Standalone Desktop application for pumping test data analysis

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Abstract

There is an immediate necessity to look into how aquifers respond to different human activities in terms of both quantity and quality of groundwater. A stand-alone desktop application for evaluation and interpretation of pumping test data can be distributed as freeware for use by groundwater experts, researchers, students, teachers, and others.

The pumping test is the most common and accepted technique for figuring out an aquifer's hydraulic properties.

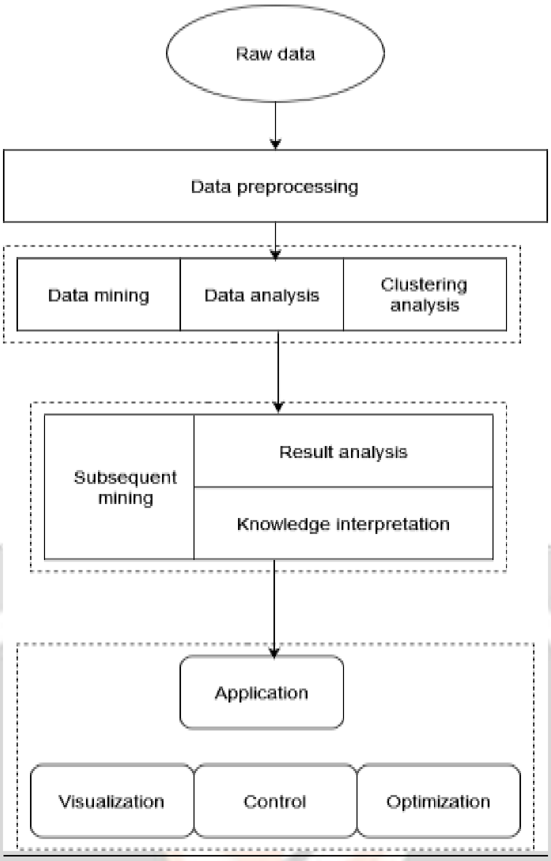
A pumping test help us determine a number of aquifers' properties, including transmissivity, storativity, and specific yield . Data from pumping tests are typically evaluated using computer programmes . Since there is no computer software offered in India for this use. The Central Ground Water Board is proposing to develop a stand-alone desktop application for the study and interpretation of pumping test data that can be used by groundwater specialists, pupils, researchers, educators, and other users. This software will be offered as freeware. The user has the option of directly entering data using interfaces or importing it from already-existing datasets.[3]

Result: a desktop programme that can analyse and interpret data from pumping tests on its own. The software application can take manual entry of data components for interpreting the graphs using theis method,wellbore storage,hantush and jacob methods . [3]

INTRODUCTION:

With the increase of human population its demands has increased and resources are limited and in one of those resources water is undisputedly holds the top spot. Since we get most of our water from groundwater resources the government and concerned authorities have increased their data collection and keep records of water levels and parameters related to aquifers. But for better and efficient use of the collected records we will use data analysis which comprises steps like data preprocessing which further includes data cleaning and data mining. Next steps include data analysis which includes result analysis ,knowledge interpretation and subsequent mining. Transmissivity (Ts) and storage coefficient(Se), two crucial aquifer parameters, are frequently assessed using groundwater pumping tests. Numerous mathematical models have been devised and released in academia to forecast the hydraulic characteristics of aquifers relying on the suitable system features and boundary conditions.The first model for forecasting rapid decline patterns in a restricted aquifer was a nonlinear equation put forth by Theiss. Later, a number of visualisation techniques for predicting Ts and Se parameters from data have been developed using the Theiss model. Theiss model has been expanded by researchers to describe many aquifer system types; for instance, Hantush created a semilogarithmic plot to analyse constrained leaky aquifers.For the analysis of pump test data from various types of aquifers, Kruseman and de Ridder offered comprehensive visual approaches. These graphical techniques may be arbitrary, and their outcomes may vary greatly.[1]

For instance, nanda and Thakur looked at the discharge rate variations that occurred during pump tests and showed how these affected Ts and Se values. One of the earliest studies to study pump test data using the least-squares method was McElwee, which showed that the automatic method produced good outcomes than the conventional visual fitting method.



