique

Based on the purpose of this study, there are two methods of analysis to be used. First, the analysis of the economic value of total losses was used to estimate the economic loss value of groundwater pollution. Second, to identify the determinants of household preferences still consume contaminated underground water, the multinomial logit method was used.

The logistics regression model in the form of opportunity with predictor variable identified as in the following equation:

$$Y_1 = \ln\left(\frac{P_r(Y=1\mid x)}{P_r(Y=0\mid x)}\right)\beta_0 + \beta_1 Income_i + \beta_2 Age_i + \beta_3 Deducation_i + \beta_4 Dis\tan ce_i + \beta_5 Hhsize_i + \beta_6 LStay_i + e_i$$

$$Y_2 = \ln\left(\frac{P_r(Y=2\mid x)}{P_r(Y=0\mid x)}\right)\beta_0 + \beta_1 Income_i + \beta_2 Age_i + \beta_3 Deducation_i + \beta_4 Dis\tan ce_i + \beta_5 Hhsize_i + \beta_6 LStay_i + e_i$$

Yi = 0: households that are not consuming contaminated underground water
Y_i = 1: households consuming contaminated underground water for cooking
Y_i = 2: households that still consume contaminated underground water for cooking and drinking water

Results and Discussion

Pollution of underground water that occurred in *Dusun Kedungpalang* and *Sambigembol* certainly give a negative impact on the surrounding community. Respondents who feel aware of pollution in their area have felt the impact of underground water pollution in their location. Respondents perceive two major impacts on their health and underground water. In this study, 72 respondents or 83% stated in the last year that their family members had suffered from itching pain that emerged after using their underground water for toilet wash (MCK) activity, while 15 respondents or 17% stated that their health was not affected.

The impact of water demand perceived by the household is the contamination of water physically, the taste and content of the substance become unclear when before there is contamination. In this study, 87 (100%) of respondents stated that they felt impacted on water requirements due to pollution of their underground water.

Based on our research, the existence of environmental pollution will undoubtedly bring up the right of compensation from PT PRIA. However, people of this village are not willing to accept compensation. The results show that 87 respondents or 100% of respondents are not willing to receive compensation. Those respondents are not willing to accept compensation because they prefer to have the environment in their village to be re-cleaned from underground water pollution.

After running regression using multinomial logit method, the equation of the use of underground water for cooking is as follows.

$$Y1=1.083566+-4.460000\mathit{Income}i+0.1177173\mathit{Age}i+0.2696086\mathit{Deducation}i+0.0122262\ \mathit{Distance}i+0.2894973\ \mathit{Hhsize}i+\ -0.0596492\ \mathit{LStay}+ei\text{ (cooking)}$$

The result of running multinomial logit shows that statistically significant variables affecting household preferences using underground water for cooking are household income and age of respondents. The coefficient value marked negative on income indicates that the lower the household income, the greater the probability of household using underground water for cooking. Coefficients marked positive on the age of respondents indicate that the greater or older age of the respondent, the greater the probability of household using underground water for cooking. In addition, the level of education, the distance the location of the house to the company, the size of the household and the length of the household living in the present location do not affect household preferences on the use of underground water for cooking.

Based on the results of running regression using multinomial logit method, the equation for the use of underground water for drinking water and cooking is as follows.

$$Y2=6.579395+-6.350000\mathit{Income}i+0.1466517\mathit{Age}i+-0.3096054\mathit{Deducation}i+0.0178084\ \mathit{Distance}i+\ -0.8456595\ \mathit{Hhsize}i+\ -0.0914552\ \mathit{LStay}\ +ei\text{ (drinking and cooking)}$$

The probability of respondent age is 0.047. Thus, Ho is rejected, or H1 is accepted at all levels of significance of 10%. Coefficients marked positive on the age of respondents indicate that the greater or older age of the respondents, the higher the probability of households using underground water for drinking water and cooking.

In addition, the level of education, the distance the location of the house to the company, the size of the household and the length of the household living in the present location do not affect household preferences on the use of underground water for cooking. The probability value of these variables is greater than 10%, which means Ho is accepted and H1 is rejected, either at the level of significance of 1%, 5%, or 10% so it can be concluded that the education level, the distance of the house location to the company, the size of the household and the length of the household stay at the location now do not significantly affect household preferences in the use of underground water for drinking and cooking water.

Based on the results of data processing, the likelihood probability value ratio is 0.000. Thus, Ho is rejected, or H1 is accepted at the level of significance of 1%. It can be concluded that household income, respondent age, respondent's education level, household distance to company, size of household, and length of households living in the area simultaneously affect household preferences in underground water use for all good consumption for cooking and drinking water and cooking. The pseudo R2 value is 0.4543, which means that 45% of the variations of the dependent variable can be explained by variations of the independent variables.

