

The Condition of Seawater Intrusions in the Groundwaters Causing Clean Water Deficits of Industrial Park in Semarang

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Abstract—The city of Semarang, located in coastal area, has a unique topography because it is divided to lowland and plateau. Industrial Park in Semarang mostly located at the lowland. To fulfill the need of clean water, generally takes the groundwater in the deep aquifer. The ground water taking that doesn't consider the cavity of groundwater cause the intrusion of seawater, mainly in the area that has the low aquifer with the maximum groundwater flow just about 1,3 litre /sec, so that it will decrease the quality of groundwater.

Clean water that can be used by the industrial area is the water that pass the quality standard. The condition of groundwater that is contaminated by the seawater intrusion will affect to the effectiveness of the general activity in the industrial area. The research of the intrusion of seawater to the groundwater in depressed aquifer describes that in 2013, 5920,96 ha or about 54,5% part from the research area as big as 10.448,6 ha mainly those that have elevation till 3 MSL (5 km from the coastline) covered a half area of West Semarang Sub-district, Middle Semarang Sub-district, North Semarang South-district and Genuk South-district. Challenge for the industrial area in fulfilling the need of clean water is homework to all of the stakeholders.

From that research, being identified that the close connected factor of the intrusion of seawater are the increasing of human population, the condition of ground's subsidence and flood. The human population is the dominant factor and has correlation to intrusion of the seawater as 96,7% while the condition of ground's subsidence and flood have a correlation effect as 97,4%. From those factors, the rule's formulation in management of groundwater in fulfilling the need of clean water can be done by Cleaner Production Program's approach.

Keywords—*industrial area, groundwater, seawater intrusion, cleaner production*

I. INTRODUCTION

Industrial Area is an area which was arranged to be developed as the tool to catalyze the growth of industry sector completed with facilities and infrastructures which are needed (Government Ordinance 24 in 2009 about Industrial Area). The Industrial Area is managed by the entity which has the continuously responsibility to the facilities of industrial area and environment. So that, the relationship between businessmen/stakeholders and the manager of industrial area is continued. Industrial area is

built to facilitate the development of economy sector and trading which is encouraged to increase the economic growth to chase the target of Gross National Product (GNP).

Krugman (2009), divided the economic growth to three eras. According to him, the period of 1980 till 1990 was called as trading era. At that time, the country which had the excellent trading would be able to prevent the economic growth. Meanwhile in 1990 till 2000, was called Information and Technology era. At that time, been marked with the appearance of communication of technology and information - based company. Then, in 2000 till 2020 in the future is named as global warming era. At this era, the industrial people are forced to realize about the importance of keeping this environment in exploration the natural resources and energy. Seeing the direction and strategy of the industrial rules, so beside the need of room and area to provide any infrastructures, the support about facilities and infrastructures such as clean water stocks facilities is needed as well.

According to Hadi (2013), the relationship between human and environment at first run in the harmonious spirit as human is the part of environment, so that the behaviour is balance with the nature's rhythm. When the population of human is increased as much as the growth of technology and the increasing need, human is no longer the part of environment, humans want to control the nature with their anthroposentent character. This characteristic causes the destruction of nature which is often considered as environmental disaster, in this case is the groundwater contamination. According to Purwanto (2005), the use of natural resources in huge amount and ignoring the balance of environment can cause a lot of bad effects which will be occurred in a quick time like a critical condition or in a long time like a chronic condition.

Generally, the groundwater flow is so complicated that getting the information and better knowledge about the intrusion of seawater in the groundwater in the depressed aquifer needs to be developed. Norhan and Kuan (2004), claimed that to understand the intrusion of seawater better, the modeling of the seawater intrusion is very needed, so the control to the management of water resources, especially groundwater in the depressed

aquifer, can give a more accurate description of the research area and in the monitoring and managing the water resources are not needed too much time and high cost. To give the better information about the ocean's water intrusion in coastal area in Semarang, in this research will develop a model of the ocean water's intrusion to the groundwater in the depressed aquifer with the equation of chloride mass transportation approach which is a groundwater – dissolved contaminants in the depressed aquifer as the form of advection – diffusion process, the depressed aquifer's role is as a porous media.

The industrial are in Semarang generally located in less than 5 km from the shoreline which is in the less than 5 MSL equation area. Most of the industrial area, in fulfilling the need of clean water uses the groundwater from depressed aquifer or known as drilled deep - well. From the research in 2013, in the area which is less than 5 km from shoreline has the groundwater from the depressed aquifer that is more than the quality standard. It indicated that to fulfill the need of clean water, the industrial area has to accept the reality of the difficulties to get the clean water that matched to the quality standard.

