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A Study on the Groundwater Tracer Test in the Dragonmount Tailing Pond , Guangxi Province

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Abstract. The dragonmount tailing pond which is taken as the study area has complex hydrogeological condition. It lies in Jingxi county, Guangxi province. In this paper, it gives out the time-concentration curve for the groundwater tracer test, makes use of single-dimensional hydrodynamic dispersion model to figures out the velocity of groundwater, coefficient of dispersion and dispersity. The mechanism of multimodal and double-humped phenomena was also investigated in the tracer test. In this paper, some situations such as leakage path, the trend of groundwater, hydraulic connection were analyzed. The research provides necessary hydrogeological basis for the design of the tailing pond and it's of great significance to evaluate the pollution of its water source and conduct the construction.

Introduction

Leakage is the engineering geological problem which is often met and must be solved, when tailing pond is built in the karst area. Once the problem of karst seepage happen, The groundwater ,lakes and farmland will be polluted by means of slag and wastewater.On the issue of study, groundwater tracer test is a very good analysis means. It is significant that research groundwater flow velocity , dispersion coefficient and groundwater movement direction in the tailing pond of karst area, it is of significance that find out the questions of hydraulic connection on the 's surface water and groundwater, internal reservoir and external reservoir.

The Dragonmount tailing pond lies in Xinyu, Jingxi county,Guangxi province, which are surrounded by mountains.In general, the west side' mountains is higher and the east side' is lower. It is composed of two depressions from east to west, Whose catchment area is about 1.25 km^2. In the region, there are various kinds of surface and underground karst forms, for example the peak dissolition fractures, water hole and caves. And in the area, the hydrological geological conditions is very complex .

Tracer test

In order that ascertain the hydraulic connection 'questions of internal reservoir and external reservoir, analyze the velocity and direction of groundwater' flowing ,evaluate the pollution problems caused by the tailings karst seepage, molybdate as the tracer is used to do the groundwater tracer test. The reagent is easy to dissolve in water. It's non-toxic and low cost which have no adverse effect on the environment.

Selection, release, sampling analysis: The natural sinkholes of upsteam reservoir are selected to deliver the tracer. The weigh of the tracer delivery is about, 225 kg and it is injected only a time, when hydraulic gradients, tracer distance and karst development is taken into consideration. The position of the layout' demand that the tracer should be received as far as possible. The experiment use external point of natural water reservoir (No. S1 ~ S20) as the points of delivery, each of the point covers with all the points of water samples rangement of reservoir area. The position of the delivery and receiving points of groundwater in the tracer test are showed in fig. 1.

Detection of the test samples and data sorting. According to the survey of sample points in tracer test, the abnormal concentration of samples are determined of 20 ppb. In accordance with the concentration change in defferent time , time and concentration curves are drawn as fig. 2 ~ fig. 5:

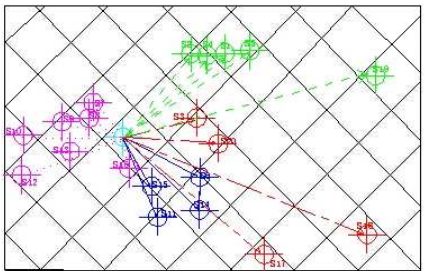

Fig. 1 The position schemes of the delivery and receiving points in groundwater tracer test

