Nat. Hazards Earth Syst. Sci. Discuss., 3, 5287–5295, 2015
www.nat-hazards-earth-syst-sci-discuss.net/3/5287/2015/
doi:10.5194/nhessd-3-5287-2015

Natural Hazards and Earth System Sciences
Discussions
Open Access

Brief Communication: Use of field test kit for detection of lead in drinking water in Philippines post the disaster typhoon Haiyan

K. Y. Liu, L. M. Cong, Z. J. Lan, R. P. Ma, L. Yu, Q. Song, Y. F. Wang, S. Ren, B. N. Lu, R. S. Deng, G. R. Li, and W. P. Li

Tongzhou Institute of Infectious Diseases and Epidemiology, Beijing, China

Received: 30 June 2015 – Accepted: 8 August 2015 – Published: 4 September 2015

Correspondence to: W. P. Li (13811617181@139.com)

Published by Copernicus Publications on behalf of the European Geosciences Union.

Abstract

On 8 November 2013, super typhoon Haiyan made landfall in Philippines. On 24 November, the Chinese hospital ship arrived in Philippines to help with disaster relief efforts. Drinking water was collected at a variety of locations, and the concentration levels of lead were determined with field test kit. The results showed that the levels of lead in 67 % of total collected water samples exceeded WHO's standard. Afterwards, the local government had taken many measures to ensure a safe water supply in next few months. This is the first report about water quality in Philippines after the disaster.

1 Introduction

Philippines is known as one of the most hazard prone countries in the world due to its geographic circumstances (World Bank, 2005; WHO, 2011a). The most catastrophic of the hazards include earthquakes, tropical cyclones, volcanic eruptions, floods and droughts (Quero, 2012; World Bank, 2005). An average of 20 typhoons occurs annually in Philippines, which arrive in the country from the Pacific Ocean over the eastern seaboard (World bank, 2005; WHO, 2011a). Typhoons have killed about 29 000 people in the country in the 20th century, and about 500 people are killed each year (World bank, 2005). Typhoons carry high concentrations of heavy metals due to their associated large water volumes (Cheng and You, 2010). Lately, Ostrea et al. (2015) reported that 4 % of collected faucet water samples were positive for lead in Bulacan of Philippines, which may be attributed to lead-polluted rivers during flooding. However, no analysis of drinking water after typhoons has been reported yet in Philippines. On 8 November 2013, the Philippines archipelago was hit by category 5 typhoon Yolanda (international name Haiyan), affecting over 13 million people (WHO, 2013). According to local official reports, more than 5000 people died and over 4 million people displaced (Alcantara, 2014; WHO, 2014). Many homes and buildings in the path of the storm had been significantly damaged or destroyed. Since the typhoon was so destructive that

NHESSD

3, 5287–5295, 2015

many foreign counties had participated in providing humanitarian assistance including China. During the period, heavy metal pollution in drinking water of households after the typhoon Haiyan was also concerned by the Chinese rescue team besides medical support and epidemic prevention.

2 Field screening for lead

On 21 November 2013, the Chinese hospital ship "*Peace Ark*" sailed from Zhoushan port in Zhejiang province of China to help with disaster relief efforts in Philippines in the wake of the devastating typhoon "Haiyan". As soon as the ship arrived in the disaster area on 24 November, the epidemic prevention squad got in touch with the WHO coordinators immediately, and joined the WASH (water, sanitation and hygiene) cluster at their requests. With the guidance of WHO and local health department, daily work was conducted in Palo and Tacloban cities in Leyte province of Eastern Samar including prevention of epidemics, pest control and water quality measurement. During the stay in Tacloban and Palo, the disease-prevention squad collected 27 samples of different drinking water using commercial water recovery bags (Nasco Whirl-Pak, USA) from wells, faucets and barrels at a variety of locations, including schools, hospitals, church, libraries and evacuation centers etc. The concentration of lead was detected with commercial filed test kits according to the manufacture's instructions (OASIS Biochem, Guangzhou, China). Each positive sample was measured at least in triplicate and by at least two inspectors.

