Geochemical Investigations at Sulphur Springs, Saint Lucia: Monitoring of the Public Health

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Abstract

Hazardous gases typically found in geothermal areas include carbon dioxide, sulphur dioxide, hydrogen sulphide and carbon monoxide. Emerging hydrothermal water may be acidic and contain calcium, sulphur, fluoride, iron, and other metal species. Over exposure to some of the elements found in the gas and water from geothermal fields can negatively affect human and animal health, property, and the environment in different ways. Preliminary results from the investigation of gas emissions and water quality show that for recreational sites at Sulphur Springs, Saint Lucia the concentrations of Pb, Cd, Fe, NO_2, and Al exceeded the USEPA's and WHO's safe drinking water standards. In-situ monitoring of SO_2 concentrations in the field indicated occasional spiking over 5 ppm, which can result in short-term health effects.

Introduction

The Seismic Research Unit (SRU) has implemented a geothermal monitoring program as part of an integrated volcano monitoring strategy for islands of the English-speaking Eastern Caribbean. Sulphur Springs Park in Saint Lucia is one of the sites included in this program. The Park is an important tourist attraction with both locals and foreigners visiting the site all year round. Some of the hot pools have been developed into bathing areas for recreational use (balneology), however, locals have also been known to drink the water. Periodic samples of fumarolic gases and geothermal water at 8 sites, including the recreational pools, distributed over the Sulphur Springs geothermal field have been collected to establish good baseline data for monitoring changes of the geothermal system and volcanic activity. In recent times, the management of the Park have expressed serious concerns about the dangers that the public and its staff are exposed to from geothermal emissions. The SRU's geothermal monitoring program is addressing this concern with a preliminary study involving in-situ gas monitoring and water quality testing to regularly check the level of emissions and exposure.

Method

GAS SAMPLING AND ANALYSIS

Sample features and sites are identified in Figure 1. The temperature and pH of each feature was measured at the time of sampling. Geothermal gas samples were collected from natural steam vents (fumaroles) and gas discharges from bubbling hot pools (drowned fumaroles), using evacuated Giggenbach flasks containing 50 ml of 5M sodium hydroxide (NaOH) following the methodology outlined by Giggenbach and Goguel (1989), developed to collect a representative sample and minimize contamination effects. Samples were analyzed using gas chromatography and wet chemistry.

IN-SITU GAS MONITORING

A Toxic Rae Meter equipped with a sulphur dioxide (SO_2) sensor was used to monitor the in-situ concentration of SO_2 at each site investigated. The meter had the ability to give real time measurements (RT), time weighted average (TWA) and short-term exposure level (STEL) as well as the peak value (PV) recorded of the toxic gas concentrations being investigated.

WATER SAMPLING AND ANALYSIS

Water samples were collected, from hot springs and pools, in 125 ml Nalgene (low density polyethylene) LDPE narrow mouth bottle and were filtered with 0.45*um* disposable filters. Samples to be analyzed for cationic species were acidified with concentrated nitric acid (HNO_3). Samples to be analyzed for anionic species were not acidified. Atomic absorption spectroscopy and Ion chromatography were used to analyze the water samples.

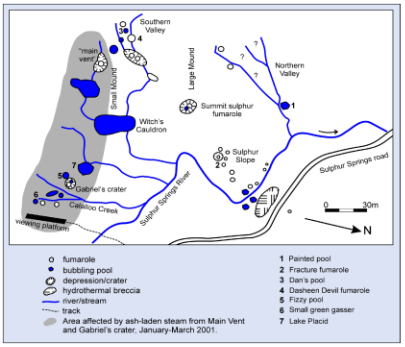

Figure 1. Sketch map of the Sulphur Springs Geothermal Field, St Lucia showing the main features sampled.

Results

GAS

The results of the in-situ gas monitoring indicated below were recorded at the end of each sampling day in the Park. On Day 1 the unit was left to record SO_2 concentrations during the night. The peak observed on Day 2 was recorded from gaseous emissions at "Fracture fumarole" on Sulphur slope (**Fig. 1**).

Specific reading taken	DAY 1 Concentration (ppm)	DAY 2 Concentration (ppm)
Instantaneous (actual gas concentration at the end of monitoring)	0	0
STEL (average concentration over 15 minute interval at end of monitoring)	0	0
TWA (accumulated average over 8 hours)	0	0
Peak (Maximum gas concentration)	3.5	6.3
Run time in hours (accumulated time since unit switched on)	17.5	1.6

Table 1. Results of Sulphur Dioxide in -situ monitoring at Sulphur Springs Park

WATER

Some of the main recreational hydrothermal sites were sampled to investigate their water quality and the results compared to international drinking water standards (USEPA and WHO) because there are no international standards for balneology available to date. The results are shown in Table 2, values in blue exceed acceptable standards.

SAMPLE	Crystal pool SL	Bath stream SL	USEPA's MCL 2003	WHO 1993
T (°C)	33.8	39.5	25	
pH	7	6	6.5 -8.5	6.5 -8.5
Fe (mg/L)	1.30	3.94	0.2	0.3
Al (mg/L)	97.29	92.62	0.05 -0.2	0.2
Cd (mg/L)	0.1018	0.1167	0.005	0.003
Cu (mg/L)	0	0	1	2
Ni (mg/L)	0.00	0.00	-	0.02
Pb (mg/L)	0.383	0.409	0.015	0.010
Zn (mg/L)	0	0	5	3
F (mg/L)	0.26	0.87	1.50	1.50
Cl (mg/L)	34.51	64.35	250.00	250.00
NO_2 (mg/L)	6.96	7.00	1.00	3.00
SO_4 (mg/L)	65.41	695.5	250.00	500.00

MCL = Maximum contamination level

Table 2: Results for hydrothermal water samples taken from pools used for recreational activity in Sulphur Springs

Conclusion

Examination of the results from the in-situ gas monitoring indicated that while the peaks recorded on both days were well over 3.0 ppm, the TWA reading remained at 0 ppm suggesting no serious long-term risk. However, short-term exposure to concentrations of 6 ppm is known to trigger asthma attacks in asthmatics and many non-asthmatics if they exercise (Baxter 2002).

The recreational water samples analyzed had more than the maximum contamination level of lead, cadmium, nitrite, iron and aluminum indicating that these waters were unsafe to drink. Locals who practice drinking of these waters can suffer from kidney damage from the relatively high levels of cadmium. The high levels of lead can result in delays in physical and mental growth in children with kidney damage, and high blood pressure in adults. Shortness of breath from blue baby syndrome leading to death if left untreated in infants after the age of 6 months can result from the relatively high levels of nitrite.

Although no balneology standards exist for hydrothermal waters, the high levels of exposure to these waters while bathing suggest that many symptoms may also be experienced by those who simply bathe regularly in the water and from accidental ingestion.

Additional dangers associated with geothermal fields include landslides, phreatic and hydrothermal eruptions and boiling pools of water.

Recommendations

Based on knowledge of the hydrothermal emissions at Sulphur Springs Park and the capabilities of the Toxic Rae meter owned by the Park's management, it is recommended that its use be continued. This would be especially important when there are visitors touring the Park. The primary gas monitored should be sulphur dioxide, for reasons explained earlier, however checks of hydrogen sulphide and carbon monoxide should also be maintained. If concentrations exceed acceptable limits, then steps should be taken to reduce exposure to the emissions. The Seismic Research Unit should also be contacted, as large increases in emissions or gas concentrations may indicate changes in the underlying magmatic system.

Additional investigations into the health hazards associated with the recreational use of hydrothermal waters needs to be conducted as many heavy metal elements are present in potentially dangerous concentrations.

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