Pengaruh pencemaran udara terhadap kualitas air sumur : studi kasus air sumur penduduk wilayah industri Cibinong-Citeureup-Gunung Putri

Ani Iryani, author

Abstrak

Kualitas udara di wilayah industri pada umumnya menunjukkan kecenderungan meningkatnya polusi yang disebabkan adanya emisi gas dari aktivitas industri dan transportasi. Jenis dan jumlah emisi atau pencemar udara bergantung pada jenis dan atau jumlah industri yang ada di wilayah itu. Pada umumnya pencemar udara yang berasal dari industri dan transportasi berupa partikel debu dan gas-gas seperti oksida nitrogen (NOx), oksida belerang (SOx), karbonmonoksida (CO), dan hidrokarbon (HC).

Emisi gas dari udara dapat langsung masuk ke badan air atau terbawa oleh air hujan dan meresap melalui tanah ke badan air. Gas-gas buang yang mengandung oksida nitrogen dan oksida sulfur (NOx dan SOx) dapat bereaksi dengan molekul-molekul air di udara membentuk asam sulfat (H2SO4) dan asam nitrat (HNO3) kemudian turun ke bumi sebagai hujan asam. Melalui sistem rembesan dalam tanah (ground wafer cycle), hujan asam ini berpengaruh terhadap kualitas air sumur.

Daerah Cibinong-Citeureup-Gunung Putri dengan luas wilayah 36,42 km2 merupakan contoh wilayah industri yang padat transportasi dan banyak aktivitas industrinya. Terdapat lebih dari 13.748 kendaraan bermotor dan 228 industri berskala besar dan sedang yang ada di Kecamatan Cibinong-Citeureup dan Gunung Putri (BPS Kab. Bogor, 2000). Jenis industri yang ada meliputi industri rumah tangga, farmasi dan obat-obatan, tekstil, kimia, otomotif, dan semen.

Berdasarkan data sebelumnya (tahun 1999), pH rata-rata air hujan di wilayah Cibinong-Citeureup adalah 5,07. Hal ini menunjukkan bahwa telah terjadi hujan asam di wilayah tersebut. Kualitas air sumur penduduk di wilayah Cibinong-Citeureup juga rendah. Berdasarkan penelitian sebelumnya, diperoleh data bahwa pH rata-rata air sumur di wilayah Cibinong-Citeureup 5,09 (tahun 1995) dan turun menjadi 4,63 pada tahun 1999.

Untuk mengetahui apakah kualitas udara berpengaruh pada kualitas air hujan dan apakah kualitas air hujan memang berpengaruh pada kualitas air sumur, maka dilakukan penelitian dengan mengukur parameter-parameter kunci. Penelitian ini bertujuan untuk: (a) mengetahui kualitas air hujan di wilayah industri Cibinong-Citeureup-Gunung Putri dan wilayah pembanding, dengan mengukur konsentrasi ion nitrat (NO3-), ion sulfat (S042), dan keasaman (pH);

(b) mengetahui kualitas air sumur penduduk wilayah industri Cibinong-Citeureup-Gunung Putri dan wilayah pembanding, dengan mengukur konsentrasi ion nitrat (NO3-), ion sulfat (SO42), keasaman (pH), logam Fe, dan kesadahan/CaCO3;

(c) mengetahui hubungan antara derajat keasaman (pH) dengan konsentrasi logam besi (Fe) dalam air sumur; dan (d) mengetahui pengaruh pencemaran udara yang berasal dari kualitas air hujan terhadap kualitas air sumur.

Hasil penelitian ini diharapkan dapat: (a) memberikan informasi mengenai kualitas air hujan dan air sumur di wilayah industri Cibinong-Citeureup-Gunung Putri terutama kepada PEMDA setempat, industri yang mencemari, dan masyarakat/penduduk di wilayah itu; (b) memberikan informasi mengenai bahaya pencemaran terhadap badan air terutama air sumur yang digunakan untuk keperluan rumah tangga kepada masyarakat/penduduk di wilayah penelitian, serta memberikan solusi untuk pengolahan air agar dapat dipakai untuk air minum.

