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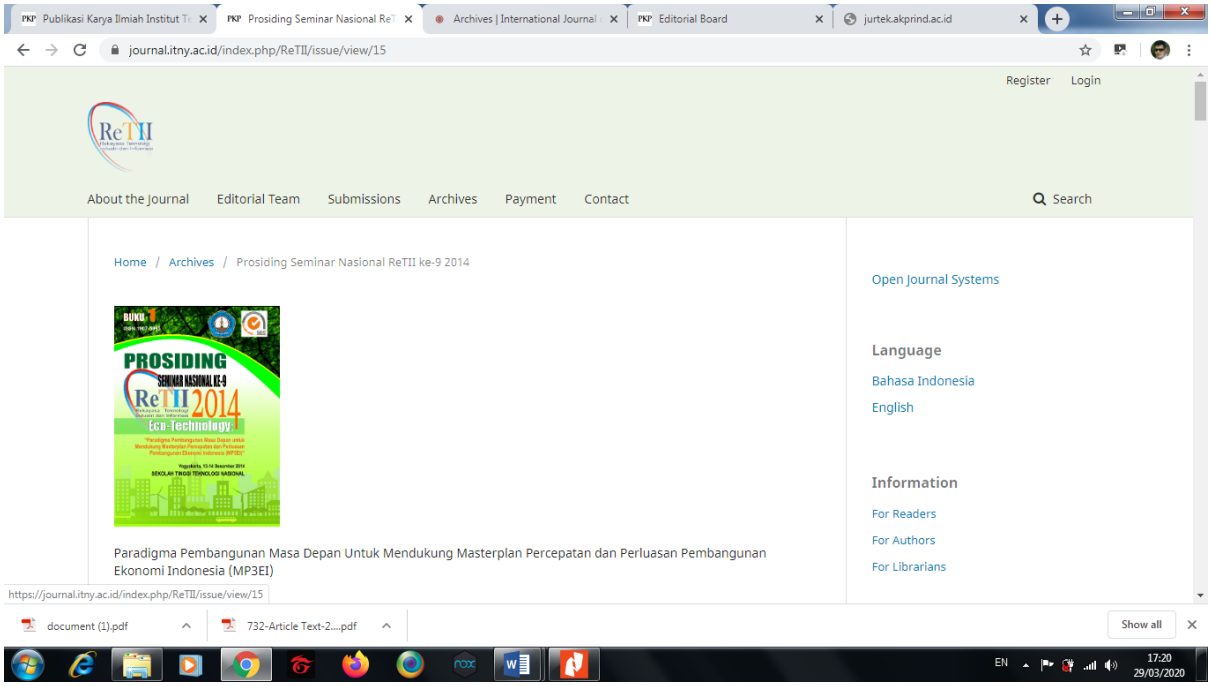
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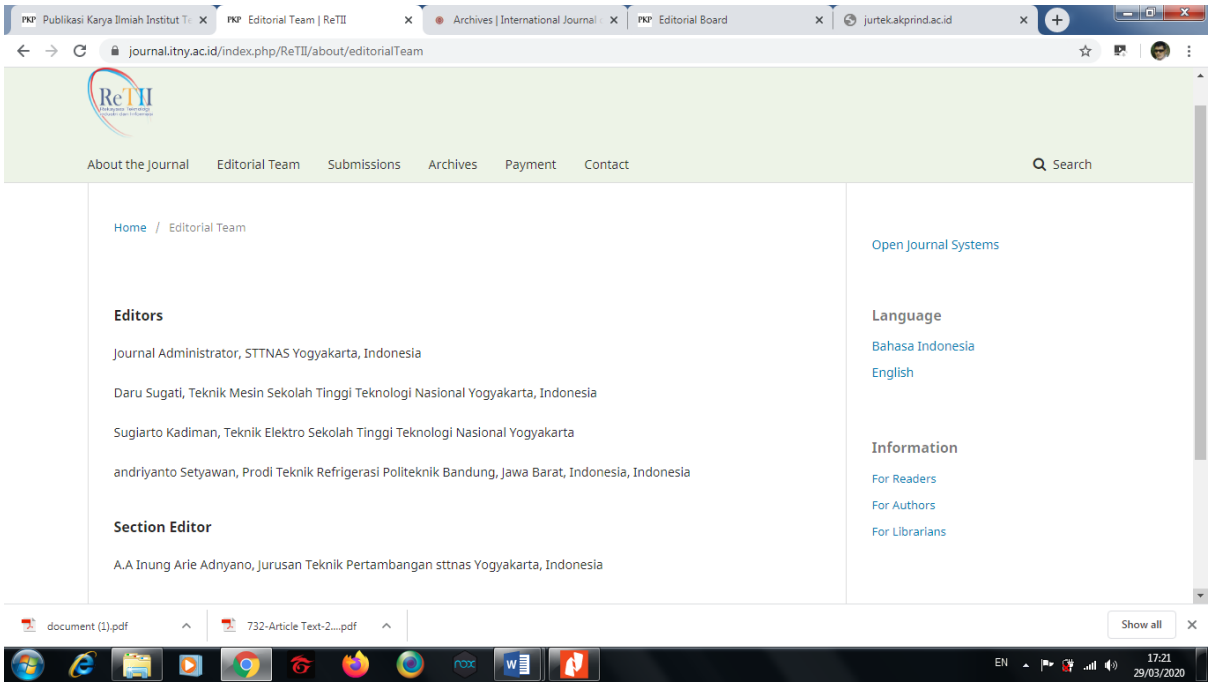
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Geological Control To The Salinity Of Groundwater

