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Technology intervention to change the perception of acid mine drainage as energy

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Abstract

The purpose of this study is to build a model of social acceptance by technology intervention in acid mine drainage (AMD) treatment, by creating an electrification cell to process mine acid water into electrical energy. This research was done using a quantitative approach with exploring the perceptions of respondents from government, private, and community elements. As a result, the technology intervention has a significant change in the respondents' new perceptions of AMD. Technology interventions that process AMD into energy are able to change the perception of stakeholders about AMD. Besides, through technological interventions, AMD can meet future water needs too.

Keywords: Social acceptance, Technology intervention, Perception.

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Intervención tecnológica para cambiar la percepción del drenaje ácido de minas como energía

Resumen

El propósito de este estudio es construir un modelo de aceptación social mediante intervención tecnológica en el tratamiento de drenaje ácido de mina (AMD), mediante la creación de una celda de electrificación para procesar el agua ácida de la mina en energía eléctrica. Esta investigación utiliza un enfoque cuantitativo con la exploración de las percepciones de los encuestados de elementos gubernamentales, privados y comunitarios. Como resultado, la intervención tecnológica tiene un cambio significativo en las nuevas percepciones de los AMD sobre los encuestados. Las intervenciones tecnológicas que procesan AMD en energía pueden cambiar la percepción de los interesados sobre AMD. Además, a través de intervenciones tecnológicas, AMD también puede satisfacer las necesidades futuras de agua.

Palabras clave: Aceptación social, Intervención tecnológica, Percepción.

1. INTRODUCTION

Coal and mineral mining activities in Indonesia have become the leading industry sector which is the prime economic movers today. Most mining methods are open pit, due to the shallow deposit mineral and coal reserve characteristics. This method of mining always leaves ex-mining pits with high acidity puddles (pH values 1-5), was known as acid mine drainage or acid metalliferous drainage (AMD). Pit Lake in mining activities which entered the post-mining become acidic when potential acid-forming rock material not managed properly. It will hard to treat overcome because it requires a long time and large processing costs.

AMD water quality with high acidity characteristics has a hazard to health quality for fish, and the food chain involved. Therefore, the environmentalists make efforts to prevent, mitigate and treat AMD, and improve the quality of the water to be acceptable to the surrounding environment. The AMD treatment processing is high cost, so become reasons to avoid it for production efficiency. The fact that AMD impact raises negative perceptions of interests, and environmental NGOs, makes AMD as one of the main problems related to mining.

The issue of AMD has become a social issue for stakeholders, including concerns about the health impacts and negative public perceptions of AMD. This causes a negative public perception of the existence of a mine. Social issues regarding the existence of AMD in mining activities are influenced by the perceptions, knowledge and attitudes of stakeholders who manage the mining sector. Extractive industries such as mining are in direct contact with the public, therefore social acceptance is needed to ensure the operation runs optimally. At the moment social acceptance has a little trust to believe that the extractive industry can behave accordingly to the law.

2. METHODOLOGY

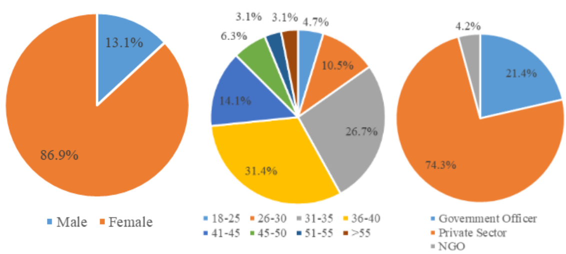
This research uses a mixed-method approach, move beyond the qualitative-quantitative division to take advantage of the strengths of qualitative and quantitative method. This research uses 16 questionnaires with 16 closed questions of Likert scale addressing indicators that are used to build social acceptance models with technology intervention. This research's location is in Kotamobagu, Manado City, and Bolaang Mongondow District, Province of Sulawesi Utara. Total of 265 respondents was chosen to meet a minimum of 10 respondents from 16 construct parameters, come from stakeholders who have concerns about AMD. This is based on an estimated maximum likelihood of 15 times the number of variables observed (SIMATE & NDLOVU, 2014).

