Shallow Well Water Salinity Viewed From Distance Of Well To CoastLine And Ground Water Level Elevation In Purus Padang Village

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Abstract. The coastal environment is an area that always changes. It depends on the power balance between topography, rocks, and its nature with tidal and wind waves. Progress in the Purus sub-district resulted in an increase in the amount of groundwater demand. If this happens, it can cause a drawdown so that the well water of the residents feels brackish or feels salty. This study aims to determine the salinity of shallow well water when viewed from the distance of the well to the coastline (x1) and groundwater level (x2) in Purus Padang Village. This type of research is field research (field research), using a quantitative approach. The sample was taken as many as 18 wells in Purus. The results showed that the salinity of well water occurred unevenly in Purus Village. If the distance of the well is further away from the coast, the salinity value will be lower. If the depth (height) of the water table is getting farther away from the sea level, the salinity value will be higher. For consumption, the salinity content in Purus Village is still within normal limits (<250 mg/l). The spread of salinity is caused by the flow of surface water.

1. Introduction
The coastal environment is the most important area for change, because it is a meeting area that has territory and the sea. This change can occur more quickly than happens in a power draw between topography, rock, and its nature with tidal and wind waves. While choosing groundwater in coastal areas a little more also contains no-nothing contained in the sea, one of them is salinity or salt. The background of this is that some of the wells ‘water feels brackish or salty, seawater intrusion on the wells’ water, decreasing the quality of well water in the Purus area, groundwater in the Purus area (close to the sea) containing salinity, increasing groundwater demand increase, and density of population settlements.

2. Literature review
2.1 Groundwater
Groundwater is all water that is below the surface of the soil in the zone of saturation (zone of saturation). Groundwater comes from rain water and infiltrate surface water first to the unsaturated zone (zone of aeration) and then seeps deeper (percolate) until it reaches the zone of saturation of water and becomes groundwater. Ground water is water in one phase of the hydrological cycle, which
is a recurring event from the sequence of stages that water passes from the atmosphere to the earth and returns to the atmosphere. The direction of groundwater flow is determined by the "Three Point Problem" method, namely by making a straight line against the contour lines of groundwater. The basic principle in determining the direction of groundwater flow is the movement from a high place to a low place. To get the direction of flow, the first step is to make the contour of ground water, the easiest way to do it is to measure into the well, the height of the well. The point is to measure the level of elevation of groundwater in the well to the sea level. Measuring several well depths, groundwater contours will be obtained with the interpolation system. The direction of flow in the study area, in accordance with the slope of the topography is north-south (Kodoatie: 1996). Namely from a high place to a more gentle (low) place.

2.2 Salinity
Meanwhile Salinity is the concentration of all salt solutions obtained in sea water. The concentration of salts is relatively the same in each sample of water or sea water, even though the extraction is carried out in a different place. Therefore, it is not necessary to measure all salinity from the sample every time. The usual way to determine salinity is to calculate the amount of salt that in a sample is called chlorinity with the following formula (Hutabarat and Evans, 1986: 55).

Salinity (%) = chlorinity x 1,817

According to Boyd (1982), salinity is the level of all ions dissolved in water. The composition of ions in sea water can be said to be steady and dominated by certain ions such as chloride, carbonate, bicarbonate, sulfate, sodium, calcium, and magnesium. Table of water classification based on salinity can be seen in table 2 below.

| Mention / Salinity term (ppt) | Salinity (ppt) |
|------------------------------|----------------|
| Freshwater                   |                |
| Fresh water                  | < 0,5          |
| Oligohaline                  | 0,5 – 3,0      |
| Brackish water               |                |
| Mesohaline                   | 3,0 – 16,0     |
| Polyhaline                   | 16,0 – 30,0    |
| Salt water                   |                |
| Marine                       | 30,0 – 40,0    |

Source: Kordi, 1996

Irregular and excessive extraction of groundwater (especially with wells both shallow and deep wells) will cause the amount of clean water flowing into the sea to be reduced, so that the balance between sea and fresh water is disrupted. Besides indirect population growth, an increase in the number of buildings, compaction of land in the coastal area will also affect this salinity, because it will reduce the catchment area or infiltration area.