The field method used for detecting lead is based on the reaction between dissociative lead ion and dithizone to produce a clathrate that can be dissolved in chloroform. Other reagents are also introduced in the marketed test kit to remove interference of other metal ions. After optimization, the commercial lead test kit contains four bottles of indicators. Briefly, the indicators are successively dropped into water, and then the result is achieved by visual comparison of the coloured mixture against a colour calibration card three minutes later. There are six concentrations corresponding to different

NHESSD
3, 5287–5295, 2015

colors marked in the colour calibration card: $0\,mg\,L^{-1}$ (yellow), $0.1\,mg\,L^{-1}$ (light orange), $0.5\,mg\,L^{-1}$ (orange), $1.0\,mg\,L^{-1}$ (dark orange), $2.0\,mg\,L^{-1}$ (pink), $4.0\,mg\,L^{-1}$ (red). The minimum detectable level of lead is $0.1\,mg\,L^{-1}$. The kit manufacturer's directions for testing of water samples were carefully followed.

3 Result

The results (Table 1) showed that the levels of lead in 18 tap water samples from 13 places were between 0.01 and $2\,mg\,L^{-1}$, which exceeded the WHO's standard of $0.01\,mg\,L^{-1}$ (WHO, 2011b). The positive samples accounted for 67 % of total collected water samples. The percent of water with the concentration levels between 0.1 and $0.5\,mg\,L^{-1}$ was 22 % in lead-positive samples. Nine tap water samples which accounted for 50 % of total positive samples had concentration levels of more than $0.5\,mg\,L^{-1}$. The rest 5 samples recorded as $0.1\,mg\,L^{-1}$ or more than $0.01\,mg\,L^{-1}$ by different inspectors accounted for 28 % of total positive samples. The concentration of lead in tap water (resident store water) sampled from the Tacloban City Convention Center was as high as $2\,mg\,L^{-1}$. The results, reported at weekly meetings on disaster relief, were a matter of great concern to the officals of WHO and regions VIII DOH (Department Of Health) of Philippines. The regional director of Philippines health department said that ensuring water quality and controlling disease were the most important work (Peng, 2013). Many measures were taken subsequently to ensure a safe water supply. The priority interventions were delivery of jerry cans, provision of safe drinking water, distribution of water test kits, testing of water-pipe systems and construction of temporary water pipelines, according to the report published on the official website of WHO on 16 December 2013 (WHO, 2013). In next few months, a water quality monitoring and response project had been developed by WHO and the Philippine DOH to strengthen the capacity of local government in monitoring water quality (WHO, 2014).

NHESSD
3, 5287–5295, 2015

4 Discussion

The commercial test kits provide semi-quantitative results, and are advertised as a simple, quick and low-cost method for assessing heavy metal hazards in the filed where qualified laboratory is not available. Although field test kits have been widely used for detecting various chemical substances in environmental samples (Ormaza-Gonzalez and Villalba-Flor, 1994; Berkowitz, 1995; Sheets, 1998; Kinniburgh and Kosmus, 2002; Ballesteros et al., 2003; Deshpande and Pande, 2005; Bhattacharya et al., 2007; Jakariya et al., 2007; Korfmacher and Dixon, 2007), comparisons between analytical results of field method and laboratory measurements were reported by a few researchers (Ormaza-Gonzalez and Villalba-Flor, 1994; Berkowitz, 1995; Sheets, 1998; Kinniburgh and Kosmus, 2002; Ballesteros et al., 2003; Jakariya et al., 2007). In 1995, Berkowitz reported that the lead test kit for detecting lead-contaminated drinking water samples was found to be reliable compared with laboratory analysis by X-ray diffraction and inductively coupled plasma-mass spectrometry (Berkowitz, 1995). In 2007, Jakariya et al. reported that, compared with laboratory measurement by atomic absorption spectrophotometry (AAS) as a gold standard, the field kit correctly determined the status of 91 % of arsenic levels in water compared to the WHO guideline (Jakariya et al., 2007). Other researchers indicated that field test kits were proved to be most suitable for mass screening of arsenic contamination in tubewells and groundwater (Kinniburgh and Kosmus, 2002; Bhattacharya et al., 2007). The field method is simple enough to be operated reliably by often relatively unskilled technicians within the time frame and financial resources available. There is no need for transport and preservation of samples. However, it is inevitable that field test kits have probabilities of giving false-positive and -negative results. The rates of false results depend on many factors including manufactures, purposes, users' subjectivities, chemical interferences, etc (Luk et al., 1993; Kinniburgh and Kosmus, 2002; Korfmacher and Dixon, 2007). In 2007, Korfmacher and Dixon reported that the rate of false negatives for the LeadCheck Swabs for detecting lead in dust was as high as 64 % (Korfmacher and Dixon, 2007). A false-positive result