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Abstract

The saline/brackish water can be found at many places in nature. This phenomena occurs under geological control of the certain place. The origin of the saline water refers to some hydrogeological processes, such as mixing of water (sea water intrusion or flushing), evolution, hydrochemical processes, connate water even man made polution. These origin of salinity should be known in order to build some mitigation ways. The mitigation process include preventive action (reduce groundwater abstraction or polution; control the groundwater flow by any geotechnical building) and remediation by chemical process. However, any saline water sometimes give benefit for society so this phenomena doesn't need remediation.

Key words : saline, groundwater, origin, treatment.

1. Introduction

There are many kind of groundwater in nature, especially in its quality. The quality of groundwater can be determined from its physical, chemical and biological characteristics. Some of the chemical parameters should determine of salinity of groundwater. Groundwater in nature can be found in fresh to saline condition.

There is saline/brackish groundwater that can be found in some places in nature. This phenomena occurs under certain geological control.

Geomorphologically, the saline/brackish water occur both at the high and low elevation. At the low elevation area, this saline water usually occur at the beach and surrounding area. This phenomena usually related with sea water intrusion. At the high elevation, saline groundwater even found at the high valley near peak of mountain.

Saline groundwater is also influenced by stratigraphic condition. Sedimentary rocks, especially which formed in marine environment often produce salinity to the water. This salinity related with salt of paleo sea water as connate water or produce by water-rock interaction between minerals and recent water. The saline water also may be resulted from interaction of minerals in igneous and metamorphic rocks and the meteoric water.

Geological structure can influence the occurence of saline groundwater because the groundwater flow depends on strike/dip of rocks and other structural phenomena likes fault, fold and joint. Sometimes, fault can serve as barrier or way of groundwater flow. Groundwater flows under geological structures control through the aquifers. Geological structures can facilititate the flow of groundwater, but sometimes these structures can block the flows. This condition can be occured in layers of sedimentary rocks which bear the impermeable layer.

Sometimes the saline water give benefit for the people surrounding area. However, saline water sometimes is assumed as polution. Some factors will influence to the occurrence and level of the salinity. Therefore we need to understand the origin of salinity in order to make some ways for mitigation. Determine the geological factors which control salinity of groundwater is a must. Then, some reason of saline water occurrence will be considered to make suggestion of some treatments to mitigate the saline/brackish groundwater.

2. Definition of Salinity

Salinity is the saltiness or dissolved salt content of a body of water. Salinity is an important factor in determining many aspects of the chemistry of natural waters and of biological processes within it, and is a thermodynamic state variable that, along with temperature and pressure, governs physical characteristics like the density and heat capacity of the water (Wikipedia, 2014).

