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The study of mercury exchange rate between air and soil surface in Hongfeng reservoir region, Guizhou, PR China

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Abstract: In summer of 2002, we measured the exchange flux of mercury between air and soil surface using the method of Dynamic Flux Chamber (DFC) in Hongfeng lake region. At the same time, we recorded meteorological parameters such as air temperature, soil temperature, wind speed and solar radiation using a multi-function mini-weather station (global water III). Soil, moss and fertilizer samples in study area were also collected. The Hg fluxes of air/soil surface rangeed from -11.0ng m^{-2} h^{-1} to 219.0ng $m^{-2}h^{-1}$, averaged at 29.2 ng m^{-2} h^{-1}(n=508). The data show that the exchange of mercury is bi-directional between air and soil surface: namely both emission and deposition of mercury occurs, but Hg emission is much more frequent than deposition process ($n_{deposition}$=3,$n_{emission}$ =505). The average mercury content in soil, moss, fertilizer sample are 249.9±24.1ng/g(n=3),450.4± 64.6ng/g(n=2),53.4ng/g(n=1) respectively.

Key words: mercury, flux, Hongfeng reservoir, soil

1. INTRODUCTION

As a toxic metal, once released into the atmosphere, mercury can reach remote area by long-range atmospheric transportation [1], so that atmospheric sources are significant in the cycling of Hg in the biosphere[2,3]. Soil surface is recognized as an important natural atmospheric source [4,5,6]. To understand bio-geochemistry cycle of mercury, a great amount of data about air/surface mercury exchange is required, but there is few reliable data on air/soil exchange of Hg in terrestrial system [2,3]. Especially, the flux of mercury emission from soil plays an important role to understand mercury cycle and transporting process.

2. EXPERIMENTAL SECTION

2.1 Sampling Site

Hongfeng reservoir is about 30 km apart from Guiyang. The sampling site (Fig. 1) is located beside the reservoir and is a small field that only several corns and peas were planted. The soil is composed by clay loam and humus mainly, and because of several days' rainfall before sampling, the humidity of soil is quite high.

2.2 Mercury flux measurement technique

An automated mercury analyzer Tekran 2573A coupled with a quartz glass chamber having low Hg blank(2.0±1.6 ng m^{-2} h^{-1}, n=12) were employed in our study. The total gaseous mercury concentrations both in outlet and inlet air of the chamber were analyzed by Tekran 2537A alternatively in a 5 min interval. All sampling lines used connecting instruments and the chamber was made from FEP Teflon™ to reduce system blank. A multi-function mini-whether station (global water III) was placed beside the flux measurement site to record meteorological parameters, such as air temperature, soil temperature, relative humidity, wind speed and intensity of solar radiation. The measurement campaign was conducted from 2002-7-23 to 2002-7-27.

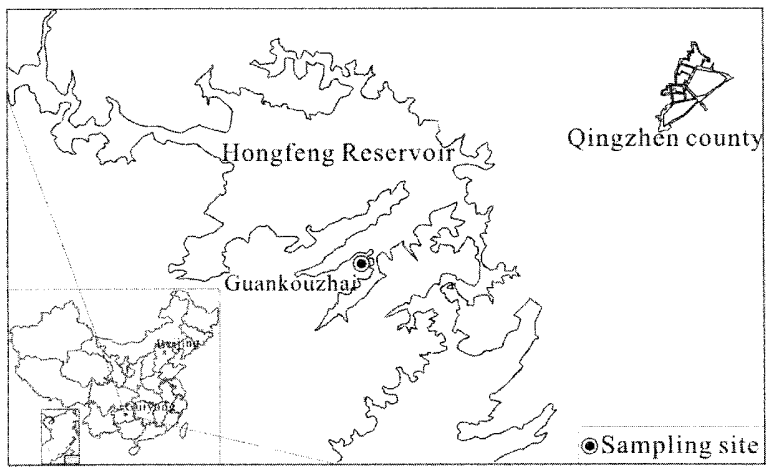

Figure. 1 The sketch of sampling site in Hongfeng reservoir, Guizhou province, China

3. RESULTS AND DISCUSSION

3.1 Mercury concentrations in soil, moss and fertilizer

The mercury concentration in soils and in moss are 250±24ng/g (n=3) and 450±65 ng/g(n=2) respectively. Since moss can be used as a bio-monitor of atmospheric mercury deposition [7,8,9], it is implied from our study that the total atmospheric mercury deposition rate could be quite large. Therefore, soil in this area is contaminated in some extent in terms of mercury due to atmospheric mercury deposition. Total gaseous mercury (TGM) concentrations in the air is relatively low with a means value of 2.7±0.7ng m^{-3} comparing to TGM concentration in the air in Guiyang [10]. Mercury concentration in fertilizer is 53.38ng/g, so that the fertilizer may contribute a small portion of mercury to the soil.

