International Journal of GEOMATE, July, 2018 Vol.15, Issue 47, pp.170-177
Geotec., Const. Mat. & Env., DOI: https://doi.org/10.21660/2018.47.73578
ISSN: 2186-2982 (Print), 2186-2990 (Online), Japan

# STAKEHOLDER INTERACTIONS MODEL OF GROUNDWATER MANAGEMENT IN SEMARANG CITY/INDONESIA

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**ABSTRACT:** This research aims at developing a stakeholder interactions model in the context of groundwater management in Semarang City. The data in this research was gathered through an in-depth interview with related stakeholders, such as the Regional Office of Energy and Mineral Resources in Central Java Province (ESDM), Industrial Estate Developer and Societies in Semarang City. Stakeholder linkage analysis is conducted using Role and Responsibility Charting (RACI) method to see the balance of responsibilities and the role of stakeholders. The number of respondents in this research is 27 respondents who are divided proportionally based on groundwater vulnerability classification (high, medium, low). The result of this research shows that there are five groundwater management activities involving the Regional Office of Energy and Mineral Resources, Industrial Estate Developer, and Societies, such as supervision and evaluation, legalization, guidance, conflict mediation and reporting.

*Keyword: Interaction model, Perception, Groundwater management, Stakeholder*

## 1. INTRODUCTION

Groundwater is one of the natural resources that play an essential role in the fulfillment of clean water needs. Given the fundamental role of groundwater, then its management should be aimed at sustainable systems, and groundwater use should be environmentally insightful. The rapid development of Semarang City is driven by the strategic location of Semarang City causing the population growth from 1.56 million in 2012 to 1.58 million in 2014 [1]. Similarly, the population density increased from 4,1472 per km2 in 2012 to 4,241 per km2 in 2014. Also, Semarang City also has some medium to a large number of industries ranged from 300-325 industries in 2012 and 2013. The increasing population and industry turns out to have significant environmental impacts, especially on the use of groundwater through deep wells or boreholes as a source of water supply

The number of boreholes which extracts groundwater in aquifers has rapidly increased since the 1980s ranged from around 400 wells to more than 1,600 wells in the 2000s and the volume of groundwater extraction has also risen from 10 to 60 million $m^3$. The excessive use of groundwater causes groundwater levels in some monitoring wells decreased up to 20 m below sea level. The abundant use of groundwater through artesian wells is due to the ability of the local water board (PDAM) of Semarang City is only serving the needs of the water source to the community less than 57% [2]. The increasing number of wells and volume of groundwater extraction will have a negative impact on the environment such as decrease of groundwater level, subsidence, seawater intrusion, a decrease of groundwater quality and flood.

From the aspect of population, zones and industrial areas can also reduce the flow of urbanization, especially for areas or industrial zones located in the suburbs. Communities from the periphery do not have to go to the city as a place to look for work, but just into zones or industrial areas that provide enough job opportunities. However, from the perspective of society around the industry, in addition to various positive impacts or advantages, zones and industrial estates also cause various negative impacts or losses, related to environmental aspects. Some adverse impacts on environmental balance are including polluted waste and environmental damage due to the activities of various types of factories in industrial zones. Various cases have emerged related to the impact of industrialization on the presence of water. For example, water pollution at Tapak River in Tugu Semarang industrial area due to waste disposal in Tugu region. Moreover, six industries which are located in Genuk Industrial Estate dumped its waste into Babon River which causing pollution of the river ponds and environmental damage in Sriwulan Village. Indeed, air pollution which was caused by steel mills in Jrakah Semarang, and drought of spring and lowering groundwater level due to groundwater exploitation in recharge area in Tambakaji [3]. Other problems arising of groundwater management is related to the miscommunication among its stakeholders have also been investigated by Ratnawati [4], Putranto et al. [5][6], and Susanto et

al. [7]. Also, as stated by the study of Karjaleinen et al. [8], public awareness related to groundwater pollution and ecosystem problems are still very low. It is allegedly also related to the demographic and social background of the community. From the government side, mapping the functional aspect of the related agencies also needs to be done to see the role and responsibility of the instances to the management of groundwater. The industry is the other side of groundwater stakeholders associated with this groundwater management. Therefore, the perceptions of related industry need to be explored.