Salinity in rivers, lakes, and the ocean is conceptually simple, but technically challenging to define and measure precisely. Conceptually the salinity is the quantity of dissolved salt content of the water. Salts are compounds like sodium chloride, magnesium sulfate, potassium nitrate, and sodium bicarbonate which dissolve into ions. Operationally, dissolved matter is defined as that which can pass through a very fine filter (historically a filter with a pore size of 0.45 μm, but nowadays usually 0.2 μm) (Pawlowicz, 2013 in Wikipedia, 2014). Salinity can be expressed in the form of a mass fraction, i.e. the mass of the dissolved material in a unit mass of solution.

Salinity level of groundwater is varied, and can be determined based on the element of chloride (Cl), or the total dissolved solid (TDS) of water (Table 1).

Table 1: The salinity level of groundwater (PAHIAA, 1986, in Disbang DKI Jakarta - Sapta Daya Karyatama, 1997 [1]; Carroll, 1962, in Todd, 1980 [2])

Water characteristic	TDS (mg/l)[1]	TDS (mg/l)[2]	EC (µmhos/cm)[1]
Fresh	≤ 1,000	0 – 1,000	≤ 1,500
Almost brackish	> 1,000 - ≤ 3,000		> 1,500 - ≤ 5,000
Brackish	> 3,000 - ≤ 10,000	1,000 – 10,000	> 5,000 - ≤ 15,000
Saline	> 10,000 - ≤ 35,000	10,000 – 100,000	> 15,000 - ≤ 50,000
Brine	> 35,000	> 100,000	> 50,000

3. Origin of Saline Groundwater

As long as the water flows below ground level, the different hydrochemical processes can occur. Genesis of saline water is also determined by a variety of hydrochemical processes which occur along the path flow.

3.1. Mixing of Groundwater

Mixing of groundwater at the area near marine ever occur between freshwater from island and saline water of marine. Mixing occurring in the groundwater at coastal areas could be seawater intrusion or flushing. There are two kind of brackish water chemistry resulted from this mixing because of these processes.

a. Seawater Intrusion

Seawater intrusion generally change the type of water from NaCl into CaCl2 type. When seawater intrudes in a coastal fresh water aquifer, an exchange of cations takes place. Sodium is taken up by the exchanger, and Ca2+ is released. The water quality thus changes from NaCl to CaCl2 type water (Freeze and Cherry, 1979).

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b. Flushing by Freshwater

The reverse process of sea water intrusin occurs when fresh water from the brine aquifer goes leaching (flushing), where brackish water will generally has the NaHCO3 type. This process takes place with refreshening, i.e. when fresh water flushes a salt water aquifer, where Ca2+ is taken up from water, in return for Na+, with a NaHCO3 type as result (Freeze and Cherry, 1979).

3.2. Evolution of Groundwater

In addition to the mixing, the chemical evolution is often a major cause of groundwater salinity. Evolution of groundwater is generally followed by regional changes of anion dominance as indicated by the Chebotarev sequence (1955, in Freeze and Cherry, 1979) as follows:

$HCO_3^- \rightarrow HCO_3^- + SO_4^{2-} \rightarrow SO_4^{2-} + HCO_3^- \rightarrow SO_4^{2-} + Cl^- \rightarrow Cl^- + SO4^{2-} \rightarrow Cl^-$

To the right sequence is characterized by an increasingly distant flow path of groundwater accompanied by increasing age.

3.3. Hidrochemical processes

The hydrochemical processes that occur in groundwater systems include dissolution - hydrolysis - precipitation, adsorption, ion exchange, reduction - oxidation, mixing, membrane filtration and metabolism microbiology (Todd, 1980). The chemical composition of groundwater depends on the chemical composition of water in the recharge and many reactions that occur in the flow system (Matthess, 1982). The other process that responsible to increase salinity of groundawater is evaporation (Hadipurwo, 1996).

3.4. Connate water

Water that has been out of contact with the atmosphere for at least an appreciable part of geologic period is termed connate water (Todd, 1980); essentially, it consists of fossil interstitial water that has migrated from its original burial location. This water may be derived from oceanic or fresh water sources and, typically, is highly mineralized.

3.5. Polution

Groundwater pollution may be defined as the artificially induced degradation of natural groundwater quality. Pollution can impair the use of water and can create hazards to public health through toxicity or the spread of disease. Most pollution originates from the disposal of wastewater following the use of water for any of a wide variety of purposes. Thus, a large number of sources and causes can modify groundwater quality, ranging from septic tanks to irrigrated agriculture (Todd, 1980). The pollution sometimes increase the chemical content of groundwater, especially in TDS, therefore it should increase the salinity. One of the polution sources with strong influence to the salinity is oil and gas industry.