Methods:

Pump Function of Theis:

The drawdown of the well can be derived by using - $\Delta D = do - d = (R/4\pi Ts)P(v)$

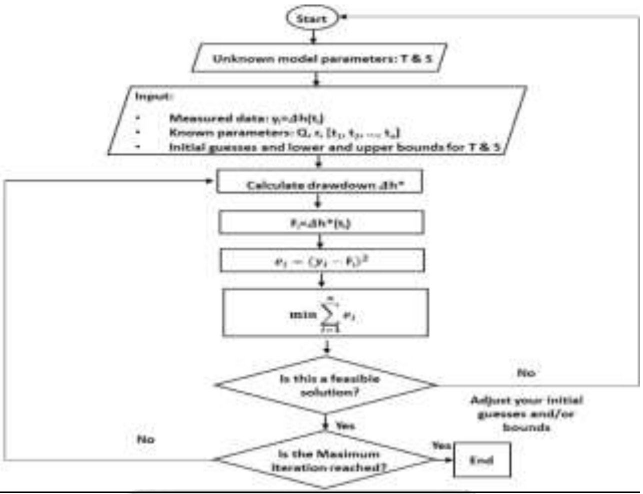
where R is the pump rate, d is the drawdown variable head, d0 is the initial drawdown head variable, $d0 - d$ is the total drawdown, Ts is the aquifer transmissivity, and P(v) is the pump function. The coarse grained value of pump function can be derived by an never ending series :

$P(v) = -0.5772 - \ln(v) + \sum_{n=1}$ (v^n/n.n!) − (v^n+1/n+1·n+1!)+(v^n+2/n+2·n+2!) −(v^n+3/n+3·n+3!) + · · ·

The following equation's definition of pump function for various values of v has been easily summed up.:
V=(r^2)Se/4(Ts)t
where Se is the aquifer storage coefficient, t represents the amount of time since pumping began, r is the radial distance from the observation well, and v is an arbitrary constant[1].

The Variable Estimation Method Used In Analysis:

The visual method, originally developed by Mr.Jacob and his team, is generally used theoretically to estimate drawdown data to the above method and approximate the Ts and Se values. To analyse the pumping test we employ a non linear solver from the python curve fitting library. The whole steps of fitting procedure can be summarised as below:



Hypothesize Values and Parameter Bounds for Ts and Se Values:

The Pumping Test Data Analysis requires the user to provide initial hypothesised values. In our project, the initial hypothesised value for Ts is set to 1 m2/d.
Approximately the minimum bound value of Ts is 0.01 m2/day, and the maximum bound is 1.0 × 105.
The confined compressibility of an aquifer is typically 1.0 × 10−6, while the unconfined specific yield is typically 0.1.

Calculation of the Transmissivity and Storing Values Fallacy

The Theis graphical method cannot quantitatively estimate the errors in the approximate values of Ts and Se, which can lead to inaccuracy in the reported parameter values.
Value Curve fitting routines used in this study provide a covariance matrix comprising the framework values with the best match. This covariance matrix's square root corresponds to the square root of the fallacy underlying the parameter values. With this error estimate, the best-fit framework values may be published with the appropriate number of noteworthy figures by adhering to the conventional rounding method, which is outlined below.

Using a standardised scientific notation, the framework values and the corresponding fallacy values are expressed. unit, it is possible to determine how many significant figures should be used. Because fallacy estimates are estimates of what we do not know, we should round them up to one (maximum of two, in rare cases). Significant figure. One can then use the first non-zero numbers of the fallacy value to shorten the estimated parameter value's significant digit.