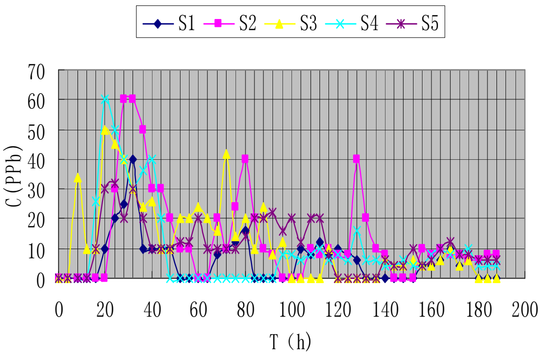

Fig. 2 S1- S5 time and concentration curve

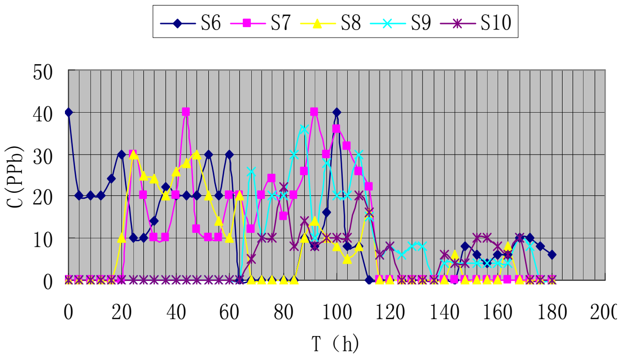

Fig. 3 S6-S10 time and concentration curve

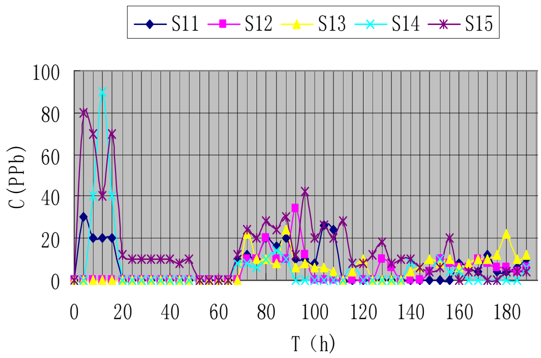

Fig. 4 S11- S15 time and concentration curve

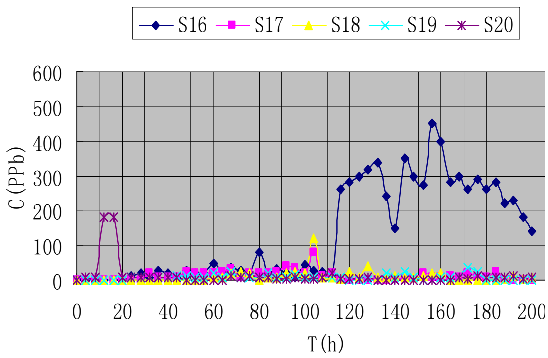

Fig. 5 S16-S20 time and concentration curve

The analysis of the tracer test

In the tracer test, tracer exist molecular diffusion and convection dispersion. Molecular diffusion is the process that make the concentration of each part of the of groundwater flow be uniformity. Convection dispersion is caused because the velocity of groundwater flow is uneven. If assumed that the reservoir by dropping tracer in karst groundwater flow field spread, fluid is incompressible; Medium is relatively homogeneous , underground water is similar to be think as the one-dimensional stable and the two-dimensional dispersion. The groundwater average flow velocity is "U".The tracer test can be analyzed use hydrodynamic disperision equation ,when tracer whose quality is m_M is injected at the delivery points.

$$\frac{\partial c}{\partial t} = D_L \frac{\partial^2 c}{\partial x^2} + D_T \frac{\partial^2 c}{\partial y^2} - u.\frac{\partial c}{\partial x}$$

C is tracer concentration, T is time, D_L is longitudinal (x axis) dispersion coefficient, D_T is lateral dispersion coefficient, U is the velocity of groundwater flow .

Groundwater tracer model construction and its analytical solution. In the karst aquifer with mesh structure, the groundwater spread around, when the velocity of groundwater flow is higher, the main condition is the turbulent state. In the above assumptions, groundwater is similarly accords with one-dimensional, approximate 2d dispersion stable flow tracer problem. This mathematical model [1] is:

$$\frac{\partial c}{\partial t} = D_L \frac{\partial^2 c}{\partial x^2} + D_T \frac{\partial^2 c}{\partial y^2} - u.\frac{\partial c}{\partial x}$$

$$C(x.y.o)=0 \qquad x^2+y^2>0$$

$$C(\pm x.y.t)=c(x.\pm x.t)=0 \qquad t>0$$

$$\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} C.n.\,L.dx.dy=m_M \qquad t>0$$

Its analytical solution is: $c(x,y,t) = \frac{m_M / l}{4\pi n\sqrt{D_L D_T t}} \exp - \left\{ \left[\frac{(x-ut)^2}{4D_L t} + \frac{y^2}{4D_T t} \right] \right\}$

In the formula: C (x, y, t) is tracer concentration varies with time, dimensional change functions; m_M is tracer quality. L is aquifer thickness, X is the longitudinal coordinate that distance of throwing point of origin system, T is tracer migration time, D_L is longitudinal dispersion coefficient, U is velocity of groundwater flow, N is the rate of karst.