The results and the validity of the questionnaire collection were then analysed using t-statistics. Furthermore, the model was built using SmartPLS 2.0® software. This software is equipped with a graphical user interface for variance-based structural equation modelling using the partial least squares path modelling method. Variables in PLS consist of endogenous and exogenous variables. Endogenous variables are variables whose variation is influenced by exogenous variables. Then create a social acceptance model using structural equation modelling (SEM) to test the causality relationship between variables, both latent variables and variables observed using SmartPLS 2.0®. This tool was chosen because it explores building models (MATHIESON, 1991).

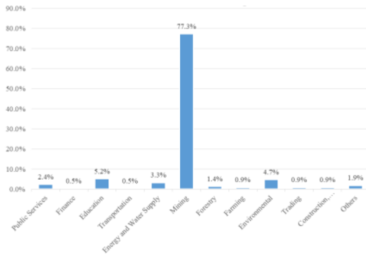
The social model that is developed is evaluated by the measurement model and the structural model evaluation. Evaluation of the measurement model is seen from validity and reliability. Validity test is seen from factor loading values more than 0.50 and Average Variance Extracted (AVE) above 0.50. Evaluation of reliability can be seen from the construct reliability of more than 0.70. Evaluation of the structural model is seen from the statistical t value. If the value of t-statistics is more than 1.96, then there is a significant effect (ZHANG, ZHOU, LIU, LIU, FUNG & LIN, 2018).

3. RESULTS AND DISCUSSION

Respondents in this research are stakeholders consisting of elements of a government officer, non-government organizations, and mining workers from the private sector. The distribution of respondents describing gender, age, occupation and occupation sector is presented in Figure 1. The selection of respondents focuses on respondents who have daily activities close to mining activities and knows about pit lake and acid mine drainage.



a.Gender b. Age (years old) c. Occupation



d. Occupation sector

Fig. 1: Respondent characteristic by gender, age, occupation and its sector

This research focus on stakeholders has been aware of the AMD issue. Before doing this, we conduct preliminary research through online social media Twitter, with the question have you ever visited a pit lake (CAMPILLO, DAHLQUIST, DANILOV, GHAVIHA, NOTTEN & ZIMMERMAN, 2017). The purpose of this preliminary research is to explore public concerns on AMD and pit lakes in the mining industry. This poll reached 13,723 people saw this tweet on Twitter®, unfortunately, those who responded to the poll were only 3,452 accounts, and it means respondents. Amount of 88.9% of respondents had never visited a pit lake, and only 11.1% had ever gone to a pit lake. This shows an indication of people who understand the real AMD issue, no more than 10% (OTHMAN, SULAIMAN & SULAIMAN, 2017).).

The variables in this research are Technology Intervention (IT) and New Perception (NP), Old Perception (OP), response to AMD (RTA), Accessibility (ACS), Knowledge (KNW), and Response (RP) variables. OP is influenced by cognitive, unconscious, and attribution.

The cognitive that shapes perceptions are influenced by behaviour as measured by questions about the use of AMD and pit lakes for communities around the mine, and responses about the use of AMD and pit lakes. Stakeholder perspectives that are influenced by experience and knowledge are measured using AMD hazard questions, and AMD processing technology (MORGAN, 2012).

Whereas respondents' experiences were measured by the accessibility of clean water, washing and cooking. The accessibility of respondents gives an effect on the unconscious which will shape the perception of responses to the surrounding events. Measurement of AAT perception in pit lake for respondents consisting of government officials, non-government officials, and mining workers. This research has 6 hypotheses which are explained in Table 1 below. The structural model in this research connects the research hypothesis which influenced several exogenous variables OP, RTA, ACS, KNW and RP to endogenous variables IT, NP.