Figure 1. Balance of sea water with fresh water
2.3 Water Quality
Clean water for humans is water that does not have a negative impact on humans who use it. The quality of the water at this time has decreased considerably in quality, we cannot avoid this as an impact of development, namely environmental pollution. The source of the pollution is from living things (eg THM or Animal and Human Feces), household waste (eg detergent that is not environmentally friendly), industrial waste, and waste that is difficult to decompose (eg batteries, metals, etc.) (http://id.shvoong.com).

Provision of clean water as a source of clean water cannot be separated from human life, this is because water is very important for humans. Humans will die quickly because of lack of water rather than lack of food. The human body itself consists mainly of water. The body of an adult, about 55-60% of the body weight consists of water, for children 65%, and for babies around 80% ((http://id.shvoong.com). The use of water which is very important is the need to drink, and to fulfill that, water must have special requirements so that the water does not cause disease for humans. Healthy water must have the following requirements: 1) Physical requirements, Physical requirements for healthy water are clear (colorless), tasteless, temperature below the outside air temperature (below normal temperature); 2) Bacteriological requirements, Water that is healthy to meet human needs must be free of all bacteria; 3) Chemical requirements, healthy water must contain certain substances in certain quantities as well.

In accordance with the principles of appropriate technology in the countryside, water originating from springs and deep wells is acceptable as healthy water, and fulfills the three requirements mentioned above, provided that water is not polluted by impurities, especially human and animal feces. Therefore, springs or wells in the countryside must get supervision and protection so that they are not polluted by people who use the water. Well water sourced from the infiltration of surface water is still susceptible to bacterial, germcidal and viral contamination. Each soil has a different seepage coefficient depending on the type of soil such as the following table:

| Type of soil | K (Koefisien Permeability) (cm/detik) | (ft/menit) |
|-------------|--------------------------------------|-----------|
| Clean gravel| 1,0 - 100                            | 2,0 – 200 |
| Clean sand  | 1,0 – 0,01                           | 2,0 – 0,02|
| Fine sand   | 0,01 – 0,001                         | 0,02 – 0,002|
| Silt        | 0,001 – 0,00001                      | 0,002 – 0,0002|
| Clay        | < 0,000001                           | < 0,000002|

2.4 Ground water level
According to K.insley, Max A. Kohler, and L.H Paulhus (1989: 163) groundwater is the position of the points (in the soil that is not depressed) with the hydrostatic pressure equal to atmospheric pressure. Whereas the groundwater level is the height of the water below the surface of the ground around the wellbore which shows a height or depth below the surface of the ground. On the surface of
the ground water, namely in the vadose zone, the soil pores may be filled with air or water, therefore it is sometimes called an aeration zone. In the phreatic zone (phreatic zone), which is below the groundwater level, cracks are filled with water, sometimes these lanes are called the zone of saturation.

3. RESEARCH METHODS
This study uses a quantitative approach, and is supported by a qualitative approach. The data obtained is to calculate what the level or percentage of salinity is quantitative data. Next to strengthen and check the validity of the data, it is complemented by observing, documenting studies, and interviewing people who understand the problem under study.

3.1 Types of research
This type of research is field research that is carried out with experiments within a certain time limit on salinity concentration (salinity) from well water sources.

3.2 Research Area
The research area is Purus Village, Padang Barat District, Padang City. The area of West Padang sub-district is 7.00 km², with a population of 59,895 people (2007 population census data) consisting of 10 sub-districts.

3.3 Data sources
3.3.1 Primary Data
Primary data is data taken directly from samples in the field. As well as the results of research at the Padang City Health Laboratory Center regarding salinity levels.

3.3.2 Secondary Data
Secondary data is population data and area maps obtained from the West Padang sub-district office, Purus village head, Central Statistics Agency, and data from the internet.