Hipotesis yang diajukan adalah: (a) terdapat perbedaan kualitas air hujan dari wilayah industri Cibinong-Citeureup-Gunung Putri dengan wilayah pembanding; (b) terdapat perbedaan kualitas air sumur penduduk dari wilayah industri Cibinong Citeureup-Gunung Putri dengan wilayah pembanding, dan (c) terdapat hubungan antara derajat keasaman (pH) dengan konsentrasi logam besi (Fe) dalam air sumur.

Penelitian dilakukan dengan metode survei dan expost facto, dimana sampel air hujan diambil dari 14 titik lokasi penelitian dan air sumur diambil dari sumur-sumur penduduk yang berada pada lokasi yang sama dengan pengambilan air hujan.

Parameter pH (derajat keasaman), daya hantar listrik (DHL), dan Total Dissolved Solids/total padatan terlarut (TDS) diukur langsung di lapangan, sedangkan pengukuran konsentrasi N03 (nitrat), S042 (sulfat), logam Fe (besi), dan kesadahan (CaCO3) dilakukan di Laboratorium Kimia, Fakultas MIPA-Universitas Pakuan Bogor.

Data penelitian terdiri atas data primer dan data sekunder. Data primer diperoleh dari pengukuran secara langsung di lapangan dan di laboratorium. Data sekunder diperoleh dari penelitian sebelumnya, studi pustaka, instansi terkait, dan dari sumber-sumber lain. Data primer dan sekunder ini kemudian dianalisis secara deskrptif dan dilakukan uji statistik Two-Independent-samples Test untuk menguji perbedaan kualitas air hujan dan air sumur di wilayah industri dan wilayah pembanding, dan uji Bivariate correlation, utuk melihat hubungan antara derajat keasaman (pH) dengan konsentrasi logam besi (Fe) dalam air sumur. Berdasarkan hasil penelitian dapat disimpulkan bahwa:

(a)Air hujan untuk wilayah industri mempunyai nilai rata-rata derajat keasaman (pH) 4,47; kadar nitrat (NO3) 3,3302 mg/L; sulfat (SO42) 3,5806 mg/L, sedangkan untuk wilayah pembanding, nilai rata-rata derajat keasaman (pH) adalah 6,13; kadar nitrat (NO3) 0,0283 mg/L dan sulfat (SO42-) 0,0079 mg/L. Jadi pada tingkat kepercayaan 95% secara statistik diperoleh nilai Z hitung (-2,58 untuk pH, -2,575 untuk S042-, dan -2,569 untuk N03), sehingga terdapat perbedaan kualitas air hujan dari wilayah industri dengan wilayah pembanding untuk parameter derajat keasaman (pH), kadar nitrat (NO3), dan sulfat (SO42-);

Air sumur penduduk di wilayah industri mempunyai nilai rata-rata derajat keasaman (pH) 4,11; kadar nitrat (NO3-) 6,19 mg/L; sulfat (SO42) 5,44 mg/L, besi (Fe) 0,27 mg/L, dan kesadahan (CaCO3) 30,10 mg/L

sedangkan untuk wilayah pembanding, nilai rata-rata derajat keasaman (pH) 6,70; kadar nitral (NO3-) 0,4011 mg/L; sulfat (SO42) 1,6599 mg/L, besi (Fe) 0,3508 mg/L, dan kesadahan (CaCO3) 34,30 mg/L. Jadi pada tingkat kepercayaan 95% secara statistik diperoleh nilai Z hitung (-2,569 untuk pH, -2,260 untuk S042-, -2,569 untuk N03, -0,584 untuk Fe dan -0,857 untuk Ca C03), maka terdapat perbedaan kualitas air sumur penduduk dan wilayah industri dengan wilayah pembanding untuk parameter derajat keasaman (pH), kadar nitrat (NO3-), dan sulfat (S042), tetapi tidak terdapat perbedaan untuk parameter kandungan besi (Fe) dan kesadahan (CaCO3);(c} Nilai koefisien korelasi (r) antara derajat keasaman (pH) dengan konsentrasi logam besi (Fe) adalah sebesar -0,976. Jadi terdapat hubungan negatif yang cukup erat antara pH dengan konsentrasi besi (Fe) dalam air sumur. Makin rendah pH (makin asam), konsentrasi besi makin tinggi.

