ISSN 0024-9521
IJG Vol. 48 No.1, June 2016 (47 - 53)

INDONESIAN JOURNAL OF GEOGRAPHY

Groundwater Salinity Distribution in Sub-District Kedung, District Jepara

Ilham Erie Maulana and Sudarmadji

Received: 24 10 2015 / Accepted: 15 01 2016 / Published online: 30 06 2016

Abstract The groundwater salinity in Kedung Sub-district, near the coastal area, is the result of the salt water that comes into the aquifers and the salt water seepage from the surface. The broad groundwater salinity is because of the recent land condition that is resulted from the deposition in the ocean. The nature of the groundwater in-Sub-distric from all aquifers consists of 14% saline groundwater, 48% brackish groundwater and 38% fresh water. The number of community that has brackish until saline ground water property is 19.202 people, so that the domestic water need for the community is 1.344.378 liters/day. Such environmental condition makes the residents make some adaptation. The adaptation of the land use aspect is by making the western region as a fishponds region and the eastern one as a rice fields region. Adaptation in community activities is to fulfill the needs by working as farmers (on the rice fields, fish ponds or salt ponds) or as the fishermen. Adaptation is also made to minimize the threat of disasters, such as the manufacture of levees, weirs or dams and diversions to prevent the spread of tidal flooding.

Keywords: Groundwater, Aquifer, Salinity, Adaptation

Abstrak *Salinitas airtanah di Kecamatan Kedung disebabkan dua aspek yaitu air laut yang menerobos masuk ke akuifer dan rembesan air asin dari permukaan. material tanah yang berupa lempung menjadikan tingginya akumulasi garam dalam tanah sehingga salinitas airtanah semakin tinggi. Sifat airtanah di Kedung dari seluruh akuifer adalah 14 % berupa airtanah asain, airtanah payau 48 % dan air tawar 38%. Airtanah tawar mayoritas berada pada akuifer dengan formasi batuan tuffa Muria. Kondisi ini menjadikan manusia akan beradaptasi kondisi alam tempat tinggalnya. Wujud adaptasi dari aspek pemanfaatan lahan adalah dengan menjadikan Kecamatan Kedung bagian barat sebagai tambak dan bagian timur sebagai sawah. Adaptasi dalam kegiatan masyarakat untuk memenuhi kebutuhan yaitu dengan bekerja sebagai petani (sawah, tambak ikan atau tambak garam) ataupun nelayan. Adaptasi juga dilakukan untuk meminimalisir ancaman bencana di daerah tersebut, seperti pembuatan tanggul, bendung ataupun bendungan dan sudetan untuk mencegah meluasnya banjir rob.*

Kata kunci: *Air tanah, Akuifer, Salinitas, Adaptasi*

1.Introduction

Water is a natural resource that has a very important role for life on Earth [Todd & Mays, 2005]. Of total amount of water on earth, the percentage of 0.001% for atmospheric ; 99,374% for the surface water while the ground water is 0.625% [Nace, 1960 and Feth 1973 in [Bower, 1978]. Although the groundwater has only a very small percentage but the experts believe that 96% of fresh water (except for the face in the geographical poles) is in the form of groundwater [Purnama, 2010]. Indonesia, as a tropical country with high rainfall, makes the groundwater gets a do you mean use:a large supplay supply. Even the water surface, according to the experts, has 30% of its supply comes from the groundwater [Indarto, 2010]. This makes most of the Indonesian population use the groundwater as the clean water source, especially for domestic needs [Notodarmojo, 2005].

Ilham Erie Maulana and Sudarmadji
Faculty of Geography, Universitas Gadjah Mada, Indonesia
Email: ilham.erie.m@mail.ugm.ac.id

Indonesia has some cities in coastal areas growing rapidly such as Surabaya, Semarang and Jakarta. regarded from the development of the region, it is certainly positive in terms of the economy. But when it is not accompanied by a good environmental management, it would be detrimental, because there would be a lot of excessive exploitations on the nature. As example Semarang in Semarang that has mostly groundwater is already salty or brackish with the increase of salt water level due to climate change [Rahmawati dan Marfai, 2013].