3.4 Population and Samples
3.4.1 Population
In this study the population is all community water wells Purus Village which is used as a source of water for daily needs.
3.4.2 Samples
The sampling method in this study was carried out by systematic sampling, by making a modified grid system based on the basic map of the research area. Then sampling is based on the grid sequence. Samples taken in the form of community well water around the node / research area were 18 sample points.
Using this method the sample points will spread to all parts of the study area and thus will be represented by the entire population.

- Sampling is carried out in a certain period, namely in conditions after rain and hot temperatures are carried out during the daytime. The sampling technique is:
  - a. Prepare the tool, which is a dark / black sample bottle
  - b. Take well water using a bucket / bucket, then rinse the bottle with well water
  - c. Fill the bottle (which is first covered with a foam cover) until it is filled with well water taken a little deeper and tilted using the aid of a stone ball tied to the rope and sample bottle then finally close the bottle tightly.
  - d. Give and mark each bottle at the sample point with the number or name of the sample
  - e. Then bring the sample to the laboratory for analysis

Along with sampling, measurements were also taken, namely:
- a. Determine the elevation and coordinates of the sample using GPS
- b. Measure groundwater level (MAT) using a meter

The way to care for samples is as follows:
- a. The sample tube must be filled with water of at least 250 ml
- b. Samples are taken to laboratories equipped with identities such as: number-sample numbers, time of collection, address of sampling and weather.

### 3.5 Instrumentation

In this study, instruments for measuring the sample are as follows:
- GPS (Garmin) to determine the coordinates and elevation of the land
- Meters to measure groundwater level (distance of surface of well water to ground level)

In testing samples a tool is needed:
- Sterilized bottles before and after sampling
- Labor tools to check salinity levels

### 3.6 Stages, Procedures, and Flow of Research

The stages in this study are:
- Preparation stage, this stage is carried out library research and observation to the field that has to do with the object of research and collect secondary data (supporting data / reference sources).
- The stage of field work and data collection, in this stage begins with a survey in the sampling area. Then proceed with determining the sample point and each point taken by well water based on the sample bottle volume. After sampling, groundwater level measurements were carried out using a meter and also determining the elevation and coordinate points of the sample using a GPS device.
- Data processing stage, water samples were examined in health laboratories by laboratory officers to determine water salinity levels and followed by the authors themselves to find out the procedures performed, salinity checks in health laboratories were carried out by Argentometry (Mohr) method for clean water and waste water. Furthermore, determining the distance of samples from the sea is measured using Google Earth software and entering groundwater level data per sample point. Furthermore, the data obtained will also be compared with drinking water quality standards according to the Regulation of the Minister of Health of the Republic of Indonesia No.492 / Menkes / Per / IV / 2010 concerning the quality requirements of drinking water.
- The preparation phase of the report, after all field data, laboratory data, and data processing are obtained are then compiled in the form of final report writing from the first chapter to the closing chapter
To see whether the variables studied reach the threshold, then the measurement results will be compared with the water standard Regulation of the Minister of Health of the Republic of Indonesia No. 492 / Menkes / Per / IV / 2010 concerning the quality requirements of drinking water.

Measurements of elevation, land surface (MT), Groundwater Level (MAT) and coordinates based on data obtained from measurements in the field using the meter and GPS are carried out as follows:

- Using the land using GPS, the sample point coordinates (x, y) are obtained
- Measure the groundwater level (MAT) on the ground using a meter
- The sample point elevation can be obtained from a GPS device that is measured directly at the time of sampling
- Measuring the distance of the sample by the sea at the sample point located on the seashore can be obtained through the processing of the next stage by using the Google Earth program.

After completion of measurements in the field, shallow well water samples are taken to the Laboratory to be tested for Salinity content.

In carrying out this research, a framework (research steps) will be described. As a first step a literature study is carried out. Next is a survey to the field or location of the study (Observation feasibility Study). Then search for secondary data (location data and technical data) and search for primary data, namely sampling, sampling, and laboratory exams. After all the data can be analyzed data consists of mapping and discussion. And finally the conclusion from all research work.