The production of oil and gas is usually accompanied by substantial discharges of wastewater in the form of brine. Constituents of brine include sodium, calcium, ammonia, boron, chloride, sulfate, trace metals, and high total dissolved solids. In the past oil-field brine disposal was handled by discharge to streams or evaporation ponds. In both instances brine-pollited aquifers became commonplace in oil production areas as the infiltrating water reached the underlying groundwater (Todd, 1980)..

4. Geological Control of Saline Water

There are many kinds of origin of saline water. In nature, this condition is usually controlled by geological factors. These factors include geomorphology, stratigraphy (aquifer properties), geological structure, and hydrogeological characteristics. The hydrogeological characteristics include groundwater

table or piezometric head which responsible to groundwater flow.

4.1. Geomorphology

Morphology of certain area has strong influence to surface water, but it also should influence to groundwater. This fact can be understood because groundwater table sometimes follow the topography of ground surface. Then, the groundwater table will determine any groundwater flow pattern.

Geomorphology can support the formation of salinity. For example, saline water in Kurulu Spring (1900 m) at Baliem Valley, is supported by groundwater flow from Habema Lake at high elevation of 4400 m asl (Hutasoit and Ashari, 1998, in Kossay, 2008). Baliem Valley is located at Jayawijaya mountain (350 – 400 m asl), especialy at Jikiwa Village, Kurulu Subdistrict, near Wamena (the capital city of Papua Province). The people surrounding area are protected from mumps because of this saline water.

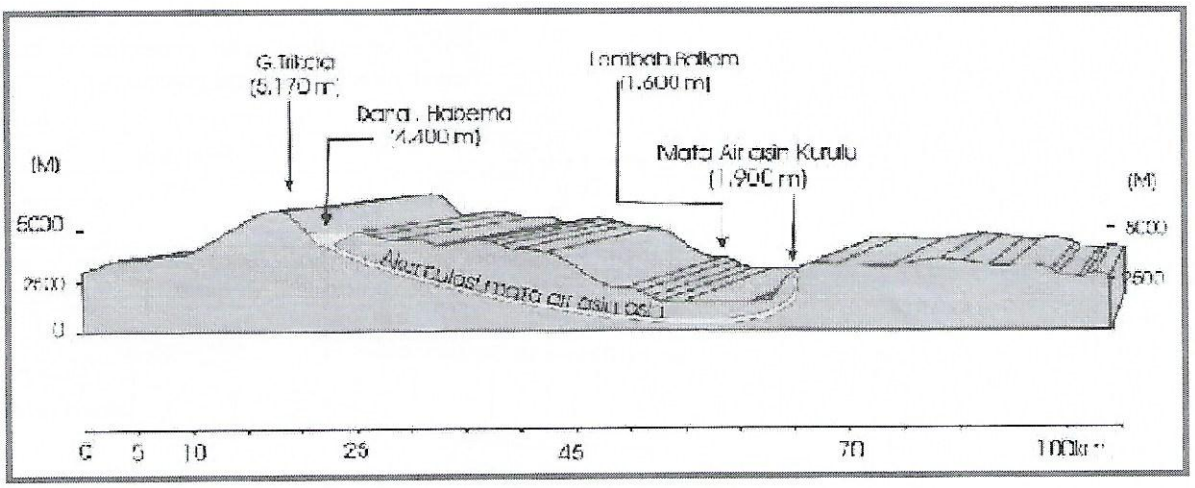

Figure 1. Geomorphology control groundwater flow of Baliem Valley (Kossay, 2008).

4.2. Stratigraphy

The layers of aquifer zone determine the potential of groundwater. Saline water should be able to flow to the aquifer from sea water or move from aquifer to the others. It depends on the condition of local or regional stratigraphy. This stratigraphy includes many kind of litology. Saline water in Baliem Valley is also supported by the occurrence of limestone of karst landform. The interaction between minerals in limestone and water may increase the salinity.

