International Journal of Scientific Research and Engineering Development-– Volume 3 Issue 2, Mar-Apr 2020

Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

A Study on Groundwater Flow Velocity at Andhra University Campus, Visakhapatnam

Sreejani TP*, Srinivasa Rao GVR**

*(Civil Engineering Department, MVGR College of Engineering, and Vizianagaram
Email: sreejanitp@gmail.com)

** (Civil Engineering Department, Andhra University, and Visakhapatnam
Email: gvrsrao@gmail.com)

--************************----------------------------------

Abstract:

The following study forms part of a multidisciplinary program of research involving the understanding of the groundwater dynamics in the study area by identifying the groundwater flow paths and performing the groundwater tracer test. Investigations of the transport of tracer in an unconfined aquifer require knowledge of aquifer hydraulic and transport properties to improve prediction of the rate and direction of movement of groundwater. The study area is Andhra University located in Visakhapatnam. The lithology of the study area is composed of red sandy soil followed by weathered rock, fractured rock and hard rock, where an unconfined aquifer is located. The field experiment is conducted by injecting in the borehole, a saturated salt-water solution and monitoring the tracer dilution with respect to the progression time in the well near the injection bore hole, until the initial situation is restored. The dilution log is obtained by measuring the electrical conductivity of the water. Using the concentration breakthrough the groundwater velocity in the study area is determined. This study is conducted all along the flow directions / pathways of the groundwater in the study area which are identified by developing a raster data using the geographical coordinates, elevations and lithological data.

Keywords **—Groundwater flow paths, Groundwater tracer tests, Breakthrough curve, Velocity.**

--************************----------------------------------

I. INTRODUCTION

Groundwater is the most preferred source of water in various user sectors in India on account of its near universal availability, dependability and low capital cost (Jha B.M. et al 2009). The groundwater used for irrigation accounts for 88 percent of total groundwater usage (Future Directions International, 2017). A common groundwater management plan is extremely a complex proposition and difficult to be arrived at due to the highly uneven distribution and utilization of groundwater resources (Jha B.M. et al 2009). Therefore, studies on local groundwater flow are essential to arrive at an effective management plan for proper utilization of the groundwater resources for specified areas.

The Tracer tests are the most reliable methods for establishing flow trajectories and hydrological connections in an aquifer system, leading to the determination of hydraulic and geometric parameters, groundwater flow paths.

This technique is known as the borehole dilution or point-dilution method (Stefano Basiric et al. 2015). The test can be conducted by introducing a salt tracer into a well section and monitoring its decreasing concentration over time. The test provides an estimate of the horizontal average linear velocity of the groundwater in the formationnear the well screen (Leonardo Piccinini et al. 2015).

II. STUDY AREA

The study area is Andhra University Campus with an extent of 422 acres located in Visakhapatnam district, Andhra Pradesh and situated on the eastern shore of India with 17° 43′ 45.38″ Northern latitude and 83° 19′ 17.61″ Eastern longitude. The elevation of the study area varies from 10m MSL to 62.5m MSL. The following figure, Fig.1 shows the study area.

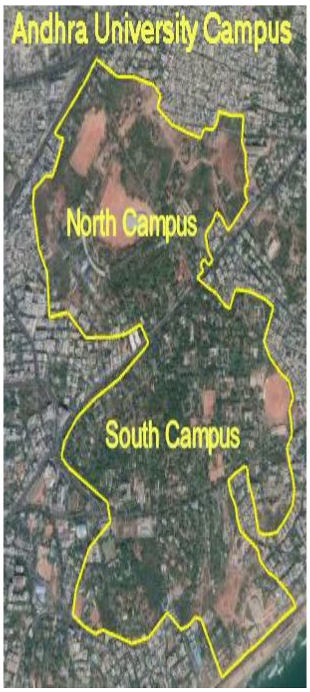

Fig. 1 Study Area

III. METHODOLOGY

Figure 2 depicts the methodology adopted in the present work. The typical approach to analyse dilution test data is derived from the assumption that the tracer is non-reactive and introduced instantaneously at concentration Co into an isolated well test section. If all tracer dilution is caused by groundwater flow through the test section and if the flow is steady, at time t>0, the tracer concentration (C) decreases by the rate:

$$\frac{dc}{dt} = -\frac{AVaC}{W} \ldots \text{ Eq} - 1$$

(Freeze and Cherry 1979)

Where;
Va = apparent velocity across the centre of the well test section,
W = dilution volume, and
A = cross-sectional area perpendicular to the direction of undisturbed groundwater flow.