Table 1: Research hypothesis and validation by t statistics

Hypothesis	Statement	Path Coefficient	Standard Error	T Statistics	Remark
H_1	OP positively effect on TI	0.247	0.050	4.927**	Hypothesis Accepted
H_2	RTA positively effect on TI	0.522	0.063	8.301**	Hypothesis Accepted
H_3	TI positively	0.643	0.042	15.475**	Hypothesis Accepted

	effect on NP				
H_4	ACS positively effect on OP	0.165	0.068	2.445**	Hypothesis Accepted
H_5	KNW positively effect on OP	0.526	0.027	19.178**	Hypothesis Accepted
H_6	RP positively effect on OP	0.568	0.036	15.978**	Hypothesis Accepted

T-statistics on OP, RTA, TI, ACS, KNW, and RP variables have a significant positive effect on each influenced variable with loading factors of more than 0.50 and T-static more than 1.96. Therefore, the hypothesis of this research can be accepted statistically. The results in Table 1 show that technology intervention (TI) is influenced by old perception. Technology intervention in AMD treatment is also influenced by responding to AMD. Referred to as respond to AMD is the respondent's response to the choice of technology to manage AMD in a former mine pit. The questions used to measure the respondent's response to the existence of AMD are the choice of technology to make AMD as energy, the former mining pit as a tourist destination and the mining pit as a centre for power generation.

Table 2: Reliability test by AVE, Composite, R square and Cronbachs Alpha

Variable	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
Accessibility	0.5211	0.7410	0.0000	0.6798	0.5211	0.0000
Knowledge	0.5275	0.7674	0.0000	0.5488	0.5275	0.0000
New perception	0.8091	0.9271	0.4140	0.8825	0.8091	0.3286
Old perception	0.3120	0.7302	0.9995	0.6509	0.3120	0.0276
Response	0.7927	0.8843	0.0000	0.7411	0.7927	0.0000
Response to AMD	0.7347	0.8921	0.0000	0.8171	0.7347	0.0000
Technology intervention	0.9107	0.9533	0.4911	0.9022	0.9107	0.1985

The results of the validity and reliability evaluation above show that the overall validity level of the instrument is indicated by the factor loading values above 0.50 and AVE above 0.50. The level of reliability shown by construct reliability is also above 0.70 (reliable), despite the old perception AVE is less than 0.5. However, the level of reliability of the indicator in measuring the variables shown in the composite reliability value is more than 0.70. This shows that the indicators used to measure all variables are reliable.

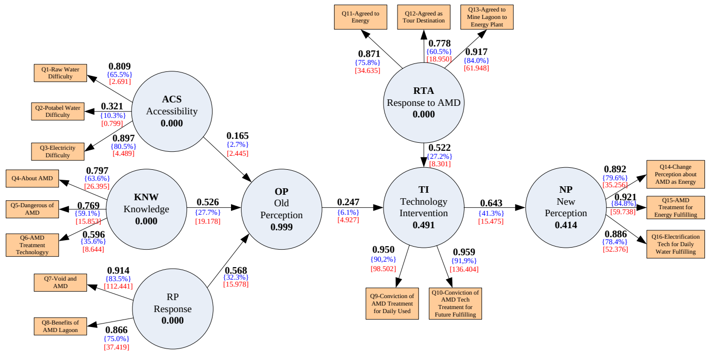


Fig. 2: Path coefficients, the influence of indicator and value of t statistics for social acceptance model through technology intervention to change new perception in AMD

Figure 2 shows that the ACS, KNW and RP variables together affect OP by 99%, which very likely to influence OP. TI against NP is 41.4% (0.414) while the remaining 58.6% is influenced by other variables, which are not included in this model. The influence of RTA and OP variables on IT was 49.11%. RTA has a greater influence compared to the effect of OP as indicated by the path coefficient from RTA to TI (0.522) bigger than OP to TI (0.247).

Alpha Cronbach coefficient shows the instrument reliability test, where the NP, RP, RTA and IT variables are more than 0.7, its means that sufficient reliability. ACS, KNW and RP variables influence OP statistically. The influence of RP (0.568) and KNW (0.526) has a higher path coefficient compared to ACS (0.165). This shows that the accessibility respondent measured from raw water difficulty, potable water difficulty, and electricity difficulty does not significantly influence Old perception about AMD as hazardous waste in the mining industry. Respondent knowledge and response about AMD is more influential on old perception. This supports the theory, that perception is more influenced by knowledge, skill, attitude which then forms convince (11,15,16).