Discussion Paper | Discussion Paper | Discussion Paper | Discussion Paper |

NHESSD

3, 5287–5295, 2015

is less serious than a false-negative result, since the latter records a sample as below the standard when its true concentration exceeds the standard (Kinniburgh and Kosmus, 2002). It will lead residents to believe that the sample is safe when it is actually not. Although false-positive and -negative rates of the field test kit used in the present study were not known, the results had made a great impact yet. The field test kit has six concentrations corresponding to different colors as mentioned in Sect. 2. It is always not easy to distinguish 0 $mg L^{-1}$ from 0.1 $mg L^{-1}$ by visual observation. 28 % of total positive samples lied in this region. More subjectivities were involved in the case of this situation, which might lead to generation of false-positive and -negative results. However, the color change is obvious and easy to identify if the concentration of lead in water is closed to or greater than 0.5 $mg L^{-1}$, which accounted for 50 % of total positive samples. Additionally, dissociated lead ions were measured with the field test kit, thereby actual contents of lead in water might be higher.

The lead in drinking water of Philippines was measured during the humanitarian assistance. Although the highest proportion of lead levels in water sample exceeded 0.5 $mg L^{-1}$ with little subjectivity involved during measurement, it was a pity that there was no firm confirmation from a qualified laboratory. Although it is uncertain whether lead pollution were caused by the typhoon Haiyan, the safety of drinking water should be taken seriously in future post-disaster recovery since Philippines has an unusually high exposure to natural hazards.

Author contributions. Analysis of the water samples were performed by all authors. K. Y. Liu and L. M. Cong prepared the manuscript with contributions from all authors.

References

Alcantara, P.: Lessons learned from the Philippine government's response to Typhoon Haiyan, J. Bus. Contin. Emer. Plan., 7, 335–346, 2014.

Berkowitz, M.: Survey of New Jersey schools and day care centers for lead in plumbing solder, Environ. Res., 71, 55–59, 1995.

NHESSD

3, 5287–5295, 2015

Ballesteros, B., Barcelo, D., Dankwardt, A., Schneider, P., and Marco, M. P.: Evaluation of a field-test kit for triazine herbicides (SensioScreen TR500) as a fast assay to detect pesticide contamination in water samples, Anal. Chim. Acta, 475, 105–115, 2003.

Bhattacharya, P., Welch, A. H., Stollenwerk, K. G., Mclaughlin, M. J., Bundschuh, J., and Panaullah, G.: Arsenic in the environment: biology and chemistry, Sci. Total Environ., 379, 109–120, 2007.

Cheng, M. C. and You, C. F.: Sources of major ions and heavy metals in rainwater associated with typhoon events in southwestern Taiwan, J. Geochem. Explor., 105, 106–116, 2010.

Deshpande, L. S. and Pande, S. P.: Development of arsenic testing field kit – a tool for rapid on-site screening of arsenic contaminated water sources, Environ. Monit. Assess, 101, 93–101, 2005.

Jakariya, M., Vahter, M., Rahman, M., Wahed, M. A., Hore, S. K., Bhattacharya, P., Jacks, G., and Persson, L. A: Screening of arsenic in tubewell water with field test kits: evaluation of the method from public health perspective, Sci. Total Environ., 379, 167–175, 2007.

Kinniburgh, D. G. and Kosmus, W.: Arsenic contamination in groundwater: some analytical, Talanta, 58, 165–180, 2002.