4. Research Result

4.1 Soil Condition

| Dot | X     | Y     | Depth   | Soil Type   |
|-----|-------|-------|---------|-------------|
| 1   | 650699.2 | 9896153 | 0 - 1,4 m | Pasir Halus |
| 2   | 650688.4 | 9896176 | 0 - 1,2 m | Pasir Halus |
| 3   | 650683.9 | 9896140 | 0 - 1 m   | Pasir Halus |
| 4   | 650689.3 | 9896113 | 0 - 1,2 m | Pasir Halus |
| 5   | 650699.2 | 9896176 | 0 - 1,2   | Pasir Halus |
| 6   | 650699.2 | 9896165 | 0 - 1,4 m | Pasir Halus |
| 7   | 650683.9 | 9896165 | 0 - 1,2   | Pasir Halus |
| 8   | 650688.4 | 9896153 | 0 - 1 m   | Pasir Halus |
| 9   | 650694.7 | 9896140 | 0 - 1,4 m | Pasir Halus |
| 10  | 650699.2 | 9896128 | 0 - 1,2 m | Pasir Halus |
| 11  | 650688.4 | 9896128 | 0 - 1 m   | Pasir Halus |
| 12  | 650668.9 | 9896111 | 0 - 1,2 m | Pasir Halus |

In there are many densely populated settlements. Coupled with the ongoing construction of flat towers, elementary schools, and hotels that increasingly add to the density of settlements. This kelurahan is also equipped with sanitation (riol) which extends along the purus village which serves to control the disposal of waste originating from residential settlements. And in the northern part of the Purus village, it is passed by the Flood Canal or Bakali Bandar.
4.2 Shallow Groundwater Front

Based on research and surveys that have been conducted in the field, it can be seen the coordinates of each sampling, distance between sample points, distance of sample points by sea, elevation (elevation) point, height difference between sample points, groundwater depth, and water level elevation land (MAT) from sea level (MAL). So that we can get a shallow groundwater contour map in Purus village, from this contour map we can also get a water flow pattern by drawing a perpendicular line from a high contour line to a lower contour. The results of the research on groundwater per sample point can be seen in the table below:

| Dot Sample | South (X) | East (Y) | Elevation (m) | Distance of sample point to MAT (m) | Distance from the coastline (m) | Elevation MAT (m) |
|------------|-----------|-----------|---------------|-----------------------------------|--------------------------------|------------------|
| 1          | 650614    | 9895854   | 5.8           | 0.39 m                            | 257                            | 5.41             |
| 2          | 650577    | 9895841   | 4             | 0.36 m                            | 218                            | 3.64             |
| 3          | 650468    | 9895770   | 4             | 0.55 m                            | 102                            | 3.45             |
| 4          | 650421    | 9896068   | 4.9           | 0.55 m                            | 89                             | 4.35             |
| 5          | 650542    | 9896031   | 3.7           | 0.49 m                            | 205                            | 3.21             |
| 6          | 650634    | 9896004   | 5.5           | 0.90 m                            | 299                            | 4.6              |
| 7          | 650641    | 9896202   | 4.9           | 0.77 m                            | 311                            | 4.13             |
| 8          | 650544    | 9896337   | 3             | 0.37 m                            | 234                            | 2.63             |
| 9          | 650500    | 9896281   | 3             | 0.62 m                            | 176                            | 2.38             |
| 10         | 650482    | 9896483   | 2.4           | 0.48 m                            | 172                            | 1.92             |
| 11         | 650555    | 9896388   | 3.4           | 0.41 m                            | 244                            | 2.99             |
| 12         | 650639    | 9896524   | 5.8           | 0.49 m                            | 332                            | 5.31             |
| 13         | 650634    | 9896717   | 5.5           | 0.37 m                            | 350                            | 5.13             |
4.3 Shallow Well Water Salinity Judging From the Distance of the Well to the Coastline (x1)
The source of salinity in the coastal area comes from the sea and the flow of groundwater (Kodoatie, 1996: 246). Freshwater waters have salinity levels of less than 0.2%, while those in salty waters can reach 3.5% (Muslimin, 1996: 95). According to RI Minister of Health Regulation No. 492 / Menkes / Per / IV / 2010 concerning the quality requirements for drinking water the standard of feasibility for Salinity itself refers to the level of chloride (<250 mg / l).