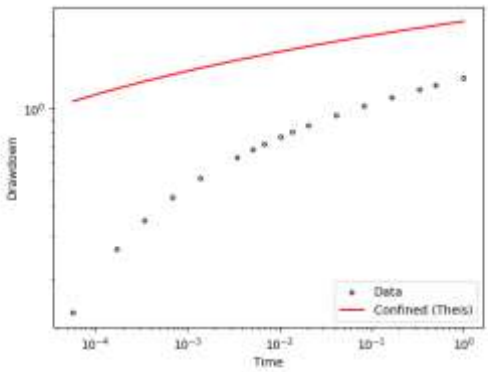
Test Problems Considered in This Study:

The data that any researcher wishes to input can be manually typed into the system i.e. aquifer hydraulic conductivity , specific storage , specific yield,thickness and aquitard thickness , vertical conductivity,specific storage,well radius and pumping rate.

Technology Implemented:

PYTHON:

Python is a popular programming language widely used for data analytics and building data analytics applications. Its simplicity, extensive library ecosystem, and powerful data processing capabilities make it a preferred choice among data analysts and data scientists.
We have used python for our data analytics application.



PYQT5 GUI:

PyQt5 is a Python binding for the popular cross-platform GUI toolkit, Qt. It allows developers to create graphical user interfaces (GUIs) for their Python applications with ease.
As mentioned above we have used python for creating application which will be used in data analysis of the pumping test data.

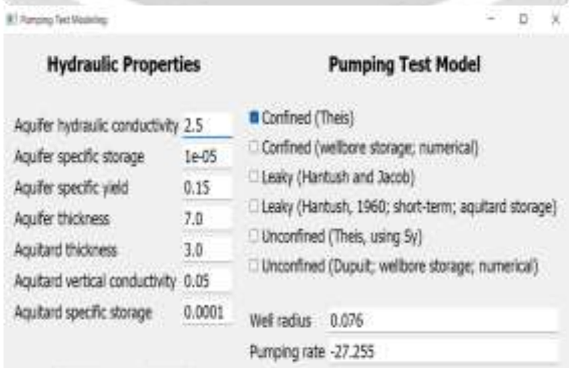
PyQt5 provides a powerful and flexible framework for building GUI applications in Python. With its comprehensive features, cross-platform compatibility, visual design tool, extensive documentation, and strong community support, PyQt5 is an excellent choice for developers looking to create modern and interactive user interfaces for their Python applications.

SCIPY:
We have used scipy module of python which is based on numpy which helps us in doing complex calculations for getting the outputs.

APPLICATION OF PUMPING TEST ANALYSIS APP:

At first the user(who is a person in civil dept or a researcher) will enter the aquifer properties and aquitard properties which will give a graph of drawdown against time which will help the user know how easily water can be extracted.

Input:



Three types of soil :

1. Confined Soil:

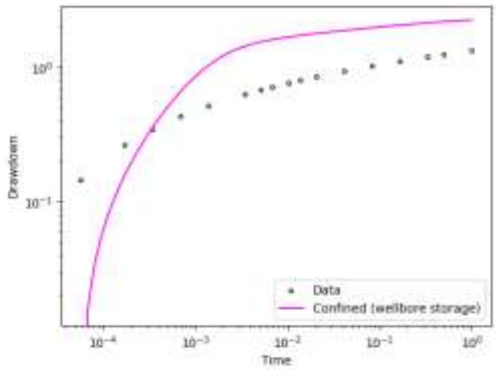
Confined soil refers to a situation where an impermeable layer, known as an aquitard or confining layer, is present both above and below the soil layer. This impermeable layer restricts the vertical movement of groundwater within the soil. As a result, the water in the confined soil is under pressure, typically referred to as artesian pressure. When a well is drilled into a confined soil layer, the water may rise above the top of the aquifer due to the pressure.

There is two methods for which we implemented:

1. Theis method: This method uses formula to give us estimation of drawdown.
And as we know taking out water from confined soil is difficult so we get

expected result.

2. Confined from wellbore storage:



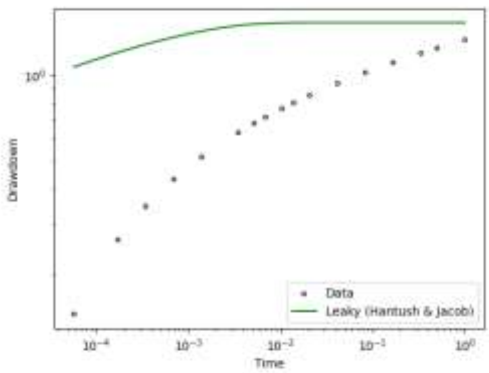
As we can see in above figure we can see that if their is a wellbore in the confined soil it takes a far less time or drawdown to get water out.