Kedung Sub-district with natural and geographical conditions is similar with the coastal areas in has the possibilities in Semarang,has possibilities in prossessing . There is a requirement to do some researches related to the groundwater salinity conditions as the initial stage of the environmental management in Kedung Sub-district. The high salinity of the groundwater can have some impacts such as health problems, reduced soil fertility, building damages, etc. [Saputra, 1998]. It is also should be the community adaptation to the natural condition in their residence should be considered also

on how the efforts of communities to adapt to the natural conditions in their residence.

The objectives of the research are as follows:
1. To find the extent of groundwater salinity in Kedung Sub-district
2. To calculate the domestic water needs of community who gets the impact of groundwater salinity in Kedung Sub-district
3. To observe the adaptation of the community to the natural conditions in Kedung Sub-district .

2. The Methods

Instruments and Materials

This research is related to the intrusion in the aquifer which was conducted in Kedung Sub-district, Jepara regency, by using several instruments, as shown in Table 3.1. The instruments used in this study are used in the majority of field activities. An instrument used during the pre- and post- field stages is only a laptop that is used for analyzing and processing of the results of field activities.

TThis study also uses some of the materials in the preparation, , and also data analysis. The materials used in this phase were RBI, geological, and also hydrogeological maps as the basis in the description of research area in general as well as consideration in results analysis. The materials used to develop results were the population data, satellite images and the field measurements data. From the results of data processing, this research would be the material in the analysis of the problems.

Time and Location of the Research

The research related to the salinity on the aquifer was conducted in the Kedung Sub-district, Jepara Regency. The restriction of the research area was using the administrative restriction as it will simplify the local governments's spatial planning and management as well as policy making. The research was conducted in May-June 2015

In terms of the physical condition of the research area that is similar to the coastal area of Semarang and Demak that has been published to have a high salinity score in the aquifer also becomes the basis for the choice of location. In addition, globally, in the hydrogeological map most of the area of Kedung Sub-district is the area of saline/brackish groundwater with various productivities, as shown in Figure 1. It is expected that this research can be seen with the physical condition of the aquifer on the chemical pollution related to the ground water salinity. The picture of the research area condition can be seen in Figure 2. Figure 2 is a geologic map which is also the basis for the division of the study area

Research Procedure

The data collection technique used in this research is the field survey with purposive random sampling method. The sampling method is conducted by dividing the research area into two rock formations, alluvium and tufa muria as shown in Figure 2. The sampling method is more focused on the alluvium formation since it is a free aquifer and directly adjacent to the sea. The population of this research is the existing wells in rock formations in Kedung Sub-district. The primary data obtained from this sampling are the data of salinity and observation location coordinates. This research does not only conduct the field survey, but also collect the secondary data collection as the data collection technique.

Both primary and secondary data collected will be processed. The secondary data such as RBI map, images and population data are used as one of the interpretation aspects of the community adaptation. The data processing of the results of field surveys is visualized in ArcGIS application. The method used is the kriging interpolation method which produces a contour map of groundwater salinity score (isohaline). The next stage is To classify the salinity score based on Table 2, the salinity level of the groundwater, which is also classified as properties of groundwater salinity. Based on these classifications, . the amount of domestic water needs of the community,except the fresh groundwater, can be calculated.

The next result is determining the domestic water needs of the community, based on the number of people who get the impact from the groundwater salinity. The method used for determination of the total population of each residential area is the weighted balance method.