Rearrangement of (1) yields:

$$\frac{\mathrm{dc}}{\mathrm{c}} = -\frac{\mathrm{A\ Va\ dt}}{\mathrm{W}} \qquad \ldots \text{ Eq} - 2$$

Integration and use of the initial condition C = Co at t = 0 leads to:

$$\mathrm{Va} = -\frac{\mathrm{W}}{\mathrm{At}}\ln\left(\frac{C}{Co}\right) \qquad \ldots. \text{ Eq} - 3$$

And then:

$$\ln C = -\left(\frac{2\ \mathrm{Va}}{\pi r}\right) t + \ln Co \ldots \text{ Eq} - 4$$

Where;

r = radius of the well,
C = tracer concentration at any time,
Co = initial concentration, t = time.
The objective of the test, however, is to obtain estimates of v. This is accomplished using the relation;

$$\mathrm{V} = \frac{\mathrm{Va}}{n\alpha} \ldots \text{ Eq} - 5$$

Where;
V = Velocity of the groundwater,
n = porosity,
α = adjustment factor (depends on the geometry of the well and on the hydraulic conductivity of the sand or gravel pack in the well).
Tracer concentration breakthrough curves are obtained by plotting the ratios of tracer concentration (C) and the initial concentration (Co) versus time.

IV. RESULT AND DISCUSSION

In total 18 flow paths L1 to L18 which are identified in the study area in earlier studies are considered for the determination of flow velocities. The model evaluation of groundwater flow velocity at flow path L11 is as follows.

A. *Data: Tracer test*

Total volume of water used = 4000 litres
Total amount of salt used = 4.2 kilograms
Distance from tracer injection well to observation well = 90 m
Radius of the tracer injection well = 1.2 m
Height of the tracer injection well = 2.1 m
Radius of the observation well = 0.0508 m (diameter of 4 inches)
Depth of the observation well = 152.4 m (500 feet)

B. *Calibration Graph*

A calibration graph is generally used for determination the concentration of a substance in an unknown sample by comparing the unknown to a set of standard samples of known concentration. In this experiment, a series of the solutions are prepared by diluting 0.1 g, 0.2 g, 0.3 g up to 1.5 g of NaCl into different water samples of 1 litre of tap water collected near the test site (A.U south campus dispensary, 17°43' 31.15" N, 83°19' 42.6" E) each. A conductivity probe is used to measure the conductivity of each solution. A calibration graph is then plotted between conductivity (µs/cm) vs concentration (g/l) after the record of test data, which will is be used to determine the concentration of an unknown NaCl solution during tracer test. The calibration graph is presented in the following figure no. 3

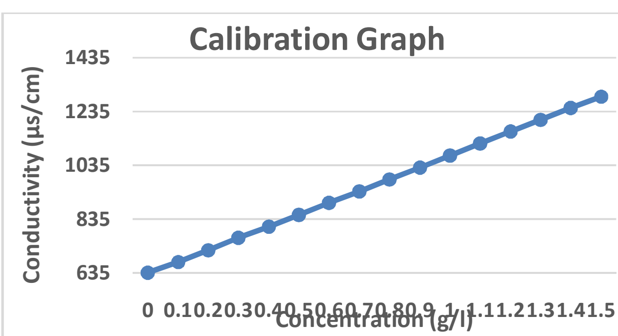

Fig. 2Calibration curve: NaCl concentration Vs Conductivity

C. *Tracer test results*

The following table vide table no.1, provided the experimental observations and results of field tracer test conducted at AU south campus Dispensary, which is on flow path L11. The concentration breakthrough is shown in figure 4.