The problem of time concentration curve two peaks, multiple peaks. In the time and concentration curves of groundwater tracer test , two peaks and multiple peaks problems often can be seen, for example fig. 6 in the tracer tests. [2]There are many reasons that cause two peaks and multiple peaks problems in the time and concentration curves of groundwater tracer test. The reason that the most important is the tracer gets to receiving points with a variety of different routes, and the tracer moves at different time in each of the migration pipe.

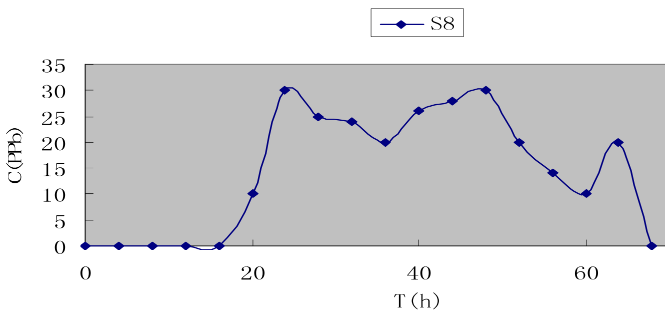

Fig.6 Apparent multiple peaks problem of S8 point in the test

Analysis and calculatioan of the time concentration curve. The number of receiving points is “20", the distance between delivery point and receiving point is “L”, there are two peaks or multiple peaks in the time concentration curve of each receiving points. According to the concentration curve, the apparent velocity is calculated in accordance with the formula “U=L/T”. then “U” is calculated based on the reference [3] pages of 63-64 linear graphic method of hydrodynamic dispersion model, dispersion coefficient and the degree of dispersion also are calculated though the hydrodynamic dispersion model. the results presented in table 1 :

Table 1. The receiving points analysis tables of groundwater tracer tests

point numbers	peaks	concentration of peaks (PPb)	time of peak (h)	distance (m)	apparent velocity (m/h)	ammonium molybdate				
						concentration of auxiliary point (PPb)	time of auxiliary point (h)	coefficient of dispersion (m^2/h)	computing velocity (m/h)	degree of dispersion α_L (m)
S1	peak1	40	33	3580	108.4	10	21	10041.5	98.6	101.8
						20	25			
S2	peak1	60	28	2780	99.2	30	24	4828.6	95.8	50.43
						50	36			
	peak2	40	80		`34.7	25	76	222.5	34.6	6.43
						10	72			
S3	peak1	34	8	2450	308.2	10	12	13714.5	286.2	47.85
	peak2	50	20		122.5	45	24	37119.5	87.1	426.3
						40	28			
S4	peak1	60	20	2540	127	25	16	4487.2	123.4	36.3
	peak2	40	40		63.5	30	32	7836.4	57	137.5
						36	36			
S5	peak1	32	28	3710	132.5	10	20	9770	127.1	76.85
						30	24			
S6	peak1	40	8	3610	451.2	20	8	223544.8	401.6	507.5
						16	16			
	peak2	30	24		150.4	16	16	39182.7	126.9	308.9
						24	20			
S7	peak1	30	24	1820	75.8	20	28	1965.5	73.6	26.7
	peak2	40	44		41.3	20	40	245.3	41.1	5.96
S8	peak1	30	24	1500	62.5	10	20	701.1	61.6	11.39
	peak2	30	48		31.3	28	44	1221.65	29.6	41.3
S9	peak1	36	88	2300	26.1	10	72	665	25.6	26.03
						20	80			
S10	peak1	22	80	3830	47.8	10	76	1551.4	47.1	33.0
		22	80			5	68			
S11	peak1	30	8	2850	356.2	20	10	156341	379	412.5
S12	peak1	34	112	3300	29.5	10	92	895.1	28.9	30.95
						20	100			
S13	peak1	22	72	1950	27.1	10	80	184.7	26.9	6.87
S14	peak1	90	12	5100	425	40	8	110450	397.8	267.6
S15	peak1	80	4	2250	562	70	8	282699	533.6	342.4
	peak2	70	16		140.6	40	12	11036	130.5	84.6
S16	peak1	20	28	1150	41.1	12	24	438.5	40.1	10.9
	peak2	30	36		31.9	10	32	115.4	31.7	3.65
	peak3	50	60		19.2	20	56	28.6	19.12	1.5
S17	peak1	20	32	8620	269.3	10	40	37711.5	259.9	145.1
	peak2	40	92		93.7	20	84	4796.9	92.6	41.8
						26	88			
S18	peak1	120	52	9860	189.6	24	44	12501	172.9	72.3
S19	peak1	14	52	8800	169.2	10	40	18180	144.4	125.9
	peak2	24	72		122.2	12	68	1264.8	121.9	10.4
S20	peak1	180	12	3310	275.8	10	8	196277	255.2	769.1
						10	20			