Table 1. List of The Tools Used in The Study

Tools name	Function
GPS (Global Positioning System)	To find the absolute location of each observation spot
Field Checklist	To record the results of observation and measurement on the field
Stationery and Board Road	To make writings and help the field recordings
Camera	To take the pictures and field documentations
Computer	To process the data and images related to the field conditions and results processing
Refraktometer	To measure the salinity score on each observation spot

The consideration of using this method is that it can be used to calculate the number of residents in a particular area, by assuming that the distribution of the population is uniform. The residents in the administrative unit are affected by salinity differently, so this equation is used. The equation of weighted balance is formulated as Equation 1. This equation is only used when there is a village has a residential with various groundwater conditions (saline and non-saline).

Information :
X : Total residents in each residential area
∑x: Total population
A : The calculated residential area
∑A: Total residential area

The data analysis performed in this study is related to the physical properties of groundwater and adaptations of the community. The physical properties of the analyzed groundwater is salinity. The data analysis were conducted descriptively and graphically. The graphical analysis of the data was presented in the form of photos, maps, diagrams and tables. The presentation in the form of pictures (photos) was to indicate the condition of the field, while the maps were used to show the distribution of groundwater salinity. The presentation in the form of tables was for the affected area data which were also visualized in the form of diagrams. At the analysis stage, data will be described related to the general research environment conditions and the analysis related to the presentation of data in a graphical form. Graphically, the stages of research are shown in Figure 3.

3. Result and Discussion

The increase of the salinity score in the groundwater is caused by the presence of pollutants that enter and mix with the fresh groundwater [Todd & Mays, 2005]. In its natural state, the groundwater in coastal areas will not mix with the saltwater as in the Geyben-Herzberg Law. This law states that in a meeting between the fresh groundwater with saltwater in coastal aquifers will form the intrerface (boundary) [Musnawir, 2001 dalam Indahwati, Muryani, & Wijayanti, 2012]. The formation of interface is due to the difference in density between the saltwater (1.025 g / cm3) with fresh water (1.000 g / cm3) [Purnama, 2010; Todd & Mays, 2005].

Reviewing from the hydrogeological condition, Kedung Sub-district has fresh, brackish, until saline groundwater. Kedung Sub-district has two geological namely , alluvium and tuffa muria as shown in Figure 2. The salinity of groundwater is assessed through measuring of salinity in wells and drilling in the coastal area. The field measurementswere conducted in an area with clay soil material in alluvium rock formations which is a free aquifer directly adjacent to the sea. The morphology of Sub-district which is sloping and has a clay material becomes one of the factors causing the

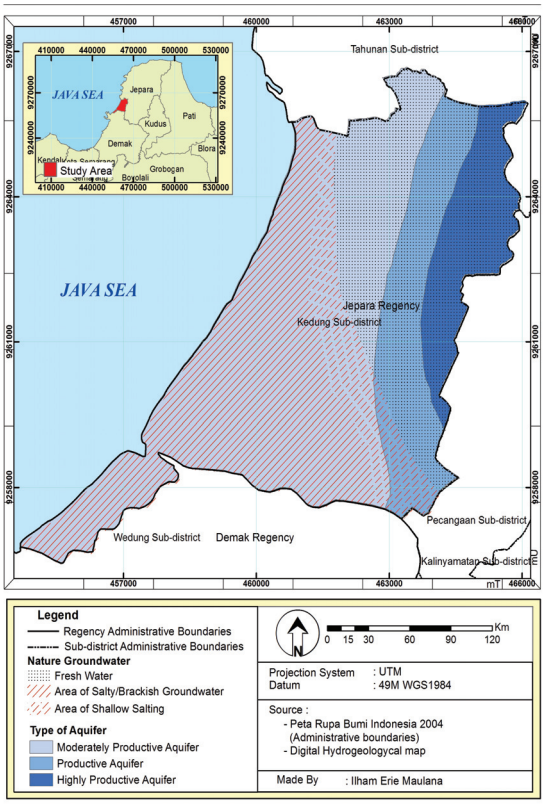

Figure 1. Hydrogeological map of Kedung Sub-District. Source : Hydrogeological map of Indonesia sheed VII Semarang (Java)