3.2 The trends of mercury exchange flux between soil and air

The mercury exchange rates from soil ranges from -11.0ng m^{-2} h^{-1} to 219.0ng $m^{-2}h^{-1}$, average 29.2 ng m^{-2} h^{-1}(n=508). The negative values demonstrated that mercury deposition from air soil occurred, from which we could conclude that the exchange of mercury between soil and air is bi-directional, namely both emission and dry deposition of mercury occurs. Emission of mercury from soil is, however, much more frequently than dry deposition of mercury(($n_{deposition}$=3,$n_{emission}$=505).if wet deposition is not considered. Mercury flux between soil and air varied with time and the flux reached peak at noon and then decreased to the minimum before the sunrise.

3.3 Correlation between mercury exchange flux and meteorological parameters

It is widely accepted that mercury emitted from soil is mainly Hg(0) and at most a small portion of dimethylmercury mainly[11,12]. Factors controlled Hg(0) evaporates from soil is various. The dominating factors constraining the formation of volatile mercury species are obviously the concentration and speciation of mercury in the matrix. The formation of volatile Hg species from the matrix Hg pool is also controlled by physical and meteorological parameters [13]. Physical parameters, such as temperature, radiation or moisture, can promote the production of volatile Hg species since they induce or stimulate these chemical formation reactions [11]. Thus, the correlations between mercury flux and meteorological parameters are very important.

Gillis(2000)[14] found that total gaseous mercury flux depended highly on soil temperature and correlated moderately with air temperature as well. Our measurement data supported the above observations since significant correlations between mercury flux and soil and air temperatures were obtained with correlation coefficients of 0.79 and 0.76 respectively. As a result of high vapor pressure, mercury would be easily diffused and evaporated from soil to air when temperature increase in ambient environment. On the other hand, when temperature decreases, the molecular activity of mercury will decrease, so that mercury prefers being adsorbed in solid phase, which will decrease mercury emissions from soil.

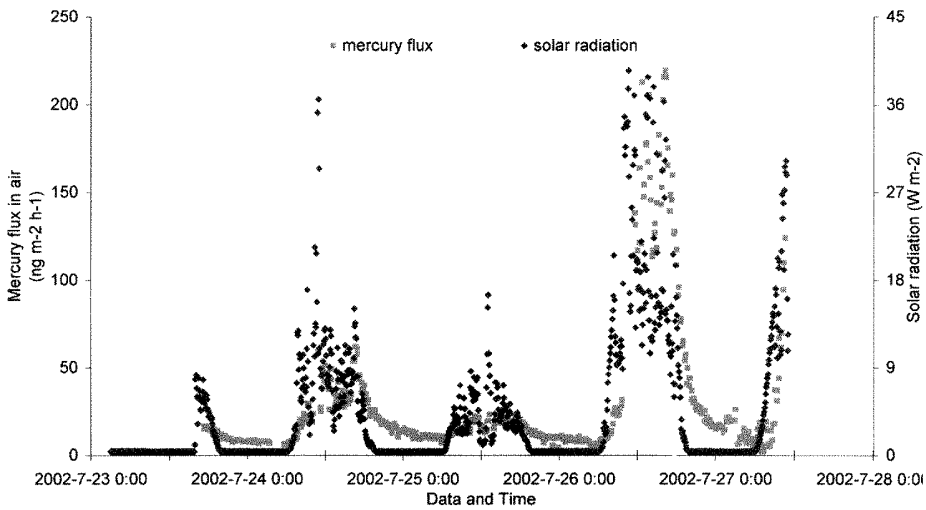

Fig. 2 The relationship between Mercury flux and Solar radiation in Hongfeng reservoir region, PR. China.

Our data showed a good correlation (r= 0.73) between mercury flux and solar radiation(Fig. 2). Gustin et al.(2002)[15] found that mercury flux between soil and air had close relationship with solar radiation in their experimental studies. Kim and Lindberg (1995)[16] found that mercury exchange rate between air and soil surface was mainly controlled by concentration gradient between mercury concentration of pore air in soil and soil surface layer when they used Micrometeorological Gradient Approach to measure mercury emission rate from soil. We know that Hg^{2+} can be photo-reduced to Hg^0 in solution [17,18], and stronger solar radiation can increase mercury concentration in the pore air of soil as a result of photoreduction of mercury in solution phase.

4.CONCLUSIONS

The relatively low mercury concentration in soil implies that there is no direct anthropogenic discharge of mercury to the soil in Hongfeng reservior region. High content in moss samples implies that Hg deposition from precipitation is quite remarkable in this area, thus soil may be contaminated from atmospheric mercury deposition. Though precipitations bring a large amount of mercury to soil, soil itself is not seriously contaminated because the residence time of Hg that deposited to soil is very short following Hg^0 escapes from soil quickly in Hongfeng reservoir region in summer (warm) season. Further study on wet deposition of mercury in Hongfeng reservior is definitely needed to better understand mercury exchange between soil and air. Mercury exchange flux between soil and air is controlled by geo-, bio-, meteorological factors. Our data showed that environmental conditions such as solar radiation, temperature and so on have strong impact on mercury flux. But the mechanisms of those processes are not clear.

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