The results of this study are slightly different from those conducted by Rauf et al. (2015) regarding household preferences for water sources. This study aims to identify the determinants of the choice of drinking water supply by households in Pakistan's Punjab province. The data used are secondary data obtained from the 2010-2011 integrated household economic survey. The method used is multinomial logit. The categories of drinking water sources used are outdoor taps, hand pump taps, motor pumps, and other water sources. The result is the family size and the number of rooms in a dwelling has a strong effect on the choice of drinking water sources. The location of respondents (rural/urban) is very significant and has a positive effect on the choice of drinking water while the transportation mode has a significant negative effect with the choice of hand pumps and motor pumps.

Total Economic Value of Underground Water Pollution Losses

The result of the calculation of the average cost incurred by each household to purchase refill or mineral water as a substitute for contaminated underground water is Rp 49,356 per month. While the average cost incurred by the household for treatment is Rp 28,698 per month. In other words, the total economic value of losses to be borne by each household is Rp 78,054 per month. The estimated economic value of total losses to be borne by residents of Dusun Kedungpalang and Sambigembol is Rp 52,290,150 per month. This explanation can be seen in Table 2.

Table 2: Economic Value of Total Losses

External cost component	Average of external cost (Rp/KK/Month)	Population (KK)	Total of External Cost (Rp/Month)
Replacement cost	49,356	670	33,068,520
Medical expenses	28,689	670	19,221,630
Total			52,290,150

Source: Primary data, processed (2016)

Based on the results, residents have entirely refused compensation at any value on the grounds of wanting their environment back from pollution compared to the value of money in the form of compensation. It indicates that the value of the existence of the water under the clean (non-use value) is higher than the value of the use of the underground water (use-value) reflected in the economic value of total damage experienced by the local people.

Factors Affecting Household Preferences to Underground Water Usage

Based on the results of multinomial logit regression, household income proved to significantly affect household preferences on underground water use for consumption needs in the form of cooking and drinking water. The negative sign on the value of household income coefficients shows that the smaller the household income, the household is more likely to use underground water. These conditions indicate that the economic factors that make one of the reasons local citizens are forced to still use contaminated underground water to meet daily needs.

Furthermore, there is an interesting finding that age variables significantly influence household preferences in the use of underground water for cooking and drinking. The positive value of the coefficient of age indicates that older respondents are more likely to use underground water for cooking and drinking. This situation is quite interesting because, in general, mature people are more aware of their health. Respondents who were middle-aged and elderly when the study stated that they had been accustomed to direct underground water consumption since young so that even if their underground water had been contaminated, they still consume the underground water.

The total economic value of losses calculated using the replacement cost and medical cost approach indicates that the external cost or loss incurred by each household is Rp 78,054 per month or 4.3% of the average income household. The estimated economic value of total losses to be borne by residents of Dusun Kedungpalang and Sambigembol is Rp 52,290,150 per month.

Based on the results of the multinomial logit regression, simultaneous household income, respondent age, respondent's education level, distance of the location of residence with company, household size and length of stay at the present location proved to significantly affect household preference to the use of contaminated underground water for consumption needs of cooking and drinking water. Partially, only the household head and age responder's income variables have been shown to significantly influence the use of underground water for cooking and drinking.

The housing economics of the Kedungpalang and Sambigembol hamlets (dusun) that are classified as weak, indicated by the significant income to household preferences using contaminated underground water, are increasingly more concerning with the external costs or the average losses that households have to bear. External costs or losses are not likely to increase in line with the increasing levels of pollution if activities that cause pollution are not immediately dismissed or searched the best way out. The rejection of compensation at any value by all respondents on the grounds of wanting their environment back from pollution indicates that the value of the existence of the non-use water is greater than the value of the used water as reflected in the value the total economic damage that is borne by the locals.

Conclusion and Recommendation

The total economic value of losses calculated using the replacement cost and medical cost approach indicates that the external cost or loss incurred by each household is Rp 78,054 per month or 4.3% of the average income household. The estimated economic value of total losses to be borne by residents of *Kedungpalang* and *Sambigembol* Hamlet is Rp 52,290,150 per month. Based on the results of the multinomial logit regression, simultaneous household income, respondent age, respondent's education level, distance of the location of residence with company, household size and length of stay at the present location proved to significantly affect household preference to underground water usage that has been contaminated for consumption needs of cooking and drinking water. Partially, only the household head and age responder's income variables have been shown to significantly influence the use of underground water for cooking and drinking.

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