Estimation of Irrigation Pumpage Using Monthly Electricity Usage — A Case Study of Changhua-Yunlin Area

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Abstract

This study aims to establish the relationship between groundwater pumpage, electricity usage and the properties of each pumping well including the motor output, the pipe diameter and the well depth. Once the relationship was established, the irrigation pumpage can easily be estimated for all pumping wells by analyzing the electricity usage and the properties of each specific pumping well. The Changhua-Yunlin area was chosen for the field application of the developed relationship in this research. A total amount of 20 pumping wells were chosen as sampling wells and the electronic meters were installed in these wells to record actual water pumpage, electricity usage and attribute data of each individual well. By combining with the data from another 3,507 wells that were calculated based on the in-situ, stage-discharge rating curve, the mathematical relationship can be established by using linear model. Seven types of linear equations were established and most of the correlation coefficients were larger than 0.71. The developed linear equations were used to evaluate the irrigation pumpage from about 156 thousand wells in Changhua-Yunlin area from 2010 to 2012. The results showed that the average annual irrigation pumpage was approximately 1.276 billion tons.

Methodology

First, we used the observation pumpage, electricity usage of 20 wells that were installed electronic water meter, and combined the unit electricity pumpage of 3,507 wells that in field test data from Water Resources Agency in recent years. To build 7 kinds of linear estimation model, which were shown in Table1.

<table>
<thead>
<tr>
<th>Well attribute data</th>
<th>Well</th>
<th>Linear model</th>
<th>Correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>P, D, H</td>
<td>1.43</td>
<td>P = 0.79 + 1.22D + 0.01H</td>
<td>0.722</td>
</tr>
<tr>
<td>P, H</td>
<td>1.432</td>
<td>P = 0.82 + 1.45D</td>
<td>0.727</td>
</tr>
<tr>
<td>P, D</td>
<td>1.438</td>
<td>P = 2.28D + 0.04H</td>
<td>0.732</td>
</tr>
<tr>
<td>P, H, D</td>
<td>1.598</td>
<td>P = 1.92D + 0.05H</td>
<td>0.749</td>
</tr>
<tr>
<td>D, H</td>
<td>1.412</td>
<td>D = 1.58D + 0.04H</td>
<td>0.783</td>
</tr>
<tr>
<td>P</td>
<td>1.696</td>
<td>P = 2.61D</td>
<td>0.299</td>
</tr>
<tr>
<td>H</td>
<td>1.618</td>
<td>H = 0.0604H</td>
<td>0.363</td>
</tr>
</tbody>
</table>

Table1: Seven kinds of linear estimation model.

Third, we used fallow layers to compare 180 thousand wells coordinates in Changhua-Yunlin area, to filter out irrigation wells. And we used four conditions of electricity usage reliability analysis to excluding non-irrigation wells electricity usage from Tai-Power Company.

Results

In this study, the irrigation wells were selected from 180 thousand wells, shown in Table2. To estimate irrigation pumpage from 2010 to 2012 in Changhua-Yunlin area, that will be divided into three parts. First part, irrigation wells applied linear estimation model were about 148 thousand wells, and results were shown in Table3. Second part, the irrigation wells applied large horsepower well were 342 wells. Third part, the irrigation wells applied no data well were 7,531 wells. The total results were shown in Table4.

Conclusion

In this study, the linear estimation model was established by using 20 electronic water meters which were installed as possible as covering entire area in Changhua-Yunlin area, and got the real-time pumping record per hour. For increasing the needed information breadth, we got the more accurate and long-time observation pumping records, and combined the in field investigation data of 3,507 wells, to calculate unit electricity pumpage by using monthly electricity usage. So we considered well attribute data (P, D, H) to build the linear estimation model, that should be better than manual calculation of unit electricity pumpage which only considered well attribute data (P, D). And that will more close to the actual pumpage.