Comparison chart between the apparent velocity and computing velocity in different time is drawn as fig. 7.According to the fig. 7,the apparent velocity and computing velocity of each point is very

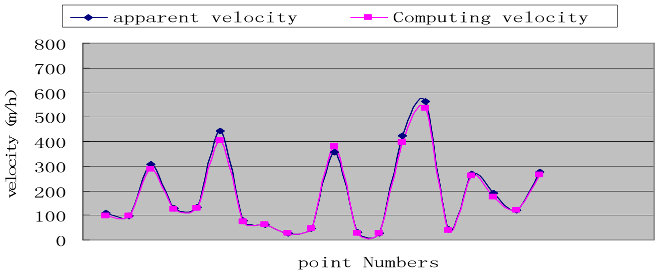

Fig.7 Comparison chart between the apparent velocity and computing velocity

close, it shows that the computing method is very scientific, the groundwater tracer model is suitable.

On the basis of the concentration curve calculation result analysis, three different kinds of groundwater karst pipeline flow are deduced to be exist in the region[4]:

The first kind is karst pipe whose velocity travels faster, for the releasing point - S6 and S11, S14, S15. After Launching tracer for four hours, the first one appears at S6, the maximum concentration reaches 40 ppb, the receiving point S11 shows tracer anomalies four hours later, and the maximum concentration reaches 30 ppb, S14 attains 90 ppb,which is the largest concentration, the maximum concentration of S5 is 80 ppb, the points' velocities range from 301 to 533.6 m/h.

Among them, S11 and S14 tracer curves present single-peak, which demonstrates that the karst pipeline flow from releasing point to S11 and S14 is single, the abnormal two-wing changes a lot, the time releasing point to the maximum concentration S14 is 12 hours, four hours later concentration drops to low value, which indicates that the tectonic releases water quickly. Distance between S11 and receiving point is 2850m, abnormity appears for eight hours, average optical velocity is 366.5 m/h, after calculation ,velocity is obtained as 379m/h, which is applicable to average apparent velocity in general; straight distance between S14 point and input point is 5100m, abnormity appears for 12 hours, average optical velocity is 425m/h.After calculation ,velocity is obtained as 379m/h, it is applicable to average apparent velocity in general and it releases water fast at this point, karst pipe is very unobstructed, releasing point is in karst water hole, when tracer flows to the karst pipe to the water point.