Jadi kesimpulan umum dari penelitian ini adalah: Pencemaran udara yang berasal dari air hujan berpengaruh terhadap kualitas air sumur.

Selanjutnya disarankan untuk mengadakan penelitian lanjutan untuk menentukan besarnya persentase distribusi dari sumber bahan pencemar (industri/pertanian), kepadatan penduduk, jenis/kondisi tanah dan akibat yang berpengaruh terhadap kualitas air sumur. Hal ini penting untuk mengetahui faktor yang paling berpengaruh terhadap kualitas air sumur dan menentukan prioritas dalam pengendalian pencemaran air sumur. Untuk sumur-sumur yang mempunyai derajat keasaman tinggi (nilai pH rendah), maka untuk menaikkan nilai pH bisa diberikan CaO (kapur). Hal ini pemah diteliti sebelumnya dimana untuk menaikkan pH satu liter air sumur dari 5,732 menjadi 7,00 (pH netral), jumlah CaO yang diperlukan adalah 0,0204 gram.
<hr>
The Influence of Air Pollution To The Quality Of Well Water(Case Study: Well Water Used by Population of the Cibinong-Citeureup-Gunung Putri Industrial Districts)Generally, the air quality in the industrial districts indicates the increase of pollution due to the existence of gas emission coming from industrial and transportation activities. The type and the number of emission or air pollutant will depend on the type and or the quantity of industries located in respective district. In general, air pollutant which comes from industry and transportation consists of dust particles and gasses such as nitrogen oxides (NOx), sulfur oxides (SOx), carbon monoxide (CO), and hydrocarbons (HC).

Gas emission from the air could directly come to the body of water or be brought by rainwater and then absorbed to the body of water through the ground. The exhausts that contain nitrogen oxides and sulfur oxides (NOx and SOx) could react with water molecules in the air to form sulfuric acid (H2SO4) as well as nitric acid (HNO3), afterwards they fall to earth as an acid rain. Through the ground water cycle system, this acid rain influences the quality of well water.

The Cibinong-Citeureup-Gunung Putri districts with area of 36.47 km2 are the example of industrial districts that have massive transportation and have many industrial activities. There are more than 13,748 motor vehicles and 228 large as well as medium scale industries which are located in Cibinong-Citeureup-Gunung Putri sub-districts (BPS [Central Bureau of Statistics] of Bogor Regency, year 2000). The industries available are including household, pharmaceutical and medicines, textile, chemical, automotive, and cement industries.

Base on previous data year of 1999, the average of the acidity (pH) of rainwater in Cibinong-Citeureup districts was 5.07. This indicates that there has been an acid rain occurred on these districts. The quality of well water used by population of Cibinong-Citeureup becomes worst. Based on the previous research, the average of acidity (pH) of well water in the Cibinong-Citeureup districts was 5.09 (year 1995) and it decreased to 4.53 in 1999. In order to find out whether the air quality gives influence to the quality of rainwater and whether the quality of rainwater really gives influence to the well water, a research it needed by measuring the key parameters.

This research has purposes to: (a) find out the quality of rainwater in the Cibinong-Citeureup-Gunung Putri industrial districts as well as in the reference district by measuring the concentration of nitrate ion (NO3-), sulfate ion (SO42'), and acidity (pH); (b) find out the quality of well water used by population in Cibinong-Citeureup-Gunung Putri industrial districts as well as the quality of well water in the reference district by measuring the concentration of nitrate ion (N03), sulfate ion (SO42-), acidity (pH), Fe metal, and hardnesslCaCO3; (c) to find out the corelation between degree of acidity (pH) and concentration of iron metal (Fe) in the well water; and (d) to find out the influence of air pollution which comes from the quality of rainwater to the quality of well water.

The output of research hopefully could: (a) gives information about the quality of rainwater and the quality of well water in Cibinong-Citeureup-Gunung Putri industrial districts to the respective local government (PENIDA), all industries who tend to create pollution as well as society / population of those districts; (b) gives information to the society / population in the research location regarding the danger of pollution to the body of water, mainly the domestic well water, and also gives a solution about the treatment for the water that would use as a drinking water.