From the various problems that arise due to inappropriate use and management of groundwater, it is necessary to conduct research related to the role of stakeholders in this field and formulate the problems appropriately to get the solution. Several previous studies have addressed stakeholders related to groundwater management in different countries using various approaches such as MCDA (Multi-criteria Decision Analysis), and participatory [8,9,10] Integrated stakeholder analysis can also help solve social, economic, technical, environmental, management and prevention of potential conflicts [11]. This study aims to formulate a model of stakeholder interaction related to groundwater management in Semarang City and map it by using RACI, formulating real problems in groundwater-related communities and designing solution recommendations for each problem. RACI is chosen because this method is simple but can help the process of data retrieval systematically in the form of an easy to understand matrix. RACI is also used in ambiguous situations and requires cross-functional analysis of stakeholder responsibilities and roles.

## 2. LITERATURE REVIEW

### 2.1 Groundwater Management

Groundwater management is not only an effort to manage aquifer resources but also to manage people who use it. For groundwater management in the framework of sustainable groundwater use, there are four critical technical components to be considered [12]:

1. Resource Evaluation: Evaluate the potential of groundwater resources
2. Resource Allocation: Appropriate allocation of groundwater resources
3. Hazard and Risk Assessment: Study of hazards and risks of groundwater use and groundwater contamination
4. Side Effect and Pollution Control

The first and second components of Resource Evaluation and Resource Allocation are obtained by evaluating the potential of groundwater resources, the evaluation of groundwater utilization and groundwater conservation zones. The third component of hazard and risk assessment is obtained by evaluating the potential for groundwater susceptibility to the adverse effects of pumping and groundwater contamination. The fourth component of knowing the negative impacts of groundwater extraction and groundwater contamination can be identified through groundwater monitoring activities

In the groundwater resource management cycle, the groundwater monitoring aims to collect data and facts that will be the source of input for groundwater resource management actions. This data can be utilized as an input in groundwater resource management if the data is evaluated and interpreted. Figure 1 shows clearly that one of the main activities in the groundwater monitoring process is the plan monitoring network. Monitored well network planning should be based on two primary objectives of groundwater monitoring:

1. Monitoring impacts of groundwater extraction
2. Monitor changes in groundwater quality

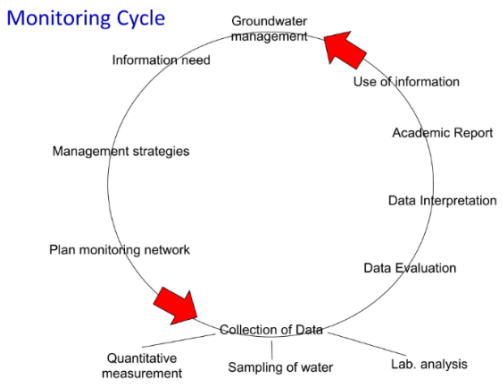


Fig. 1 Monitoring activity cycle of groundwater resource management [12]

### 2.2 Role and Responsibility Charting (RACI)

Role and Responsibility Charting (RACI) or matrix of assignment of responsibilities is a matrix that describes the role of various parties in the completion of a job in a project or business process [13]. This matrix is particularly useful in explaining the roles and responsibilities between departments within a project or process. RACI stands for Responsibility, Accountable, Consulted, and Informed. Responsibility is the person who has to do the task until it is done. Accountable is the person who is able to make the direction and authority of an activity. Consulted is usually a person who has the expertise to be asked a suggestion to determine the final decision or action. Informed is the person who needs to be informed about the decision or action that has been done.

There are five processes on how to implement RACI formation. First, describe every activity that happened. Second, make a phrase to show the result

of the decision made. Third, decisions and activities need to be applied to role functions rather than targeting individuals. Lastly, create a matrix representing roles and activities and enter each letter R / A / C / I. Once all the relevant data has been compiled and entered into the matrix, any existing differences need to be solved.

When implemented correctly in an Organization, RACI Chart will be able to: (1) identify the workload that has been provided to certain employees or departments, (2) ensure that a process is not missed, (3), ensure new employees are explained about their roles and responsibilities (4) find balances between the lines and responsibilities of a project, (5) redistribute intergroup work to complete work faster, (6) resolve conflicts, (7) document the roles and responsibilities of people within the organization [14].

## 3. RESEARCH METHODOLOGY

Research begins with stakeholder identification, stakeholder analysis and role, modeling of interaction among stakeholders, identification of problem statement related to groundwater management, and ending with interaction model analysis.