The results of the shallow water salinity testing based on the distance to the shoreline in the Purus village have the following data:

**Table 5.** Salinity test results of shallow wells based on well distance towards the coastline in Purus Village

| Sample Point | Concentration Chloride (mg/l) | Salinity (mg/l) = Cl⁻ x 1,817 | Standard of eligibility Chloride (mg/l) | Distance to the coastline (m) | Explanation |
|--------------|-------------------------------|-------------------------------|---------------------------------|-------------------------------|-------------|
| 1            | 20.67                         | 37.83                         | 250                             | 257                           | Eligible    |
| 2            | 18.66                         | 34.14                         | 250                             | 218                           | Sda         |
| 3            | 41.52                         | 75.99                         | 250                             | 102                           | Sda         |
| 4            | 44.08                         | 80.67                         | 250                             | 89                            | Sda         |
| 5            | 38.05                         | 69.63                         | 250                             | 205                           | Sda         |
| 6            | 9.33                          | 17.07                         | 250                             | 299                           | Sda         |
| 7            | 13.90                         | 25.44                         | 250                             | 311                           | Sda         |
| 8            | 3.11                          | 5.691                         | 250                             | 234                           | Sda         |
| 9            | 11.71                         | 21.42                         | 250                             | 176                           | Sda         |
| 10           | 86.89                         | 159.0                         | 250                             | 172                           | Sda         |
| 11           | 10.06                         | 18.41                         | 250                             | 244                           | Sda         |
| 12           | 12.26                         | 22.43                         | 250                             | 332                           | Sda         |
| 13           | 6.22                          | 11.38                         | 250                             | 350                           | Sda         |
| 14           | 9.70                          | 17.74                         | 250                             | 202                           | Sda         |
| 15           | 19.40                         | 35.48                         | 250                             | 88                            | Sda         |
| 16           | 12.26                         | 22.43                         | 250                             | 188                           | Sda         |
| 17           | Ttd                           | Ttd                           | 250                             | 240                           | Ttd         |
| 18           | Ttd                           | Ttd                           | 250                             | 351                           | Ttd         |

Source: research data

![Graph showing relationship between well distance and salinity](image)
**Figure 6.** Salinity profile in terms of the distance of the well to coastline (from the closest distance to the coastline)

Analysis using logarithmic regression method found that the trend of the relationship between the distance of the well from the coastline and salinity is a linear line in Figure 11. The trend data is the regression result. The results of the regression analysis show that in general the salinity value decreases when the distance is far from the coast.

4.4 Shallow Well Water Salinity Viewed From Ground Water Level Elevation (x2)

The sample points have elevation points higher than the sea. So that the groundwater level will also be more than the sea level. Moreover, sampling takes place during the rainy season so that the volume of groundwater in wells is more and higher.

Salinity test results of shallow well water based on groundwater level in Purus Village are as follows:

