Two-Week Monitoring Groundwater Flow Direction and Velocity under Tidal Fluctuation at Saga Lowland

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1. Introduction

Saga Plain belongs to Ariake Sea Coastal region where is known as a lowland area in Japan, consisting of primarily soft ground (Shimoyama, et al. 2010) and much affected by the ocean tide. An environmental monitoring around this area had been established to measure the physical and quality of groundwater under the potential effect of the Ariake Sea Coastal Road construction. Nowadays, the sea level is increasing day by day due to the influence of the global warming (Kyushu University S-8 Research Group et al., 2014). Thus, it is also necessary to consider the physical of groundwater under the tidal fluctuation for further planning in the lowland area. This research will monitor the flow direction and velocity of the groundwater at Saga Lowland under tidal fluctuation within a half of moon cycle.

2. Establishment of the observation

One observation wells were installed for the flow velocity and the flow direction measurement. Figure 1 shows the monitoring location which belongs to Kubota district.

The flow velocity and direction is measured by the heat-capacity groundwater flow direction/velocity meter shown in Fig. 2. The measuring instrument consists of a heater and 16 temperature sensors arranged on the circumference, and when groundwater is heated by a heater, a temperature sensor create the upstream side by the groundwater which has flowed and detects the low temperature compared with a temperature sensor in a downstream side. This distribution of temperature is used and the current direction current velocity is calculated.

Fig. 1 Monitoring locations

To contrast a measurement period with a tide, we based on

Fig. 2 Heat-capacity flow direction/velocity meter

Table 1. Monitoring Tide Cycle

Date (yy/mm/dd)	Moon Cycle	Tide Cicle							
		High Tide				Low Tide			
		Time	Tide Level	Time	Tide Level	Time	Tide Level	Time	Tide Level
2012/2/22		9:50	474	21:49	476	3:30	8	15:53	49
2012/2/23		10:18	476	22:21	475	4:02	12	16:23	42
2012/2/24		10:41	472	22:50	467	4:30	22	16:48	41
2012/2/25		11:01	464	23:17	453	4:54	38	17:11	44
2012/2/26		11:21	452	23:44	432	5:16	58	17:32	54
2012/2/27		11:41	433	*	*	5:39	84	17:55	69
2012/2/28		0:12	405	12:03	408	6:04	115	18:22	91
2012/2/29		0:45	374	12:30	378	6:33	151	18:59	119
2012/3/1		1:30	340	13:09	344	7:13	188	20:01	147
2012/3/2		2:45	313	14:23	314	8:30	220	21:52	157
2012/3/3		4:50	314	16:44	313	10:53	221	23:31	134
2012/3/4		6:20	346	18:15	350	12:23	188	*	*
2012/3/5		7:15	387	19:14	394	0:39	96	13:18	145
2012/3/6		8:00	427	20:04	437	1:33	57	14:05	102
2012/3/7		8:42	461	20:52	472	2:22	23	14:48	63
2012/3/8		9:22	488	21:37	497	3:07	1	15:30	30

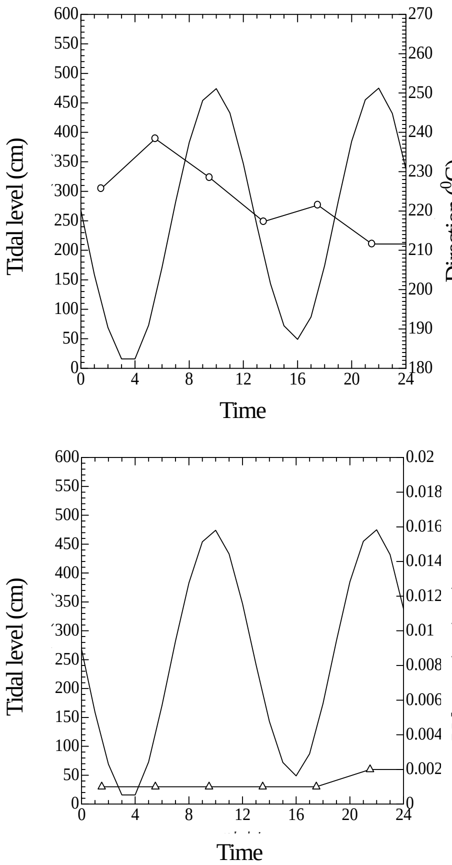

Fig. 3 Monitored results at new moon (2012/02/22)