The first stage is the determination of stakeholders involved in groundwater management. This stage aims to identify the parties involved in groundwater management. The technique used in identifying stakeholders is by conducting in-depth interviews with the Regional Office of Energy and Mineral Resources of Central Java Province. After getting stakeholder and its function, then research continued with making model of interaction based on the result of the interview which has been done.

The second stage aims at obtaining the role and responsibility function of the parties that have been established. The tool used in this stage is using Role and Responsibility Chart Index. The data used to analyze that is obtained by using the interview to the Regional Office of Energy and Mineral Resources (ESDM) in Central Java Province.

The third stage aims to identify the existing problems related to the interaction between stakeholders in groundwater management. The problem statement was obtained by conducting interviews with the relevant parties. A total of 27 respondents involved in this data collection include community members (23 people) and industrial managers (4 persons). It is sufficient and represents the research population because the research area is focused on the lowland areas of Semarang with varying levels of vulnerability. Selection of respondent location is adjusted to groundwater vulnerability zone to contamination that has been done before. This area of research can be seen in Figure 2. The characteristic of the respondents can be seen in Table 1.

Table 1. Respondent characteristic

| Variables | | Data |
|---|---|---|
| Age (years old) | | 41±8 |
| Education background | Junior high school | 1 |
| | High School | 11 |
| | Diploma/bachelor degree | 13 |
| | Master | 2 |
| Job | Entrepreneur | 6 |
| | Housewife | 8 |
| | Employee | 12 |
| | Student | 1 |
| Gender | Male | 15 |
| | Female | 11 |

## 4. DATA COLLECTION AND ANALYSIS

### 4.1 Stakeholder Analysis

In groundwater management indeed involves many parties. The following are the parties involved in groundwater management based on interviews and literature studies.

1. The Regional Office of Energy and Mineral Resources (ESDM) in Central Java Province is one of the government agencies that specifically handles issues related to energy and mineral resources by laws and regulations. The Office of Energy and Mineral Resources has the following functions:
   a. Formulate work programs in the field of energy and mineral resources.
   b. Formulate policies in the field of energy and mineral resources.
   c. Implement policies in the field of energy and mineral resources.
   d. Government affairs in the field of energy and mineral resources by legislation.
   e. Implementation of evaluation and reporting in the field of energy and mineral resources.
   f. Implementation of the administration of energy and mineral resources.
   g. Implementation of other functions and tasks of assistance provided by the Governor in the field of energy and mineral resources by the laws and regulations.

   Division in the Regional Office of Energy and Mineral Resources related to groundwater management is Geological and Groundwater Division. This division has functioned as a constituent of technical policy, norms, standards, procedures, criteria, plans, programs, evaluation, reporting, provision of technical recommendations for conservation areas, and implementation of mapping, research, investigation, engineering, modeling, and

technical guidance on inventory and groundwater conservation.

2. Industrial Area Manager

Industrial Estate is an area where centralization of industrial activities equipped with supporting facilities and infrastructure developed and managed by Industrial Zone Company. Industrial Estate in Semarang currently tends to choose to use groundwater, because the Local Water Board (PDAM) is unable to fulfill industrial demand. Also, the industrial sites that coincide above the groundwater basin become the impetus for them to exploit their potential. Besides the cheaper cost, the continuity is more assured. However, industrial areas also need to obtain permits, such as the use of artist and drilling wells. Therefore, the industry besides acting as a water user, but also has a role in meeting the conservation of water utilization

3. Society

As an effort to provide clean water sufficiency, the government has given authority and responsibility to the Local Water Company, but in fact, it has not been able to fulfill adequately until now. This situation encourages people to use groundwater to meet the needs of clean water as support for daily activities. Therefore, the community acts as a groundwater users, but there are also some permits that need to involve communities related to land use by the industry.

