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The Chemical Study of Tsunami Deposits in South Thailand - Review

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Abstract

Our paper is a review of published results of tsunami deposit chemical studies. These sediments were deposited by the 26 Dec. 2004 tsunami in southern Thailand. All research was carried out by teams of geologists, chemists, and biologists from Adam Mickiewicz University, Poznań.

Keywords: tsunami sediments, salts, heavy metals, metalloids, aluminium, SOM

Introduction

The tsunami waves formed on 26 Dec. 2004 as a result of an earthquake of magnitude M_S=9.0 near Sumatra Island caused great destruction along the coasts of the Indian Ocean. The disaster caused by the tsunami waves took 100,000 human lives and it had enormous economic and ecological consequences.

One of the countries significantly suffering from the tsunami was Thailand. The government of this country appealed to a number of countries for help investigating detailed recognition of the phenomenon and its effects. Among others, a group of research workers (geologists, chemists, biologists) of A. Mickiewicz University, Poznań, Poland, was invited to study tsunami effects on land ecosystems. This paper reports on the chemical investigation in the above area conducted by the Poznań group in 2005-08. Studies of the long-term effects of tsunami on the environment are ongoing [1, 2].

Study Area and Scope

The study area was located in Phang Nga province: Nam Khem (samples 9-13), Bang Mor (samples 14 and 15), Thung Tuk (sample 16) located on Kho Khao Island, and on Phuket Island - Palong Bay (samples 1 and 2) and Patong (samples 3-8). Starting from 2005 to 2008, each year 15 samples of the tsunami sediments and one control sample from the area not reached by the tsunami waves (the ancient city of Thung Tuk) were collected. Usually the distance between the sampling site and the coastline was of a few hundred metres. Samples 1, 9 and 12 were collected at distances of 50-100m from the coast, while the farthest inland site of sample collection most distanced was 1100m from the coast (sample 13) [1].

Geological analysis concerned the determination of the type of sediment material, percent contribution of the individual granulometric fractions and the sorting of the sediment. The details of geological analysis of tsunami deposits are given in the following papers: Szczuciński et al., 2005 [1] and Szczuciński et al., 2007 [2]. Each sample was subjected to the determinations of the content of water-soluble salts (Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-} the sample salinity), heavy metals (Cd, Cr, Cu, Ni, Pb, Zn) in the hydrochloric acid leachable fraction (2M HCl) and metalloids (As, Sb, Se) in the exchangeable fraction (phosphate buffer) [1, 2]. Moreover, the identification of inorganic species of As(III) and As(V) in the exchangeable fraction was made [3-5]. In the samples collected in 2005 the total content of mercury and the content of mercury in different

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fractions of the sediments obtained by sequential extraction (chloroform, water, sodium hydroxide, hydrochloric acid, aqua regia) were also determined [1, 6]. In the samples of the tsunami deposit collected in 2005, content of the labile aluminium species in different granulometric fractions was also determined [7]. On the basis of the analytical results, chemometric parameters also were calculated. The mobility and bioavailability of mercury in the sediments was compared to that of mercury in the freshwater sediments [8]. The self-organizing map (SOM) algorithm was applied for evaluation of the effect of the tsunami on the geochemistry and the environment of the land area studied. These studies were based on the results of chemical analyses of tsunami deposits [9].

Results of the Studies

To assess the potential effect of the sediment on the land ecosystems a series of analyses were made to establish the content of water-soluble salts, heavy metals in the acid leachable fraction and metalloids in the exchangeable fraction. The analyses were repeated in the samples collected at the same sites after a year in order to find out the influence of the rainy season on the structure and composition of the sediments (in the rainy season in Thailand the precipitation is of 3,300 mm). The results obtained for the samples collected in 2005 showed very high salinity of the tsunami sediments. For example, the content of Na^+ varied from a few to tens of thousands mg kg^{-1}, while that of Cl^- - from a few to over one 100,000 mg kg^{-1} [1]. The content of these ions in the reference sample was 29 mg kg^{-1} of Na^+ and 300 mg kg^{-1} of Cl^- [2]. The content of salts in the sediments decreased each year from 2005 to 2008 [10]. This decrease in salinity was a result of washing out the easily water-soluble salts by rain. No analogous decrease was observed for the heavy metals and metalloids present in the bioavailable fractions. The content of Cd, Cu, Pb and Zn was higher in the tsunami sediments than in the reference sample, while the contents of Cr and Ni were at the same level. Not only was no decreasing effect of the rainy season on the contents of heavy metals and metalloids noted, but in some samples an increase in their contents was observed in consecutive years. The latter phenomenon can be related to the geochemical processes taking place in the sediments.

According to the speciation analysis of arsenic, the sediment samples from 2005 were characterized by a much elevated level of As(III) and As(V) relative to their levels in the reference sample. As(III) was present in all samples of the tsunami sediments collected in 2005. A relationship was found between the speciation and the total content of inorganic arsenic in the sediments. The ratio of As(V) to As(III) depended on the site of sample collection [3, 4]. No such dependencies were observed in subsequent years, when the content of As (III) in the tsunami sediment samples (except for 3 samples collected in 2006) was below the limit of quantification.

The total content of mercury in the samples collected in 2005 was lower from or similar to that in the reference sample [1]. However, results of the sequential extraction [6] showed that mercury was mainly bound to the least bioavailable sulphides 75%, organomercury compounds 14%, and humic matter 9%. Although total mercury content was similar in the tsunami sediments and in the reference sample, the highly toxic organomercury fraction contribution was higher in the latter. According to the comparative analysis of mercury fractionation in the tsunami and river sediments, the contents of organomercury species and mercury sulphide were higher in the tsunami sediments than in the river sediments. But the contributions of the water-soluble fraction and mercury bound to humic matter was higher in the river sediments [8].