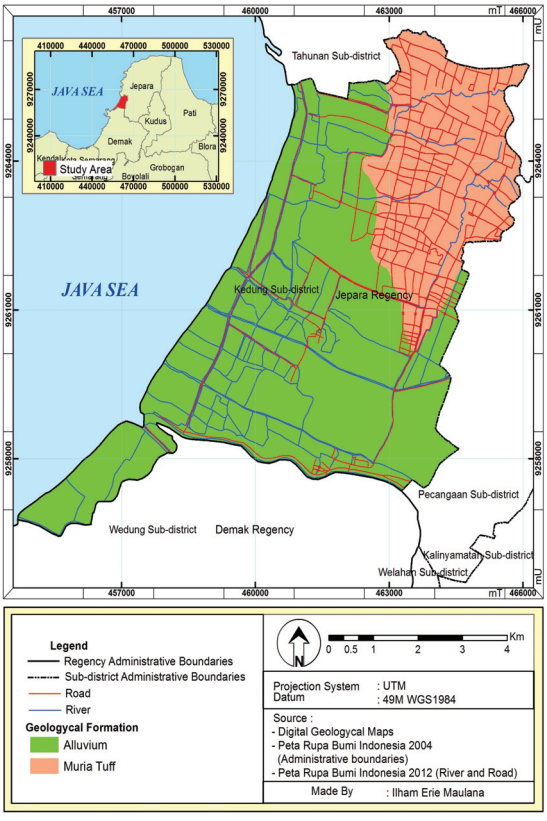

Figure 2. Geological Map of Kedung Sub-District. Source: Digital geologycal maps

Table 3. Results of Groundwater Salinity Measurements

X	Y	Salinity (‰)
459034	9260414	29
459100	9260369	28
459206	9260303	18
458875	9259742	19
458998	9259456	28
459315	9260237	40
459310	9260114	34
458110	9259226	30
458706	9260261	30
458920	9260734	30
459246	9261307	32
459842	9262230	33
460629	9263900	41
461629	9265002	1
461669	9265956	1
460812	9259628	0
463177	9259500	0
463525	9260080	0
463963	9260892	0
464202	9261268	0
464163	9261015	0
461103	9264795	27
459222	9260552	30
458408	9259013	32
457109	9258158	39

Source : hydrology team Lecture Field Work 3 Department of Environmental Geography, Faculty of Geography and observation data

high salinity in the groundwater. The salinity tests were performed in 25 observation points in Kedung Sub-district, as shown in Table 3.

The results of measurements of salinity then were to be processed to produce a map of groundwater salinity as shown in Figure 4. The salinity of groundwater in Sub-district is not only from the result of intrusion, but also from the seepage of the rest tidal flood and by the land formation due to the sedimentation in the sea. The high salinity score in the groundwater in coastal area of Sub-district can be caused by two aspects, such as the salinity of the salt water and the accumulation ofsalt sediment. The salinity of salt water in Jepara conducted in Panjang Island (± 1.6 km from the coast) is relatively high at between 30‰ to 46‰ [Rudiyanti, 2011]. The clay soil material in the coastal area of Sub-districtwill strongly bind the salt water. This results in the high accumulation of salt in the soil. The topography of flat alluvium formation widen the tidal flooding which impacts on the wider saline or brackish groundwater. The determination of the groundwater property is described in Figure 4, derived from the classification of isohaline based on Table 2. Almost the half of groundwater in the Kedung Sub-district is the brackish water, as shown in Table 4, whereas most of the fresh water is in Tuffa Muria Formation.

The domestic water need is the volume of water needed to meet the daily needs. The daily water needs which are included to the domestic needs include: water needs for bathing, washing (clothes and dishes), cooking and drinking. The determination of the domestic water needs in this research is based on the results of interviews with the local residents. The results of calculation of the domestic water needs are obtained from interviews which are later compared to the volume of domestic water needs according to SNI 19-6728.1-2002. The domestic water needs according to SNI is used as a comparison to calculate the water needs in more detail with more samples so The description is more general. It is in order to avoid a significant deviation from the volume of domestic water needs.