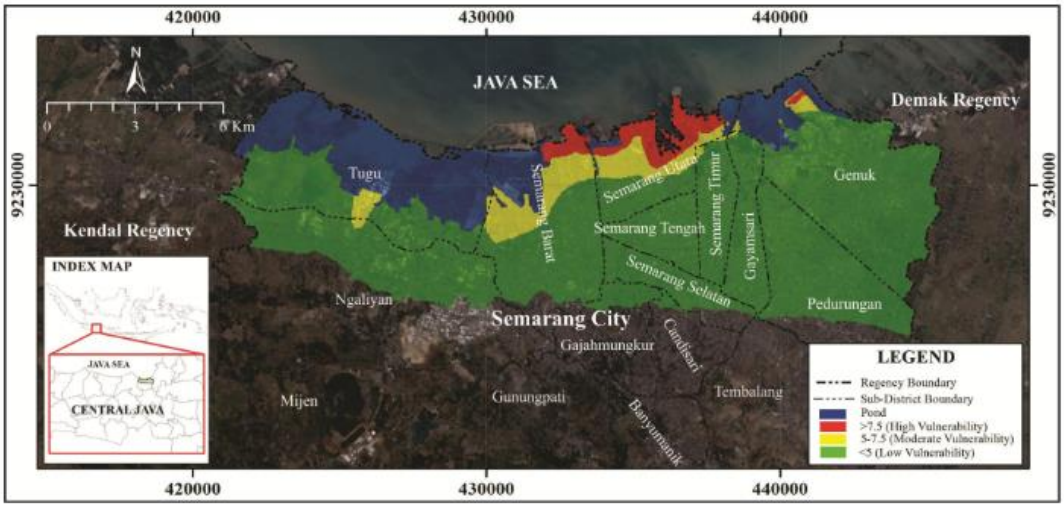


Fig. 2 Areas of research and classification of vulnerabilities

Figure 3 shows a model of interaction between stakeholders related to groundwater management.

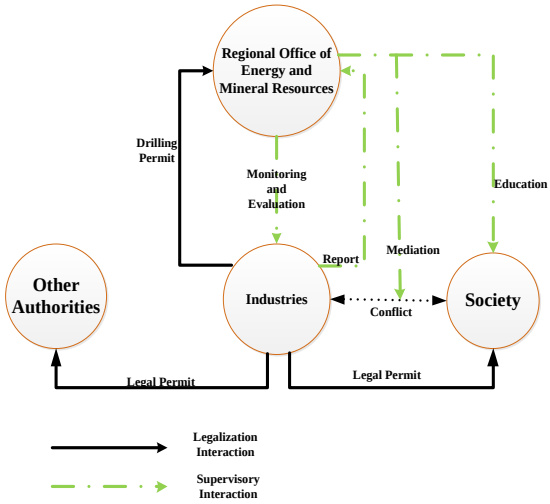


Fig. 3 Model of Groundwater Management Stakeholder Interaction

## 4.2 RACI Chart Analysis

The following is the RACI Chart to identify roles and responsibilities of stakeholders as shown in Table 2.

*4.2.1 Vertical Analysis*

- The Regional Office of Energy and Mineral Resources (ESDM) in Central Java Province
  The Regional Office of Energy and Mineral Resources as a representation of the government certainly has a role that needs to be involved in all groundwater use activities, such as monitoring and evaluation, licensing, guidance, conflict mediation, and reporting. However, in addition to being responsible for such activities, it may also provide technical recommendations related to the processing of permits submitted by the Industry.
- Industry
  Industries as groundwater users are also required to carry out activities, such as licensing, conflict mediation, and periodic reporting to The Regional Office of Energy and Mineral Resources. Also, the industry also has a role to

socialize with the surrounding community regarding the use of groundwater.

- Society
  Society has the right to obtain information related to the exploration, drilling, and use of groundwater around their area. The obligation of the community that is in addition to maintaining the utilization of groundwater well also must conduct reporting related problems of groundwater management by the surrounding industry or the community itself.

Table 2. Role and Responsibility Chart

| Decisions/Activities | | Industries | Society | DEMR |
|---|---|---|---|---|
| Monitoring and Evaluation | | I | I | R |
| Permissions | Groundwater Exploration | R | I | A/C |
| | Groundwater Drilling | R | I | A/C |
| | Groundwater Use | R | I | A/C |
| Community Development | | A | - | R |
| Conflict Mediation | | R | R | A |
| Reporting | | R | A/I | I |

*4.2.2 Horizontal Analysis*

- Permissions
  Figure 4 shows the flowchart of liability in the conduct of permission.