2. Leaky Soil:

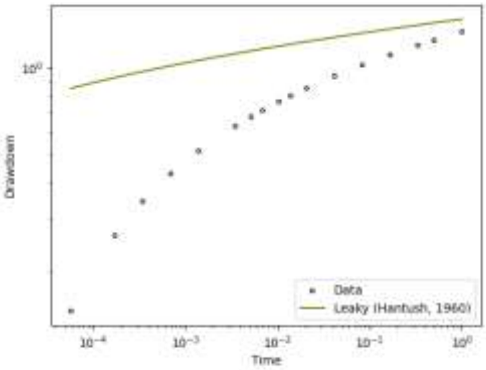
Leaky soil, also known as semi-confined soil, is a condition where the soil is bounded by an aquitard below it but lacks an impermeable layer above it. This means that water can seep into or out of the soil layer from the top, allowing some vertical movement of groundwater. However, the presence of the lower aquitard restricts the vertical flow to some extent.

We have implemented two methods for leaky soil:

1. Hantush and jacob method :
Hantush and Jacob are two influential hydrogeologists known for their contributions to the field of groundwater flow and aquifer analysis. They have developed mathematical models that are widely used for simulating groundwater flow in aquifers.



2. Hantush method(1960):

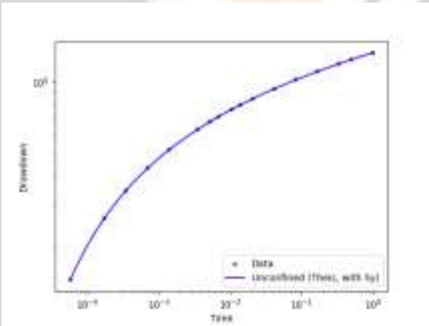


3. Unconfined soil:

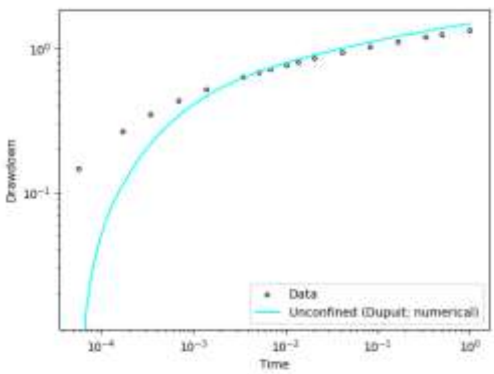
Unconfined soil, also called a water table aquifer, refers to a situation where there is no impermeable layer above the soil layer. In this case, the water table represents the upper boundary of the groundwater, and it fluctuates depending on factors such as precipitation, evaporation, and water extraction. The water in the unconfined soil is not under pressure, and its level is typically at or near the ground surface.

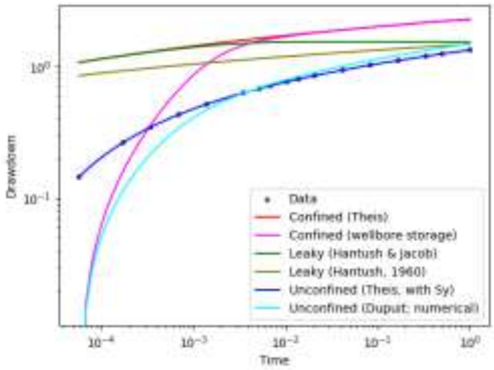
We have implemented two methods for this type of soil:

1. Theis method:



2. Dupuit method for wellbore storage:





Above image compares all methods that we have shown above in one graph.

Future enhancements:

As we have implemented the application to help the user to get data easily for different kind of soils but we can make changes to the system as per user feedback and add more parameters if needed and we can even add more equations or any other function that would be needed or even to correct some error in our theoretical understanding of the subject as we have limited knowledge of the civil topics.

References

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