Cronbach's Alpha value in Table 2 reinforces the reliability of the variables measured in this study. The seven construct variables measured have values above 0.5 which indicate that all construct variables measured with latent variables were acceptable. However, there are other indicators not measured in this study besides AMD knowledge, AMD hazards and AMD processing technology, so Knowledge as a constructed variable affecting old perception (OP) is 0.5488.

Table 3: T statistic for instruments and indicators

Instruments	Indicators	Loading Factor	Standard Error	T statistic
Q_1 How does your level of difficulty in reaching clean water, washing, for cooking	ACS	0.809	0.301	2.691
Q_2 How does your level of difficulty in obtaining drinking water	ACS	0.321	0.402	0.799
Q_3 How does your level of difficulty in obtaining electricity	ACS	0.897	0.200	4.489
Q_4 Do you know about acid mine drainage/ acid rock drainage?	KNW	0.797	0.030	26.395
Q_5 What is the danger of acid mine drainage in your opinion?	KNW	0.769	0.049	15.853
Q_6 What do you know	KNW	0.596	0.069	8.644

about mine acid water treatment technology?				
Q_7 Are acid mine drainage and pit lakes pits useful for us/the community around the mine?	RP	0.914	0.008	112.441
Q_8 Do you believe that pit lakes with acid mine drainage can be utilized for our lives?	RP	0.866	0.023	37.419
Q_9 Are you sure you if the former mine acid water that has been processed can be used for drinking, bathing, washing and other daily needs?	TI	0.950	0.010	98.502
Q_{10} Are you sure with the technology of post mine acid water treatment, will be able to be a source of water to meet future water needs?	TI	0.959	0.007	136.404
Q_{11} Would you agree if the acid mine drainage in a mine pit is used as an energy source?	RTA	0.871	0.025	34.635
Q_{12} Do you agree if the pit lakes pit is managed to become a water tourism destination?	RTA	0.778	0.041	18.950
Q_{13} You agree when pits are managed as a source of generation of energy?	RTA	0.917	0.015	61.948
Q_{14} If acid mine drainage can be processed into electrical energy, then I change my opinion, that mine acid water can be a useful source of energy for my life	NP	0.892	0.025	35.256

Q_{15} Processing acid mine drainage into electricity can help us fulfilling electricity	NP	0.921	0.015	59.738
Q_{16} If acid mine drainage using electrification cells can separate dissolved heavy metals, then water can be utilized for our lives.	NP	0.886	0.017	52.378

The indicators used to measure ACS, KNW and RP variables have a t value of statistics more than 1.96, except for Q_2 where it is less than 1.96. This means that all indicators have significantly affected ACS, KNW, and RP variables. Loading factor Q_3 is 0.897, meaning that access to electricity has an effect of 80.5% (0.897^2 x 100%) on the access they involved. The level of difficulty with drinking water is not significant. Respondents felt that getting potable water did not affect accessibility. Knowledge (KNW) was measured using 3 indicators namely knowledge about AMD (Q_4), dangerous of AMD (Q_5), and knowledge of AMD processing technology (Q_6). Knowledge of AMD treatment technology has an influence of 35.6% (0.596^2 x 100%), not significant, where t statistic is 8.644 more than 1.96.

TI describes the use of AMD treatment technology for drinking, bathing, washing and other water needs in the future. The model in Figure 2 shows that 90.2% of respondents believe that AMD's intervention technology can be used for drinking water, bathrooms, washing and other needs. AMD processing technology interventions can form a new perception of 91.9% to meet water needs in the future. New perceptions regarding changes in respondents' perceptions of AMD can be utilized. The change in perception is influenced by the Q_{14} indicator of 79.6% (0.892^2 x 100%). Indicator Q_{15} affects new perception by 84.8% (0.921^2 x 100%). While the influence of the indicator Q_{16} was 78.4% (0.885^2 x 100%).