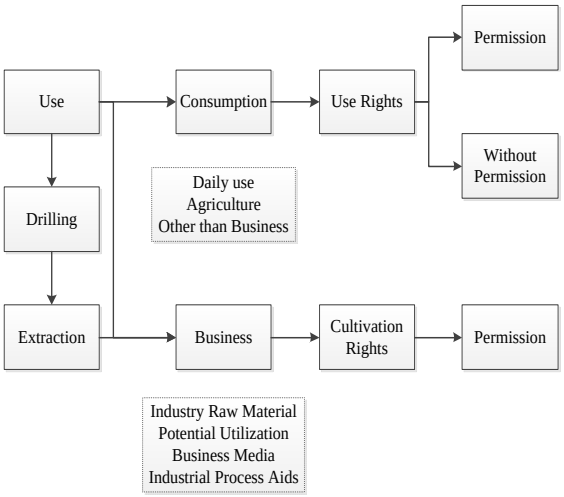


Fig. 4 Flow Chart of Water Usage [15]

In addition to licensing, in Figure 4 there are also several other types of permits, namely: groundwater exploration permits, drilling/excavation, operation/ utilization of groundwater. The parties involved in this activity are the industry as the user must take care of the licensing to the Regional Office of Energy Resources and Minerals and also need to get permission from the surrounding community related to groundwater utilization activities.

- Coaching
  This activity is a proactive activity of the Regional Office of Energy and Mineral Resources with the aim of educating the public about groundwater management. The community is expected to conserve the utilization of groundwater as well as to maintain the sustainability of groundwater. The industrial area can also play a role in these activities by regularly build a community around.
- Conflict Mediation
  Groundwater management has several conflicting issues, such as excessive groundwater abstraction, groundwater abstraction invulnerable and critical zones, unauthorized groundwater abstraction, drilling regardless of technical and environmental requirements, groundwater contamination causing degradation of water quality. As a reactive effort related to the conflict, the Regional Office of Energy and Mineral Resources must be a mediator between industry and society related to the occurred problems.
- Reporting
  An industrial activity shall report to the Regional Office of Energy and Mineral Resources on a regular basis relating to monitoring and discharge of groundwater used. This reporting can help the Regional Office of Energy and Mineral Resources to monitor the condition of groundwater used.

### 4.3 Problem Analysis

Interviews were conducted with stakeholders to obtain perceptual data of each party on the utilization and management of groundwater. The results of interviews with stakeholders regarding the use of groundwater can be seen in Table 3 and Table 4.

Table 3 shows the actual conditions by communities and industrial zones located in three vulnerability zones (Fig. 2) i.e. low, medium, and high. Types of groundwater conditions are divided into four, namely: flowing and hygienic, flowing but muddy, limited but hygienic, and limited and muddy.

Table 3. Recapitulation of groundwater conditions

| No | Zone | Types of groundwater conditions | Stakeholder |
|---|---|---|---|
| 1 | High | flowing and hygienic | 2 Industries |
| | | flowing but muddy | - |
| | | limited and hygienic | 2 Society |
| | | limited and muddy | - |
| 2 | Medium | flowing and hygienic | - |
| | | flowing but muddy | - |
| | | limited and hygienic | 2 Society |
| | | limited and muddy | 1 Society |
| 3 | Low | flowing and hygienic | 12 Society |
| | | flowing but muddy | 8 Society, 2 Industries |
| | | limited and hygienic | - |
| | | limited and muddy | - |

Table 4. Results of stakeholder interviews

| No. | Stakeholder | Zone | Information |
|---|---|---|---|
| 1 | Society 7 | High | The community took water in the mosque and bought from another neighborhood because there was no water supply from PDAM (the local water board) and springs (dry) |
| 2 | Society 8 | High | There are no artesian wells in the community due to competition with industrial sector, and no water supply from PDAM, already complaint to the energy and mineral resources agency (ESDM) but no respond |
| 3 | Industry 1 | High | Use artesian wells in the same depth with the community wells, thus some complaint from the community, no water supply from PDAM |
| 4 | Industry 2 | High | Use artesian water, and community never complain about drought |
| 5 | Society 4 | Medium | Community utilize water from PDAM because artesian water have strong smells, yellowish and unusable, while water from PDAM also smells of chlorine, sometimes drought occurred in the community |
| 6 | Society 5 | Medium | There is no Corporate Social Responsible for nearby the community due to the impact of industrial activities |
| 7 | Society 6 | Medium | Water from PDAM have chlorine content; the community utilize water from the artesian well while water from dug wells has a taste (salty). There are some Corporate Social Responsible, and there are no impact of industrial activities |
| 8 | Society 1 | Low | Previously it is drought area, but there is an artesian aid well from local government, but the quality is poor |
| 9 | Society 2 | Low | Limited existing artesian wells so that water supply from PDAM needed. In the dry season, there is no water supply both from artesian and PDAM so delivery water from another neighborhood. There is no water supply from local government or Corporate Social Responsible from the nearest hotel (Candisari Hotel). Muddy water occurred before the hotel was built |
| 10 | Society 3 | Low | Community use water from PDAM for drinking because artesian water has taste and needed supply from the local government |
| 11 | Industry 3 | Low | Water from PDAM for daily used |
| 12 | Industry 4 | Low | Artesian water is limited utilized not for drinking water, thus water from PADM is primarily consumed |
| 13 | Society 9 | Low | Artesian water is flowing properly and hygienic, while water from PDAM is limited supplied |