| Sample Point | Concentration Chloride (mg/l) | Salinity (mg/l) | Standard of eligibility Chloride (mg/l) | Elevation (m) | Elevation Ground Water Level (m) | Distance to The coastline (m) |
|---------------|--------------------------------|----------------|----------------------------------------|--------------|----------------------------------|-------------------------------|
| 1             | 20.67                          | 37.83          | 250                                    | 5.8          | 5.41                             | 257                           |
| 2             | 18.66                          | 34.14          | 250                                    | 4            | 3.64                             | 218                           |
| 3             | 41.52                          | 75.99          | 250                                    | 4            | 3.45                             | 102                           |
| 4             | 44.08                          | 80.67          | 250                                    | 4.9          | 4.35                             | 89                            |
| 5             | 38.05                          | 69.63          | 250                                    | 3.7          | 3.21                             | 205                           |
| 6             | 9.33                           | 17.07          | 250                                    | 5.5          | 4.6                              | 299                           |
| 7             | 13.90                          | 25.44          | 250                                    | 4.9          | 4.13                             | 311                           |
| 8             | 3.11                           | 5.691          | 250                                    | 3            | 2.63                             | 234                           |
| 9             | 11.71                          | 21.42          | 250                                    | 3            | 2.38                             | 176                           |
| 10            | 86.89                          | 159.0          | 250                                    | 2.4          | 1.92                             | 172                           |
| 11            | 10.06                          | 18.41          | 250                                    | 3.4          | 2.99                             | 244                           |
| 12            | 12.26                          | 22.43          | 250                                    | 5.8          | 5.31                             | 332                           |
| 13            | 6.22                           | 11.38          | 250                                    | 5.5          | 5.13                             | 350                           |
| 14            | 9.70                           | 17.74          | 250                                    | 4            | 3.61                             | 202                           |
| 15            | 19.40                          | 35.48          | 250                                    | 1.8          | 1.25                             | 88                            |
| 16            | 12.26                          | 22.43          | 250                                    | 2.1          | 1.63                             | 188                           |
| 17            | Ttd                            | Ttd            | 250                                    | 4            | 3.59                             | 240                           |
| 18            | Ttd                            | Ttd            | 250                                    | 3            | 2.51                             | 351                           |

*Source: research data*

**Table 6.** Salinity test results based on shallow wells Groundwater level in Purus Village

**Figure 7.** Salinity profile in terms of groundwater level (from the closest to sea level)
From the profile above it is explained that salinity levels taken from sample point 1 to sample point 18 have different groundwater depths so that they have varying salinity values except at points 17 and 18 which do not have salinity levels with groundwater depth 3, 59 m and 2.51 m. Therefore, it can be obtained irregular or scattered graph patterns with different salinity. The trendline that illustrates the pattern of salinity relations with the depth of the groundwater explains the tendency that generally the depth / depth of the water table is higher / higher than the sea level, the higher the salinity value.

Limitations in research:

- In the distribution of salinity according to the distance to the coastline and ground water level only see the effect of surface water and shallow groundwater while the relationship between sample points is not reviewed.
- This research is only conducted in one season, so to get more accurate results there needs to be another season and regular time.

5. Conclusions and recommendations

5.1 Conclusions

- Shallow groundwater level in Purus village between 5.8 m - 1.8 m.
- Salinity of shallow well water at each sample point occurs unevenly in Purus village. The highest salinity is 159.0 mg / l at the 10th point at a distance of 172 m from the coastline and the ground water level is 1.92 m above sea level. And the lowest salinity is 5.69 mg / l at point 8 at a distance of 234 m from the coastline with a groundwater level of 2.63 m. And there are two unidentified points of salinity.
- The profile of the distance between the well and the coastline with salinity generally illustrates that the farther the distance from the well to the coastline the lower the salinity value, while the profile of the relationship between the depth of the groundwater and salinity also generally shows that the farther the depth (height) groundwater to the sea level, the salinity value is higher.
- The salinity content in the Purus village is still within the normal limit for consumption, in accordance with the Regulation of the Minister of Health of the Republic of Indonesia No. 492 / Menkes / Per / IV / 2010 concerning drinking water quality requirements and eligibility standards for Salinity (<250mg / l).

5.2 Recommendations

- There needs to be retesting in certain seasons and other parameters as a comparison to find out the quality of shallow groundwater in the Purus Village in full
- There is a need for further and repeat research to find out the shallow groundwater elevation so that it is known that shallow ground water level fluctuations in Purus Village
- For the Purus village community to supervise the quality of shallow well water by paying attention to the technicality of well construction, drainage, good septic tank construction and maintaining and maintaining it properly, because the spread of salinity is influenced by surface water flow and or shallow groundwater flow.

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