The other example is saline groundwater in Jakarta Groundwater Basin (JGB). In this basin, there are saline groundwater can be found at both shallow and deep aquifer zones. Hadipurwo (1996) show there were some origin of saline/brackish groundwater in JGB as below:

a. Aquifer I zone (< 40 m depth) : seawater intrusion, leaching, evaporation, flushing.
b. Aquifer II (40 – 140 m depth) and III zones (>140 m depth) : leaching, flushing.

Those saline/brackish groundwater is influenced by stratigraphy of JGB which consist of quaternary sediments (Figure 2).

4.3. Geological Structure

Many kinds of geological structures, like fault, fold and joint can influence the groundwater flow. Consequently, saline water

formation will be supported or decreased by these structures.

Saline water at Parangwedang is originated from mixing of meteoric water and old groundwater, influenced by magmatic activity or the intrusion of seawater in past time through the aquifers (Listyani, 2008). This saline water is supported by fault in the boundary of Nglanggran Formation (Figure 3).

4.4. Hydrogeology

The properties of aquifer and condition of groundwater table/piezometric level will determine groundwater flow as well as salinity. The origin of salinity is strong influenced by hydraulic parameters of aquifer especially on its porosity and permeability.

The connate water (Hutasoit and Ashari, 1998, in Kossay, 2008) of saline water in Baliem Valley is also formed by hydrogeologic condition of paleo marine sediments. This saline water may be trapped in the rocks when deposition process at the past time. The origin of connate water here is supported by isotope (O & H) analysis.

The salinity of groundwater at Parangtritis caused by infiltration of tidal seawater and controlled by the flushing of seawater by fresh water (Listyani, 2009).

This flushing process is influenced by loose litology of aluvial deposites. This sediments act as good aquifer because of their high porosity and permeability. The brackish water here is usualy formed when high tides.

5. Saline Water Treatment

Because of many kind of origin of saline water, there are many kind of treatment to mitigate this water (if the water assumed as polutant). In brief, the proposed ways of treatment can be noticed in Table 2.

6. Conclusion

This can be summarized about the geological control of saline groundwater.

1. The saline groundwater can be found at many locations under geological control.
2. There are geological characteristics influence in the occurrence of saline water, include geomorphology, stratigraphy (litology),

   geological structure and hydrogeology of certain area.
3. Some treatment to mitigate the saline water which can be proposed are reduce the abstraction, control groundwater flow with geotechnical building, or remediation by chemical process.

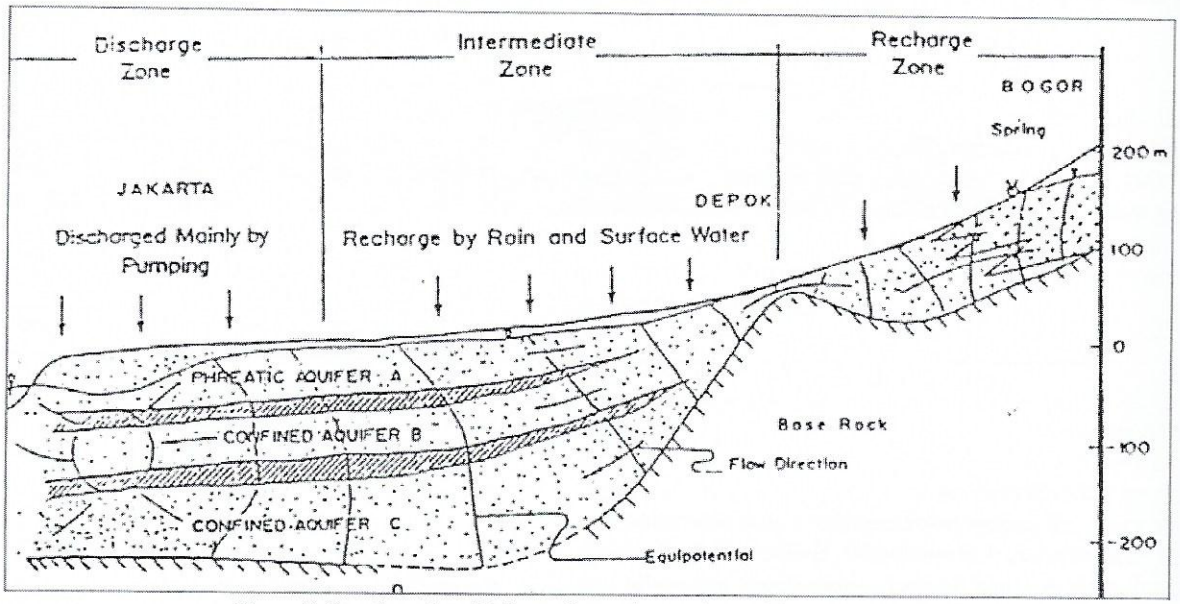

Figure 2. Stratigraphy of Jakarta Groundwater Basin (Naryanto, 1996)