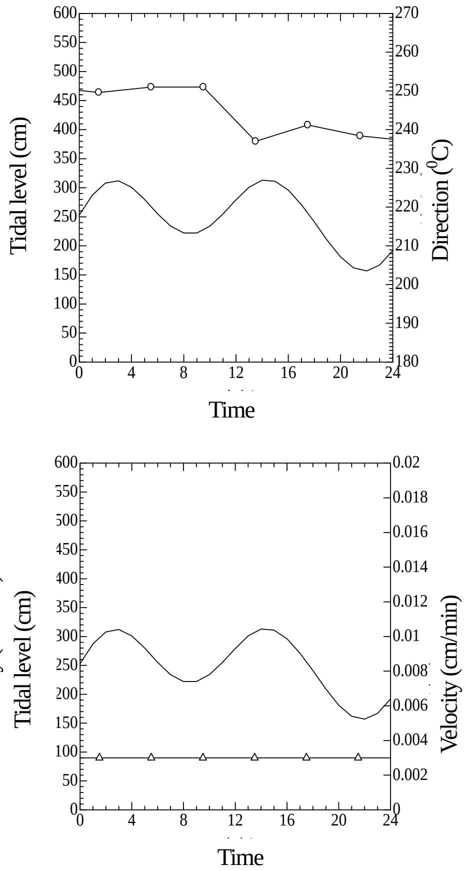

Fig. 4 Monitored results at haft moon (2012/03/01)

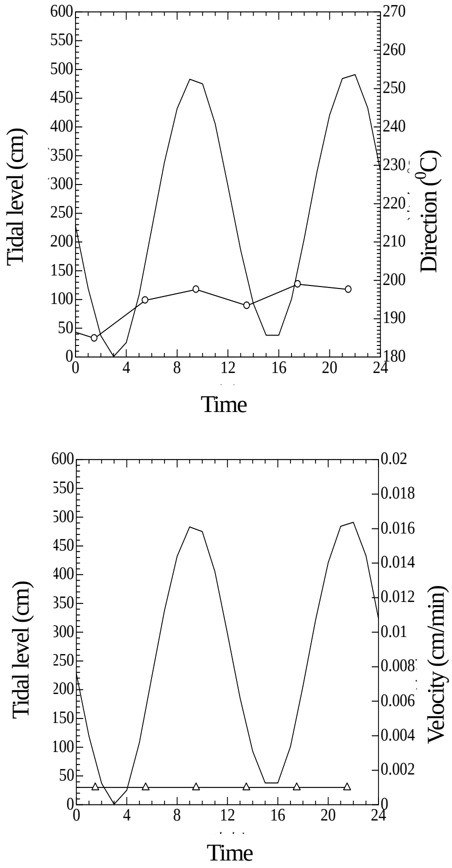

Fig. 5 Monitored results at full moon (2012/03/08)

the physical of moon cycle, which takes place from 2012/02/22 (new moon) to 2012/03/08 (full moon). We investigate the tide cycle of Saga Lowland resulted as in Table 1. From Table 1, the tide level fluctuated much in new-moon day and full-moon day and less in half-moon day. To express all situations of tide level, we monitored 6 times/ day at 1:00; 5:00; 9:00; 13:00; 17:00; 21:00 o'clock.

3. Monitoring results

Two weeks of measurement were conducted in Kubota district, the obtained results show that the flow velocities of the groundwater were between 10^{-3} cm/sec and 4×10^{-3} cm/sec, and the direction is generally southwest. Typical results were shown in Fig. 3, 4 and 5 at measured date 2012/02/22 (new moon), 2012/03/01 (half moon) and 2012/03/08 (full moon), respectively. The velocities were 10^{-3} cm/sec, 3×10^{-3} cm/sec, 10^{-3} cm/sec at new moon, haft moon, and full moon, respectively. There observed results reveal that they were mostly unchanged under the tidal fluctuation within a day, however, there is small change during two week measurement. Velocity is a little increased at half moon. The maximum velocity is not at the measurement at full moon. This is because of the elapse time needed to permeate through long distance of subsoil. In summary, the velocity and direction of ground water at the measured location have little effect from the tidal fluctuation.

4. Conclusions

Though in the view point of engineering, tidal fluctuation may affect on the groundwater in terms of velocity and direction, the observation results indicate that tidal fluctuation during two week measurement does not make a big change in velocity and direction at the monitoring location in Kobuta district. However, the effects are tightly depended on the location and the sensitivity of measurement method. Since the tide fluctuation is increasing day by day due to the effects of global warming, influences of tidal fluctuation on groundwater along the coast should have further studies.

References 1) Kyushu University S-8 Research Group et al. : *Proc. Symposium Adaptation of the Water-Sediment-Related Disasters in Global Warming Era*, Saga University, 56p, 2014.; 2) Shimoyama et al. : Geology of the Saga district, *Quadrangle Series*, *1:50,000*, No.71, NI-52-11-9, Geological Survey of Japan, AIST, 97p, 2010