TABLE I
TRACER-DILUTION EXPERIMENT

Time(min)	Conductivity (µs/cm)	Concentration, C (g/l)	C/C_0
0	854	0.5133	0.4766
30	878	0.5488	0.5095
45	888	0.5844	0.5426
60	912	0.6653	0.6177
75	946	0.7177	0.6663
90	944	0.7133	0.6623
105	948	0.7222	0.6705
120	952	0.7311	0.6788
135	966	0.7622	0.7077
150	961	0.7511	0.6974
175	954	0.7355	0.6829
190	948	0.7222	0.6705
205	935	0.6930	0.6434
220	930	0.6813	0.6325
235	937	0.6976	0.6477
250	935	0.6930	0.6434
275	935	0.6930	0.6434
290	920	0.6581	0.6110
305	905	0.6232	0.5786
320	892	0.5933	0.5508
335	888	0.5844	0.5426
350	875	0.5555	0.5157
365	871	0.5466	0.5075
380	858	0.5177	0.4806

Where;
C0 = Initial concentration =1.077 g/l, (conductivity=1106 µs/cm)
C = Concentration with respect to the time, g/l

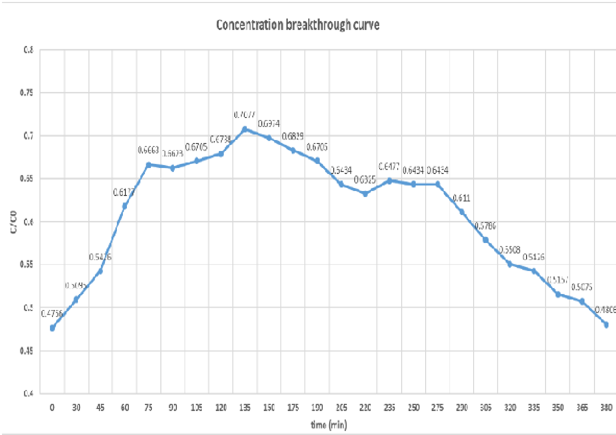

Fig.3 Concentration Breakthrough Curve

Similar tests are conducted at different locations all along the different flow paths.

V. CONCLUSIONS

From the figure 4, representing the concentration breakthrough of the tracer test conducted, it is observed that the maximum C/C0 values are obtained after 135 minutes of the tracer solution injection. It is further observed that the groundwater conductivity using which the relative concentration of the tracer solution is obtained became normal i.e, restored to the original conductivity after 380 minutes.Using the equations 4, 5 and the peak C/C0 values, the velocity of the groundwater flow is obtained as 0.4559m/day. This value is in conformity with the range of groundwater flow velocities for the aquifer located in fractured rock zones (Freeze and cherry, 1979). The average groundwater flow velocity in the study area is found to be 1.469 m/day.

REFERENCES

[1] Jha B.M., & Sinha S.K. (2009), *Towards Better Management of Ground Water Resources in India,* Central Ground Water Board, Volume 24, No.-4 Oct- Dec, 2009.

[2] Freeze, R.A. and Cherry, J.A., 1979, *Groundwater,* Englewood Cliffs, New York (USA): Prentice- Hall.

[3] Leonardo Piccinini, P. Fabbri, and M. Pola (2015), *Point dilution tests to calculate groundwater velocity: an example in a porous aquifer in NE Italy*, Hydrological Sciences Journal, Doi: 10.1080/02626667.2015.1036756.

[4] Sebastien lamontagne, John Dighton and William Ullman (2002), *Estimation of groundwater velocity in riparian zones using point dilution tests,*Commonwealth Scientific and Industrial Research Organisation (CSIRO for Land and Water).

[5] SrinivasaVittala S., Govindaiah S. and Honne Gowda H. (2006), *Digital Elevation Model (DEM) for Identification of Groundwater Prospective Zones,* Journal of the Indian Society of Remote Sensing, Vol. 34, No. 3, 2006.

[6] Stefano Basiric, Giovanni B. Crosta, Paolo Frattini, Alberto Villa, and Alberto Godio (2015), *Borehole Flowmeter Logging for the Accurate Design and Analysis of Tracer Tests*, Vol. 53, Groundwater–Theme Issue 2015.