The determination of the affected population

Table 5. Domestic Water Needs Calculation of Population Affected High Salinity Groundwater Values

Village	Nature Groundwater	Area (m2)	Total Population		Domestic water (liter/day)	Water Needs (liter/day)	
			Total	Each of Nature Groundwater		Total	Affected
Sukosono	Freshwater	2250611,19	6938	6938		485660	
Rau	Freshwater	451657,64	3235	3235		226450	
Tanggultlare	Brackish water	58901,66	626	626		43820	43820
Kerso	Freshwater	816208,15	4413	4413		308910	
Menganti	Freshwater	984325,09	6976	6976		488320	
Dongos	Freshwater	1239491,41	7262	7262		508340	
Bulakbaru	Brackish water	49933,76	756	756		52920	52920
Bugel	Freshwater	889190,56	7644	7618		533232	
	Brackish water	3081,92		26		1848	1848
Panggung	Brackish water	79526,88	1960	1824		127673	127673
	Salty water	5934,31		136	70	9527	9527
Sowan Lor	Freshwater	940470,34	7948	7948		556360	
Jondang	Freshwater	272846,66	2276	2276		159320	
Surodadi	Brackish water	352115,10	3729	3729		261030	261030
Wanusobo	Freshwater	596336,44	2319	2319		162330	
Sowan Kidul	Freshwater	583254,73	6237	6237		436590	
Kalianyar	Brackish water	55520,01	528	528		36960	36960
Kedungmalang	Brackish water	198905,37	4722	4201		294038	294038
	Salty water	24692,03		521		36502	36502
Tedunan	Brackish water	270057,74	2436	2436		170520	170520
Karangaji	Brackish water	205914,69	4422	4422		309540	309540
		10328975,67	74427			5209890	1344378

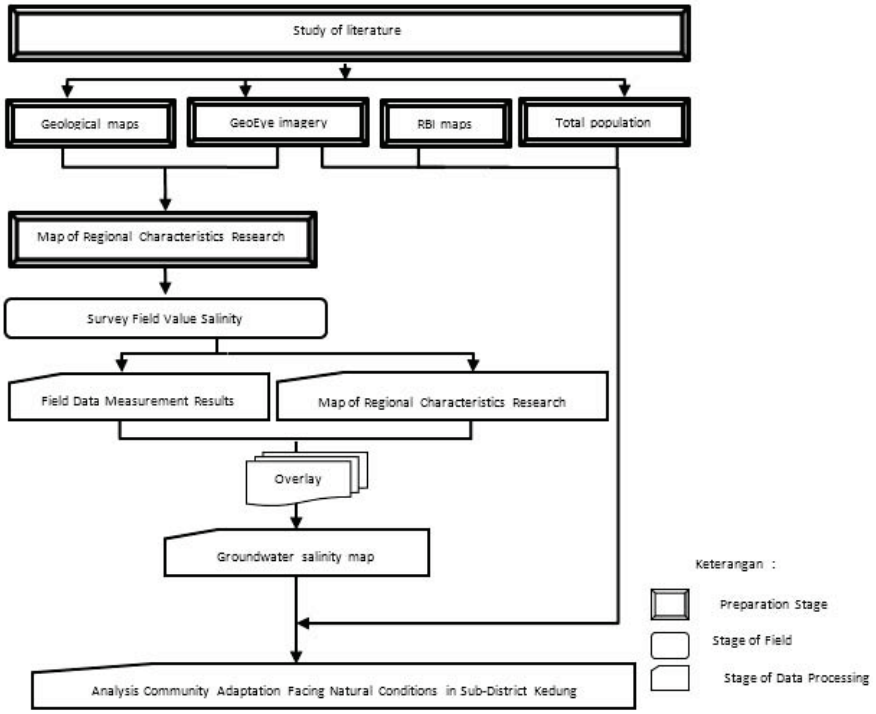

Figure 3. Flow diagram of the study.