II. METHODS

A. Location And Date Of Research

The research of the supply of water resources for the industrial area was done in the coastal area in Semarang in 2012 – 2013.

B. Research Planning

This research type is the analytical descriptive research using the survey method and presented in analytical descriptive type. The survey method was done by collecting some information from the measurement result in the area about the groundwater quality from the depressed aquifer. The field data was about the chloride (Cl) concentration from the groundwater in depressed aquifer compared by the quality standard of the drinking water (PERMENKES. 492/MENKES/PER/IV/2010), Then being analyzed using the model approach. Next, the step was using the clean technology approach to do the groundwater converting for the industrial area.

C. The Scope Of This Research

The scope of this research is the drilled deep well which is mostly the controlling drilled well managed by The Department of Energy and Mineral Resources of Central Java; The measurements of Chloride (Cl) concentration from the groundwater is compared by the quality standard to find out the condition of the ocean water's intrusion; The factors which is related with the condition of the intrusion such as increasing population factor, flood factor, and the ground's subsidence have a significant correlation; The model approach using the Chloride (Cl) Mass Transportation equation as the dissolved contaminants in the form of advection – diffusion equation with one dimension.

D. Population and Sampel

The population of this research is the deep – drilled well in the coastal area of Semarang, meanwhile the sample of this is a few deep – drilled wells in the low aquifer area and some deep – drilled wells in the high aquifer area.

E. The Variable Of The Research

The dependent variable of this research is the Chloride (Cl) in mg/L, and the independent variable is time (t) in year. Besides, there are some other variables like the ground retardation factor (R), diffusion coefficient (D) and the velocity of groundwater flow (v).

F. The Data Processing

The data is Chloride (Cl) concentration level in mg/L measured from the groundwater in the drilled - well sample and connected with the time in year, then will be discovered a valid model form for the condition of research area. Then, the clean technology step for the industrial area is being done to be the effort of groundwater conservation.

III. RESULTS AND DISCUSSION

A. Geographical Condition

Semarang has the variation of landscape because there are coastal area, a flat land with the 5 – 10 MSL height that lied from the middle of the city till the east part with the huge area, then a valley area or plateau about 300 m above the sea level. Semarang is located between 6°50' - 7°10' South Latitude and 109°35' - 110°50' East Longitude, bordered in the west with Kendal Sub-district, in the east with Demak Sub-district, in the north with Semarang Sub-district, and in the South with Java Ocean with the shoreline about 13,6 km. The coastal area is about 65,22%, the area is a land with elevation is 25% and 37,78%, and a valley area with the elevation is 15%-40%.

B. The Condition of The Ground

The salinity levels of the condition of the groundwater are identified by the amount of the Chloride (Cl) concentration in the measured groundwater with the amount of Chloride (Cl) concentration less than 250 mg/L, claimed as good quality and potable water. The next is for the sample of groundwater that has the Chloride concentration amount more than or the same as 250 mg/L is claimed as the bad quality water that isn't potable, the water has the high salinity levels. The measurement of the amount of Chloride (Cl) concentration had been done by the former researchers such as Mulyana, Wahid, Sihwanto, and Hadi which started in 1992 till 2008, used some groundwater sample that came from the controlling wells which is managed by the Department of Energy and Mineral Resources of Central Java. The illustration of the groundwater which has high salinity level in 2009 and 2035 is presented in Fig. 1.