The proposed hypothesis was: (a) there is difference between the quality of rainwater in the Cibinong-Citeureup-Gunung Putri industrial districts and that of the reference district; (b) there is difference between the quality well water of population in Cibinong-Citeureup-Gunung Putri industrial districts and that of the reference district; (c) there is a correlation between the degree of acidity (pH) and the concentration of iron (Fe) in the well water.

Research is carried out by using a survey and ex post facto methods where the samples of rainwater were collected from 14 research locations, while sample of well water were collected from the residential wells at the same location whit that of samples of rainwater were collected.

Degree of acidity (pH), electric conductivity (DHL), and total dissolved solids (TDS) parameters were measured directly on the spot, while concentration of N03 (nitrate), SO4 (sulfate), Fe (iron), and hardness (CaCO3) were analyzed at the Laboratory of Chemical, Faculty of Mathematics and Natural Sciences (MlPA) University of Pakuan, Bogor. Research data consist of primary and secondary data. Primary data were obtained by direct measurement on the spot and at the laboratory. Secondary data were obtained from previous research, bibliography (references), related institutes, as well as other sources of information. These primary .and secondary data were, then analyzed descriptively and statistically with Two-

Independent-Samples Test to examine the difference of rainwater and well water quality in the industrial districts and the reference district. One more test called Bivariate Correlation is done in order to see the correlation between the degree of acidity (pH) and the concentration of iron (Fe) in the well water.

Research conclusions were:

(a) Rainwater in the industrial districts has average value of acidity degree (pH) of 4.47; nitrate (NO3-) content of 3.3302 mg/L; sulfate (SO42-) content of 3.5806 mg/L, while rainwater in the reference district has the average value of acidity degree (pH) of 6.13; nitrate (NO3) content of 0.0283 mg/L and sulfate (SO42-) content of 0,0079 mg1L. Thus, at 95% level of confidence, statistically it was obtained the calculated Z value (-2.58 for pH, -2.575 for S042-, and -2.569 for N03-), so that there was a difference between the quality of rainwater in the industrial districts and that the reference district for the parameter of degree of acidity (pH), nitrate (NO3-), and sulfate (SO42') content;

(b)Well water used by population of the industrial districts has average value of acidity degree (pH) of 4.11; nitrate (NO3') content of 6.19 mg/L; sulfate (50422') content of 5.44 mg/L,; iron (Fe) content of 0.27 mg/L; and hardness (CaCO3) of 30.10 mg/L, while well water in the reference district has the average value of acidity degree (pH) of 6.70; nitrate (NO3-) of 0.3508 mg/L; and hardness (CaCO3) of 4.30 mg/L. Thus, at 95% level of confidence, statistically it was obtained the calculated Z value (-2.569 for pH, -2.260 for 5042-, -2.569 for NC3-, -0.584 for Fe and -0.857 for CaCO3). So that there was a difference between the quality of well water of the industrial districts and that of the reference district for the parameter of degree of acidity (pH), nitrate (NO3-) content and sulfate (SC42..) content, but there is no significant difference for the parameter of iron (Fe) content and hardness (CaCO3);

(c) the value of correlation coefficient (r) between the degree of acidity (pH) and the concentration of iron (Fe) is -0.976. Hence, there is a close negative correlation between pH and concentration of iron (Fe) in the well water. The lower (the more acid) the pH, the higher the concentration of iron (Fe).

The general conclusion of this research is: Air pollution which come from rainwater affected to the quality of well water. For the next step, it is suggested to conduct a further research to determine the distribution percentage of the source of pollutant materials (industry/agriculture), population density, type/condition of soil and aquifer that influence to the quality of well water. This is important to be done to find out the most influencing factor to the quality of well water, and to determine the priority in reference ling the well water pollution. To increase the pH value for the wells that have high degree of acidity (low pH value), it could be added with CaO (quick lime). It has been examined previously, where 0,0204 gram of CaO was needed to increase the pH of one liter of well water from 5.732 to 7.00 (neutral pH).