| No. | Stakeholder | Zone | Information |
|---|---|---|---|
| 14 | Society 10 | Low | Artesian water is flowing properly and hygienic |
| 15 | Society 11 | Low | Dug well has color (yellowish) but still utilized in emergency. Moreover, water is muddy |
| 16 | Society 12 | Low | Water from PDAM is flowing, but water from dug well is color and muddy with some suspended material inside. |
| 17 | Society 13 | Low | Water from dug well is color and muddy while water supply from PDAM is frequently off and sometimes flowing in the specific hours |
| 18 | Society 14 | Low | Water from dug well is color and muddy while water supply from PDAM is limited. Community consume water from private supplier |
| 19 | Society 15 | Low | Sometimes water from dug well have smell |
| 20 | Society 16 | Low | Artesian water is flowing and hygienic |
| 21 | Society 17 | Low | Artesian water is flowing and hygienic |
| 22 | Society 18 | Low | Artesian water is flowing and hygienic |
| 23 | Society 19 | Low | Artesian water is flowing and hygienic |
| 24 | Society 20 | Low | Artesian well is flowing and hygienic and available for limited community |
| 25 | Society 21 | Low | Artesian well is flowing and hygienic for private consumption |
| 26 | Society 22 | Low | Artesian water is flowing and hygienic |
| 27 | Society 23 | Low | Artesian water is flowing and hygienic |

The results as shown in Table 4 are in line with Valentino's [16] study which states that seven out of eight industrial estates in Semarang City utilize artesian water while only one industrial estate is consuming dug well water. In addition, the industry as a groundwater user has an obligation to make efforts in conservation and utilization of groundwater. However, there are only two industrial estates, namely Tugu Industrial Estate and Terboyo Industrial Estate which provide artificial groundwater recharge by using a well while five other industrial estates have no groundwater conservation program due to there is no obligation of the regional regulation implementation.

Related to managerial implications, this study gives different results for each stakeholder. The Regional Office of Energy Resources and Minerals in Central Java Province need to understand that there are still issues that still need to be considered related to community and industry interaction in terms of groundwater use. In addition, The Regional Office of Energy Resources and Minerals in Central Java Province needs to intensify education and assistance for industries and communities related to the use of groundwater. The public needs to understand that there are authorities who help oversee the use of groundwater, provide education assistance related to groundwater and mediate the problems of citizens with the industry. The industry needs to be more open and responsible for the use of groundwater and to understand the relevant regulations.

## 5. CONCLUSION

The results of the research formulate three stakeholders involved in groundwater management in Semarang City which are the Regional Office of Energy and Mineral Resources (ESDM), industrial area managers and the Society. Subject related to groundwater management is Geological and Hydrogeological disciplines. This subject has functions as a constituent of technical policy, norms, standards, procedures, criteria, plans, programs, evaluation, reporting, provision of technical recommendations for conservation areas, and implementation of mapping, research, investigation, engineering, modeling, and technical guidance on inventory and groundwater conservation. The industrial sectors besides acting as a water user, but also have a role to preserve the groundwater the program and its utilization. The community has the right to obtain information related to the exploration, drilling, and use of groundwater surrounding their area. The obligation of the community that is to maintain the utilization of groundwater well, and also must conduct reporting related to the problems of groundwater management by the surrounding industrial estates adjacent or its community.

## 6. ACKNOWLEDGMENTS

Authors are whishing thankful to the Lembaga Penelitian dan Pengabdian Masyarakat/LPPM at the Diponegoro University for the funding with the scheme of "Riset Publikasi Internasional/RPI" with the Contract No. 276-57/UN7.5.1/PG/2017.

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