S6, S15 tracer curves present double-peak, which notes that there are at least two major karst groundwater channels, hydraulic connection is good, such as S6 point in the chart above, peak 1 that is corresponding to average flow velocity is 401.6 m/h, while peak 2, which is corresponding to average flow velocity is 126.9 m/h, this basically represents the actual movement condition of groundwater. Such as the table above, the degree of dispersion of the two peaks differs considerably, peak 1 may correspond to tortuous cranny channel, peak 2 reflects that the karst channel is relatively unobstructed. For S15 point, peak 1 that is corresponding to average flow velocity is 533.6 m/h, while peak 2 which is corresponding to average flow velocity is 130.5m/h, obviously, the average flow velocity of peak 1 is far overweigh peak 2, but the degree of dispersion of peak 1 is bigger than the second one, which demonstrates that the fires peak is corresponding to tortuous cranny channel, and relatively, the channel of peak 2 is very close. Peak 2 is corresponding to the unobstructed karst pipeline flow, but relatively, channel distance of peak 1 is farther.

The second kind is karst pipe whose velocity travels moderately, for the releasing point – S3 and S17, S18, S20. After Launching tracer for eight hours, the abnormal value appears at S3, the maximum concentration reaches 30 ppb. The time that S17, S18, S20 appear tracer unusual values is respectively 32 hours, 56 hours, 12 hours, the points' velocities range from 172. to 286.2 m/h .and the computing velocity basically embodies the actual condition of groundwater movement because that it is lesser difference from the apparent velocity. Among them, S3, S17 tracer curves present double-peak, S18, S20 tracer curves present single-peak. S18 and S20 tracer curves present single-peak, which demonstrates that the karst pipeline flow from releasing point to S18 and S20 is single. S3, S17 tracer curves present double-peak, which notes that there are at least two major karst groundwater channels. flow velocity of the Peak 1 and the degree of dispersion of the peak 1 are far bigger than the peak 2 about S3 which demonstrate Peak 1 is corresponding to the unobstructed karst pipeline flow, peak 2 is probably in tortuous fissure channel of limestone .

The third kind is karst pipe whose velocity travels slowly or slower, for the releasing point – S1 and S2, S4, S5, S19; S7 and S8, S9, S10, S12, S13, S16. After calculation, the velocity of water point – S1 and S2, S4, S5, S19 is obtained as 94.2 ~ 145.5 m/h, the maximum density reaches 32 ~ 60 ppb. Among them, S1 and S5 tracer curves present single-peak, which demonstrates that the karst pipeline flow from releasing point to S1 and S5 is single, S2, S4, S19 tracer curves present double-peak, which notes that there are at least two major karst groundwater channels, the concentration is lower, which notes that its hydraulic connection is worser than S1–S5, suppose that the leakage paths connection is from obstructed karst pipeline flow or tortuous cranny channel.

The velocity of water point – S7 and S8, S9, S10, S12 ,S13, S16 is obtained as 94.2 ~ 145.5 m/h , the maximum density reaches 10 ~ 340 ppb. Except for the concentration of S16 point, the rest of the points 'concentration is lower. In general, such points' degree of dispersion is low, which suggests that the leakage paths connection is from tortuous cranny channel and its hydraulic connection is worser.

The maximum concentration of the point S16 which last much time is very high ,even though the flow velocity of S16 point are relatively small .After analysis , the point S16 is the main focal point of karst water. Among them, S16 and S7, S8 tracer curves present duble or multi-peak, which demonstrates that this kind of water point subsist two or more processes far leakage path.

Conclusions

Through comprehensive analysis on the tracer test and the computing result of single-dimensional hydrodynamic dispersion model, the following conclusions can be got:

(1) Flow velocity of model computing result equals optical flow velocity in general,this demeostrates that the model is applicable.

(2) According to the computing result, the flow velocity vary from within. [5]Judging from the velocity, it is concluded that the general trend is towards south-east and there is obvious hydraulic connection between the inside and outside the pond.

(3) Through the research on the multimodal and double-peak model, different leakage route patterns of each receiving point are analyzed.

(4) When the tailing pond is completed, the tailing liquid of the surface water may leak towards south-east along the path. This may pollute the groundwater and the environment. Thus, the protection of leakage should be made preparations for.

Acknowledgements

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