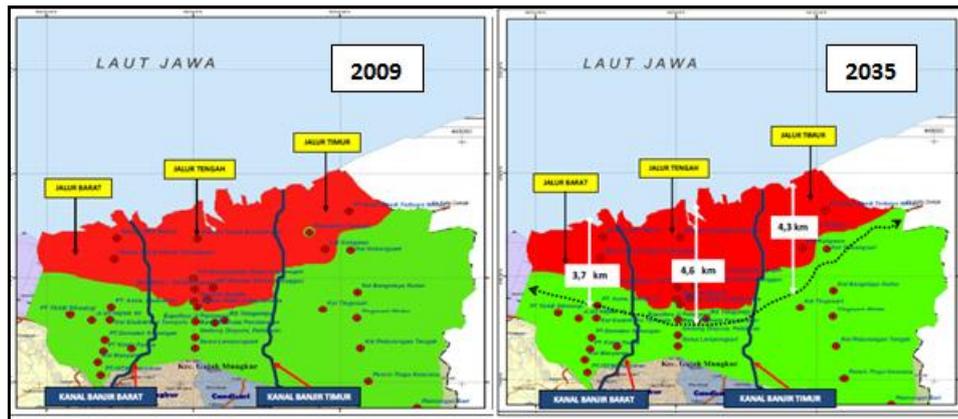
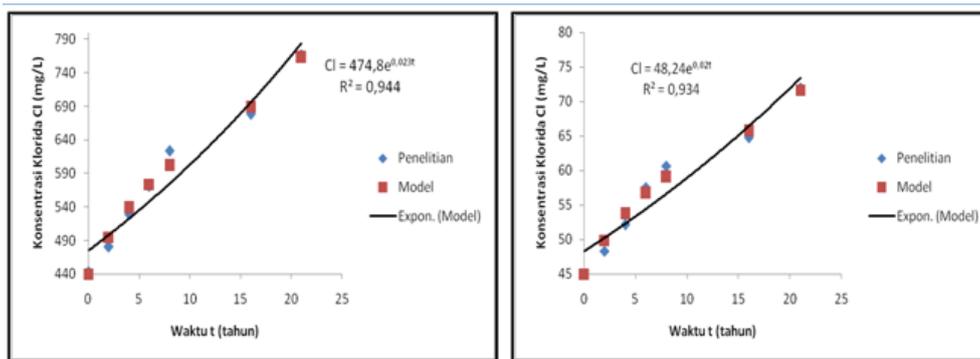


Figure 1. The condition of seawater intrusions in the Confinent Aquifer



(a) Low Aquifer

(b) Low Aquifer

Figure 2. Trend of Seawater Intrusions on Groundwater in Semarang

Fig. 1 presented that the salinity condition in the coastal area in Semarang identified by the height of Chloride (Cl) concentration in some deep – drilled wells which has elevation less than 3 MSL locate in about 5 km from shoreline tended to be increasing the same as the time addition. The coastal area that is potential to have the ocean water’s intrusion is as high as 5.920,96 or about 54,5 % from the whole research area which is 10.448,6 ha. This describes that the groundwater management in some areas with the radius about 5 km from the shoreline need the seriously controlling effort.

Some correlated factors with the condition of ocean water’s intrusion in Semarang such as: the increasing human population has the correlation level about 96,7% followed by the land condition which is often flooded with the increasing ground subsidence has correlation level about 97,4%, the correlation level is almost 100% that means in the controlling of groundwater use has to care about the flood factor and the human population especially in industrial area.

The model’s development of the groundwater contamination by the ocean water’s intrusion which is marked by the high level of Chloride (Cl) concentration in the groundwater is done by the advection – diffusion process approach in the low aquifer area (water debit less 1,3 liter/sec) or high aquifer area (water debit more than 9 liter/sec). The Model of the research result is presented in Fig. 2.

Fig. 2 shows that in the low aquifer in the coastal area of Semarang using C_0 amount from the field measurement in 2013, in the 2035 the area will have been having intrusion problem, but in the high aquifer will not have intrusion problem in 2035.

C. Conservation of Groundwaters With Cleaner Production

The proactive approach (Damanhuri, 2010) and Purwanto (2013) is the strategy which was known in 1970 in industrial sector, usually known as cleaner production or clean technology that targeted the controlling effort in environmentally friendly groundwater use. This concept simply included:

1. The better rules in groundwater use and wastewater management through good house keeping
2. No wasting in groundwater use
3. Reusing the usable wastewater
4. Replacing groundwater with the water from PDAM
5. Modifying the process or, if needed, replacing the old process and technology so that the wastewater is as minimal as it can be and with the small dangerous level
6. Separating wastewater based on the types so that it will be easily to handle

Ideally, the approach process is developed to the sequences priority to handle the wastewater generally below:

1. **Reduce** : using groundwater as minimal as you can
2. **Reuse** : if there is wastewater, use them directly
3. **Recycle** : the rest of wastewater is processed to be used again

The management of water resources in Industrial area must include 5 aspects which are the modification from Aboejoewono (1999) in managing city litters as a economic and aesthetic commodity. So that the approach used in managing water resources in industrial area planning is increasing the management system in water resources based on the participation of the human population in industrial area.

IV. CONCLUSION

1. Groundwater, one of the water resources used in industrial area, Semarang, had a decreasing quality.
2. The decreasing of groundwater quality is affected by the continuously uncontrolled exploitation.
3. The Industrial Area, as one of the groundwater user, need to conserve groundwater by the clean technology program.
4. In managing the water resources in industrial area, there are 5 aspects: operational technical, institutional, law and rules, financing and participation of the people around.

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