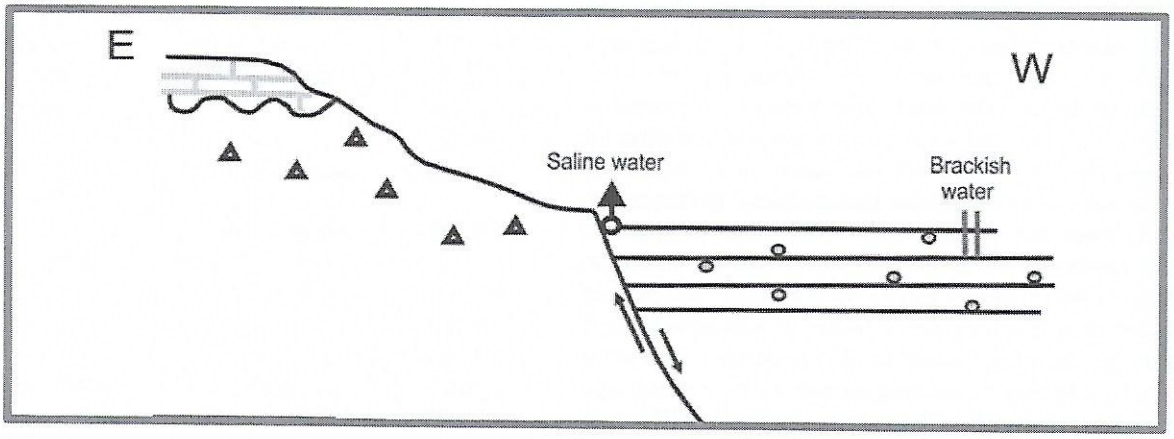

Figure 3. Fault should be supported the occurrence of saline water in Parangwedang Spring Listyani, 2008).

Table 2: Some examples of the treatments proposed to mitigate saline water.

Example of Location	Origin/Geological Factor	Treatment
Jakarta Groundwater Basin	Seawater intrusion; leaching	-Reduce groundwater abstraction -Build the geotechnical building to prevent or divert groundwater flow -Remediation by chemical process
Baliem Valley, Papua	Water-rock interaction; connate water	No treatment because this water gives benefit (provide iodine) for people at surrounding area.
Parangwedang, Yogyakarta	Meteoric water mixed by heat of past volcanic activity	- No treatment (good for tourism & skin pain therapy)

References

Freeze, R.A. dan Cherry, J.A., 1979, Groundwater, Prentice-Hall Inc., Englewood Cliffs, New Jersey.

Hadipurwo, S., 1996, Kajian Intrusi Air Asin di Jakarta, Proceedings of The 25th Annual Convention of The Indonesian Association of Geologists, IAGI, Jakarta.

Kossay, V., 2008, Lembah Baliem, "The Big Valley", http://lembah-baliem. blogspot. com.

Listyani, T., 2008, Pengaruh Litologi Batuan Samping terhadap Hidrokimia Mataair Panas Parangwedang, Kabupaten Bantul, Daerah Istimewa Yogyakarta, Final Report, Kopertis Region V, Yogyakarta, unpublished.

Listyani, T., 2009, Identifikasi Intrusi Air Laut di Wilayah Gumuk Pasir Parangtritis, Final Report, Kopertis Region V, Yogyakarta, unpublished.

Naryanto, H.S., 1996, Dampak Penyadapan Airtanah di Daerah Cengkareng dan Sekitarnya, Jakarta, Proceedings of The 25th Annual Convention of The Indonesian Association of Geologists, IAGI, Jakarta.

Todd, D.K., 1980, Groundwater Hydrology, 2nd Ed., John Willey & Sons Inc., New York.

Wikipedia, 2014, Salinity, http:// en.wikipedia.org.