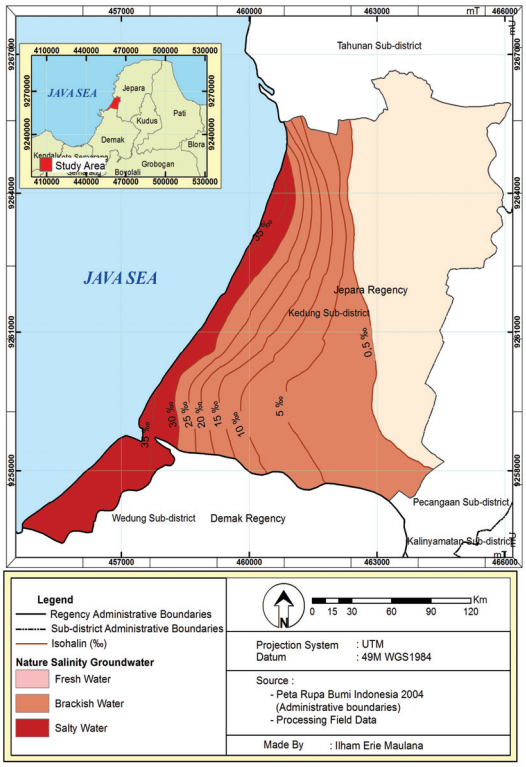

Figure 4. Map isohalin and nature of groundwater in Kedung Sub-District, Jepara.
Source: Data processing

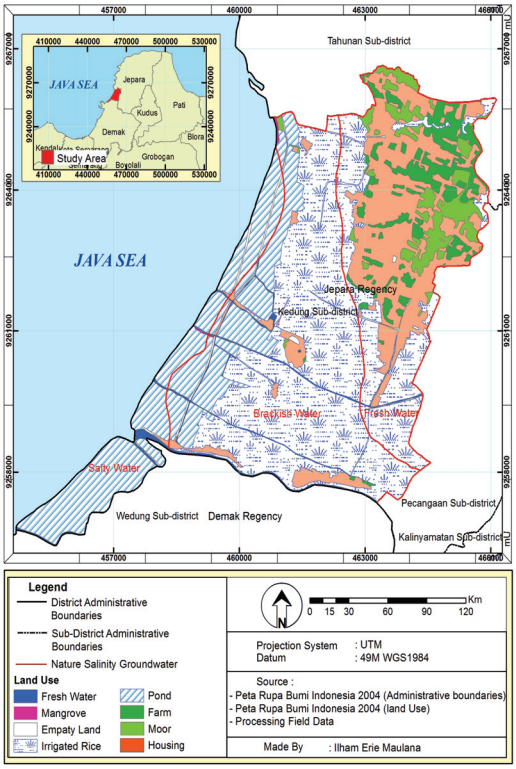

Figure 5. Map nature groundwater and land use Kedung Sub-District.

of ground water with high salinity score is based on the existing residential area. Based on the property of the groundwater and the extent of the residential area will result in the extent of the residential area affected by the salinity of the groundwater. Based on the extent of the affected residential area will result in the number of people affected by the method of weighted balance sheet. The results of the processing of salinity and demographic data can determine volume of domestic water needs of the population affected by the groundwater salinity (Table 5). According to Table 5, the volume of water needed to meet the domestic water needs of the population affected by the intrusion is 1.978.156 liters/day. The water volume is 25.8% of the total volume of domestic water needs of the entire population in Kedung Sub-district.

The natural conditions that have been described previously will certainly affect the adaptation of the community in Kedung Sub-district. The adaptations which are described in this researche are the land use and the community efforts in fulfilling their needs. The Manifestation of community spatial adaptation can be seen in Figure 5.