Korfmacher, K. S. and Dixon, S.: Reliability of spot test kits for detecting lead in household dust, Environ. Res., 104, 241–249, 2007.

Luk, K. K., Hodson, L. L., O'Rourke, J. A., Smith, D. S., and Gutknecht, W. F.: Investigation of test kits for detection of lead in paint, dust, and soil, EPA 600/R-93/085, Environmental Protection Agency, Research Triangle Park, NC, 1993.

Ormaza-Gonzalez, F. I. and Villalba-Flor, A. P.: The measurement of nitrite, nitrate and phosphate with test kits and standard procedures: a comparison, Water Res., 28, 2223–2228, 1994.

Ostrea, E. M., Ostrea, A. M., Villanueva-Uy, M. E., Chiodo, L., and Janisse, J.: Alluvial and riparian soils as major sources of lead exposure in young children in the Philippines: the role of floods, Environ. Sci. Pollut. Res. Int., 22, 5082–5091, 2015.

Peng, Y. N.: Can we survive after surviving?, available at: http://usa.chinadaily.com.cn/china/2013-12/10/content_17163019.htm, last access: 20 May 2014, 2013.

Quero, R. A.: Reframing coordination challenges for public-private partnership in disaster preparedness, Procedia – Social and Behavioral Sciences, 57, 440–447, 2012.

Sheets, R. W.: Use of home test kits for detection of lead and cadmium in ceramic dinnerware, Sci. Total Environ., 219, 13–19, 1998.

NHESSD
3, 5287–5295, 2015

Use of field test kit for detection of lead in drinking water in Philippines

K. Y. Liu et al.

World Bank (East Asia and Pacific region rural developement): Natural disaster risk management in the Philippines: enhancing poverty alleviation through disaster reduction, document type other rural study, report number 33822, volume 1 of country Philippines, available at: http://documents.Worldbank.org/curated/en/2005/10/8387918, last access: 12 June 2015, 1 October 2005.

World Health Organization: The Philippines health system review, Health Systems in Transition, 1, available at: http://www.wpro.who.int/philippines/areas/health_systems/financing/philippines_health_system_review.pdf, last access: 21 May 2014, 2011a.

World Health Organization: Guidelines for Drinking-Water Quality, 4th Edn., available at: http://www.who.int/water_sanitation_health/publications/dwq_guidelines/en/, last access: 20 May 2014, 2011b.

World Health Organization: Typhoon Haiyan Philippines: Public health risk assessment and Interventions, 2nd Edn., available at: http://reliefweb.int/report/philippines/public-health-risk-assessment-and-interventions-typhoon-haiyan, last access: 20 May 2014, 16 December 2013.

World Health Organization: Health cluster bulletin – Philippines, Issue #16, available at: http://reliefweb.int/report/philippines/philippines-health-cluster-bulletin-issue-16-14-march-2014, last access: 20 May 2014.

Table 1. Water quality monitoring from 27 November to 5 December 2013 in Tacloban and Palo, Philippines for lead using field test kits.

Location	Water monitoring	Lead concentration ($mg L^{-1}$)
Tacloban City Convention Center	Tap water (transport water)	0.1–0.5
	Tap water (resident store water)	2
	Tap-water	0.1–0.5
Leyte Provincial Hospital	Tap-water	0.1–0.5
Palo, Leyte	Tap-water	0.1
Philippine Science School	Tap-water	0.5–1
Chinese-Philippinese Families (21) in TAC. CITY	Tap-water	0.1
Panalaron Center School	Tap-water	0.1–0.5
Sto. Nino Extension Bmcy. C Tacloban	Tap-water	0.1
Gov. Carlos Jericho L. Petilia	Tap-water	> 0.01
	Tap water (resident store water)	0.1
Sto. Nino Sped Center School	Tap-water	1.5
Bgy Pawing	Tap water (resident store water)	1.0
Missionaries of Charity Mother Teresa	Tap-water	1.0
San Fernando Central School	Tap-water	1.3
	Tap water (resident store water)	1.5
	Tap-water	1.5
Kapangian Central School	Tap-water	1.8

NHESSD
3, 5287–5295, 2015