The content of the labile aluminium species in the grain size fraction (0.18-0.125mm) of the tsunami sediments was up to 2.0 g kg^{-1}, while in the reference sample it was 4.1 g kg^{-1} [7] (caused by the differences between the origin of the tsunami deposits and reference sample). The natural content of labile aluminium fraction in soil from this region is higher (caused by the laterization process) then level of labile aluminium concentration in marine sediments and tsunami deposits.

The application of a self-organizing map to results of chemical analyses provides visual information on the relationship between variables describing the chemical composition of tsunami sediments. SOM also allows investigation of the dominant compounds in the sediment samples of different origin [9].

The tsunami sediment samples were also used for working out the new analytical techniques. For the first time the speciation analysis of inorganic arsenic species in the exchangeable fraction was performed. The extraction of this bioavailable fraction was made with the use of phosphate buffer of pH=6.0. The relevant procedures are described in the paper by Kozak et al. [5]. The tsunami sediments and water collected from the area covered by the tsunami waves were used for optimization of a new method of extraction of solid state samples and simultaneous determinations of arsenic and antimony in the exchange fraction of the sediments [11, 12].

Conclusions

The tsunami sediments from southern Thailand were highly salined. The content of salts decreased in subsequent years, but was still greater than in the reference samples. The acid-leachable fraction of the sediments contained heavy metals at elevated levels. Their content was strongly correlated with content of the water-soluble salts. Also, the content of arsenic in the exchangeable fraction was higher in the tsunami sediments. The correlation between arsenic speciation and the site of sample collection found for the samples from 2005 may indicate a relationship between the origin of the sediments and their chemical composition. Determination of the contents of As(III) and As(V) species in the exchange fraction of sediments of different types may be helpful in identifying their origin. The total content of mercury in the tsunami sediments was at levels similar to the reference sample; only the content of organic mercury species was higher in the sediment samples.

Investigation of the tsunami sediments is ongoing. In 2006 and 2008 a few hundred samples were collected at different sites (along with the reference samples) whose analysis is expected to provide information on the tsunami sediments from a perspective of a new component of land ecosystems.

References

1. SZCZUCIŃSKI W., NIEDZIELSKI P., RACHLEWICZ G., SOBCZYŃSKI T., ZIOŁA A., KOWALSKI A., LORENC S., SIEPAK J., Contamination of tsunami sediments in a coastal zone inundated by the 26 December 2004 tsunami in Thailand. Environmental Geology, **49**, 321, **2005**.
2. SZCZUCIŃSKI W., NIEDZIELSKI P., KOZAK L., FRANKOWSKI M., ZIOŁA A., LORENC S., Effects of rainy season on mobilization of contaminants from tsunami deposits left in a coastal zone of Thailand by the 26 December 2004 tsunami, Environ. Geol., **53**, 253, **2007**.
3. NIEDZIELSKI P., Speciation analysis in the tsunami sediments studies, LAB, **3**, 26, **2006** [In Polish].
4. KOZAK L., NIEDZIELSKI P., Speciation analysis of arsenic in tsunami sediments samples, VIII Środowiskowa Konferencja Naukowa Chemików „Chemia w zrównoważonym rozwoju" Poznań 5-7.06. **2006**, materiały pokonferencyjne [In Polish].
5. KOZAK L., NIEDZIELSKI P., SZCZUCIŃSKI W., The methodology and results of inorganic arsenic speciation in mobile fractions of tsunami deposits by hyphenated technique of HPLC-HG-AAS, International Journal of Environmental Analytical Chemistry, **88**, 989, **2008**.
6. BOSZKE L., KOWALSKI A., SZCZUCIŃSKI W., RACHLEWICZ G., LORENC S., SIEPAK J., Assessment of mercury mobility and bioavailability by fractionation method in sediments from coastal zone inundated by the 26 December 2004 tsunami in Thailand, Environ. Geol. **51**, 527, **2006**.
7. ZIOŁA-FRANKOWSKA A., FRANKOWSKI M., SZCZUCIŃSKI W., SIEPAK J., Analysis of labile aluminium form in particular grain size fractions of tsunami deposits, [in preparation].
8. BOSZKE L, ASTEL A., Fractionation of mercury in sediments from coastal zone inundated by tsunami and in freshwater sediments from the rivers, Journal of Environ. Science and Health, Part A, **42**, 847, **2007**.
9. ASTEL A., BOSZKE L, NIEDZIELSKI P., KOZAK L., Application of self-organizing mapping in exploration of the environmental impact of a tsunami disaster, Journal of Environ. Science and Health, Part A, **43**, 1016, **2008**.
10. KOZAK L., NIEDZIELSKI P., SZCZUCIŃSKI W. [in preparation].
11. NIEDZIELSKI P., KOZAK L., WIELGUS M., Batch system of in-situ extraction and hydride generation atomic absorption spectrometry in simultaneously arsenic and antimony determination in post-tsunami and lake sediments samples, Talanta, [in press].
12. KOZAK L., NIEDZIELSKI P., The batch system hydride generation atomic absorption spectrometry in simultaneous arsenic, antimony and selenium determination in water samples, International Journal of Environmental Analytical Chemistry, [in press].