In terms of land utilization, land use (Figure 5) also considers the natural conditions. The first is the majority of residents which are in Tuffa Muria Formation. The selection of the house location in tuffa muria formation is very rational because this area has a more stable bedrock (soil material). It is located in a quite high position (>12 mdpal) which makes it safe from the threat of tidal flood, besides also has an adequate source of fresh water. Residents in alluvium formation require special adaptations. The adaptation are by making a stronger foundation and the soil should be piled higher in order to make the land more stable and to protect from tidal flooding. The residential location is also analogous to professions of the community such as in the Southern of Kedung Sub-district in which there are settlements that extend from the west to east. This is because there is a great river in the Southern of Kedung Sub-district,namely. Serang River which bank is used as a port for the ships.

The land utilization in alluvium formation are a ponds area (fish and salt), agriculture (rice fields and farms) in the western and eastern sides as in Figure 8. In the western side, there are many diversions used to drain water into the ponds. The watering of salt ponds also use the ground water pumped by a windmill in the areas with saline ground water. There is also a barrier created in the form of embankment between the ponds and paddy fields to prevent the salt water flows into the fields. There are also barriers and embankments built on both sides, so that when there is a tide flooding, the salt water does not flow away.

In fulfilling the daily needs and running economic activities, the community also adapt to natural conditions. The fulfillment of basic needs such as clean water also needs an adjustment,i.e. by taking water in the tuffa muria aquifer or using the services of local water company for the coastal community. As many

coastal people work as fishermen,as well as fish and salt farmers, people who worked on the rice fields have a house and the rice plants quite far from the coast.

The adaptation is also done in the form of physical development. One of the physical adaptations is manufacturing the embankmet bonth in the banks of the river and along the coast to resist the tidal flood. The effort to minimize the tidal flooding is also done by making a lot of diversions. Diversions are also utilized by the community to irrigate the pond with the help of windmills. There is also a weir or dam so that the salt water does not enter too far into the river.

4. Conclusions

1. 48% of the groundwater is brackish and 14% is saline in Kedung Community, which both are on the sloping coastal area.
2. The required water volume needed to fulfill the domestic water of the community which has a high salinity on the groundwater (brackish and saline) is 1.244.378 liters/day, equals to ¼ of the total volume of domestic water needs in Kedung Sub-district
3. The majority of adaptation made by the community is by changing the environmental conditions based on their desires, such as the selecting hose, diversion making, embankment making, and realizing he coastal area as the salt ponds.

References

Bower, H. (1978). *Water Resouurces Environmental Engineering (1st ed.)*. New York: McGraw-Hill inc.

Indahwati, N., Muryani, C., & Wijayanti, P. (2012). *Studi Salinitas Airtanah Dangkal Di Kecamatan Ulujami Kabupaten Pemalang Tahun 2012*. UNS Surakarta. pg.1–11.(in Bahasa Indonesia)

Indarto. (2010). *Hidrologi : Dasar Teori dan Contoh Aplikasi Model Hidrologi*. Jakarta: Bumi Aksara. (in Bahasa Indonesia)

Notodarmojo, S. (2005). *Pencemaran Tanah dan Air Tanah (1st ed.)*. Bandung: ITB Press. (in bahasa indonesia)

Purnama, I. L. S. (2010). *Hidrologi Air Tanah (1st ed.)*. Yogyakarta: Kanisius. (in bahasa indonesia)

Rahmawati, N and Marfai, M. A. (2013). Salinity Pattern in Semarang Coastal City. *Indonesian Journal of Geology*. 8(2), 111–120.

Saputra, S. (1998). Telaah Geologi Terhadap Banjir Dan Rob Kawasan Pantai Semarang. *Jurnal Ilmu Kelautan*. 3(1), 85–92.

Todd, D. K., & Mays, L. W. (2005). *Groundwater Hydrologi (3rd ed.)*. New York: Jhon Wiley & Sons, inc.