The number in the middle of the circle KNW, RP, OP, TI, RTA, NP in Figure 2 is the value of R square, which illustrates how much the ability of the independent variable to explain the dependent variable. The ACS, KNW, RP, and RTA constructs do not have R Square because they are not predicted by other constructs. OP has an R Square of 0.999, which means that the OP can explain variations of TI by 99.1%, with the remaining 0.9% explained by factors other than OP. Likewise, TI has an R Square of 0.491, meaning that OP and RTA can explain the NP variance of 41.4%, while the remaining 58.6% is explained by other factors. Whereas NP can be explained by IT by 41.4% and the rest which have 58.6% is explained by other factors were not carried out in this study. For example, respondents' field trip at AMD pit lake locations in the former mine pits that had been constructed by AMD-based power plants. Respondents who see clearly with a field visit can be explored memory, creativity, consciousness, love, anxiety, and addictions.

Structural models that show the relationship between OP with ACS, KNW and RP can be seen in equation (1), the relationship between TI with OP and RTA can be seen in equation (2), and the relationship between NP and TI can be seen in equation (3).

$$OP = \gamma_1 * ACS + \gamma_2 * KNW + \gamma_3 * RP + \zeta_1$$

$$TI = \beta_1 * OP + \gamma_4 * RTA + \zeta_2 \text{ (2)}$$

$$NP = \beta_2 * TI + \zeta_3$$

Equation (1) explains that old perception (OP) of pit lake and acid mine drainage is influenced by knowledge, accessibility, response and other factors. Equation (2) explains that technology intervention is influenced by old perception, response to AMD and other factors (□□□ which were not included in this research. Equation (3) explains that the new perception of AMD can be influenced by technology interventions and other factors.

The measurement model for the relationship between variables and indicators from Figure 1 shows that exogenous factors indicated the reflective to the construct of ACS, KNW and RP. ACS measurement model (equation 4), KNW measurement model (equation 5), RP measurement model (equation 6), RTA measurement model (equation 7), TI measurement model (equation 8), and NP measurement model (equation 9) as follows:

$$ACS = \gamma_{11} Q_1 + \gamma_{12} Q_2 + \gamma_{13} Q_3 + \varepsilon_1$$

$$KNW = \gamma_{21} Q_4 + \gamma_{22} Q_5 + \gamma_{23} Q_6 + \varepsilon_2$$

$$RP = \gamma_{31} Q_7 + \gamma_{32} Q_8 + \varepsilon_3$$

$$RTA = \gamma_{41} * Q_{11} + \gamma_{42} * Q_{12} + \gamma_{43} * Q_{13} + \varepsilon_4$$

$$TI = \gamma_{51} * Q_9 + \gamma_{52} * Q_{10} + \varepsilon_5$$

$$NP = \gamma 61 * Q_{14} + \gamma 62 * Q_{15} + \gamma 63 * Q_{16} + \varepsilon 6$$

Equation (4) explains that Accessibility affecting Old Perception about AMD in mining activities which are measured using Q_1, Q_2, Q_3 and other factors (□□□ which were not included in this research. Equation (5) explains that respondent knowledge about AMD is measured by questions Q_4, Q_5, Q_6, and other factors (□$_{□}$□ which were not included in this research. Meanwhile, equation (6) explains that responses affecting old perception about AMD are measured using questions Q_7, Q_8 and other factors (□$_{□}$□ which were not included in this research. Response as an exogenous variable is the translation of behaviour which is one aspect of forming perceptions according to Tuan (1977).

4. CONCLUSION

The old perception of AMD in the Pit Lake and impact of mining activity others are strongly influenced by the difficulty of accessibility to raw water and electricity, even though the knowledge and response are higher than accessibility. Respondents knew that AMD is dangerous but they believe that AMD treatment technology can be utilized to meet the human needs. The highest factor in changing new perceptions about AMD is the respondent's knowledge related to AMD, the dangers of AMD and AMD treatment technology.

The model developed in this study shows technology interventions that process AMD into energy can change the perception of stakeholders about AMD. Through technological interventions, AMD can meet future water needs too. However, this study needs to be continued to find the rest of the variables that are not measured in this study.

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