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Health Impact of Exposure to Arsenic-Contaminated Drinking Water in Vietnam

The public health situation of the population of Hanam Province in Vietnam is of great concern, as it is exposed daily to arsenic-contaminated drinking water. Optimising arsenic (As) removal efficiency of current sand filters at household level or switching to cleaner or As-free water sources is crucial to prevent or reduce community health risks.

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Drinking water from tubewells in Hanam Province

The history of tubewell water use for drinking purposes dates back to the 1980s, when UNICEF introduced and provided tubewells to the rural areas of Vietnam and to the Hanam Province, located some 60 km south of Hanoi. Use of tubewells has widely spread with the introduction of electricity, as it facilitates extraction of groundwater from tubewells by electric instead of manual pumps. The Chuyen Ngoai commune in the Duy Tien district of Hanam is a lowland area near the Red River. It is located in an area where flooding occurs practically every year and the population therefore prefers to draw its water from tubewells rather than from deep wells, now almost entirely contaminated and filled up. The commune does not dispose of any waterworks or water supply. The inhabitants can only use rainwater and tubewell water for drinking and daily activities. Rainwater is used mainly for drinking and tubewell water for other purposes like bathing, washing and watering. 61.3 % of the households use both water sources for drinking, while 38.7 % use tubewell water throughout the year. The majority of households use tubewell water for drinking in January, February, November, and December when rainwater is scarce.

Arsenic contamination and weak removal efficiency with sand filters

We collected 150 tubewell water samples from the same households before and 150 water samples after sand filtration to determine As concentration by atomic absorption spectrometer. The results revealed that 98.7 % of the water samples before filtration were heavily contaminated with As. The As concentrations in water prior to filtration ranged from 8–579 ppb (mean: 301 ppb), thereby exceeding the limit of 10 ppb for drinking water (Figs. 1 and 2). Since the majority of households design and build their own sand filters (Photo 1), the filters usually do not meet the standard for As removal. For example, 95.3 % of the sand filters do not meet the required thickness, or 66.9 % of the households do not adhere to the time required to replace/clean the filters and 90.5 % do not conform to the aeration standard. Average As concentration in water after filtration amounted to 26.5 ppb, which is still higher than the limit for drinking water for 80.4 % of the surveyed households (Fig. 2). Although As contamination distribution was heterogeneous amongst villages in the Chuyen Ngoai commune (Fig. 1), no difference in As concentration before filtration was observed amongst the villages or between the areas.

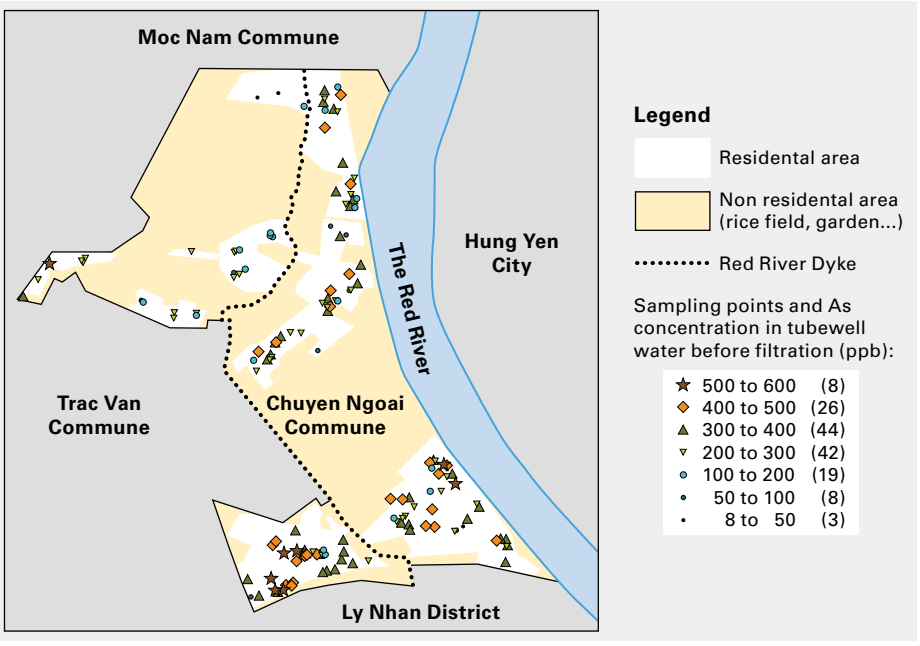

Figure 1: Sampling site and As contamination (before filtration) in the Chuyen Ngoai commune.

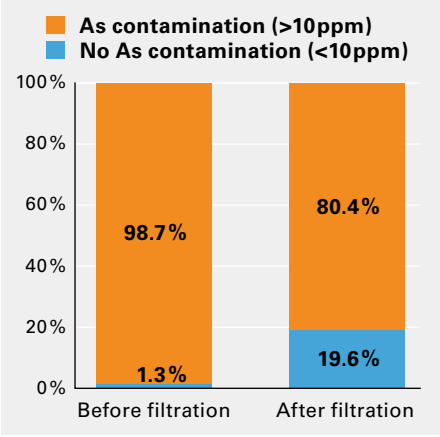

Figure 2: As concentration in tubewell water before and after sand filtration.

Health risks caused by As contamination

Assessment of the health risks was conducted by the Australian Environmental Health Risk Assessment Framework combined with analysis of As accumulated in

Photo 1: Sand filter with tubewell in Chuyen Ngoai, Hanam.

hair samples of 150 persons. Exposure was determined not only by measuring As concentrations in tubewell water samples as aforementioned, but also by estimating the water volume consumed as drinking water by 150 interviewed households. This provided data on the daily consumption volume via the oral route. As arsenic enters the body through the oral route, other exposure pathways, such as bathing and washing, were not considered. The health risk was characterised by comparing the As levels in water with the national technical regulations on drinking water quality, and by comparing the daily consumption dose with the Tolerable Daily Intake (TDI) value established by WHO. Finally, the cancer risk of people exposed to As-contaminated water sources through eating and drinking was estimated by applying the Cancer Slope Factor index and lifetime average daily dose.

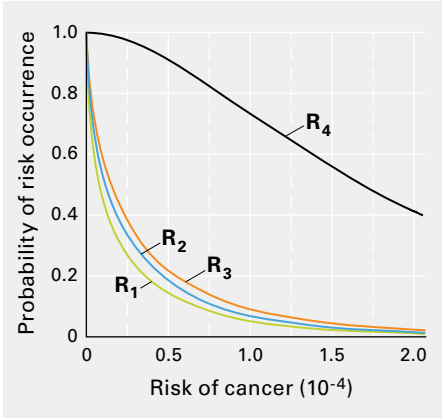

Figure 3: Estimated risk of cancer due to As-contaminated water.
R1: Current consumption of filtered water, R2 and R3: Risk after 5 and 10 years of drinking filtered water, respectively, R4: Risk of consuming filtered water over a lifetime.

Twenty-four hair samples (16 %) had As levels exceeding the limit of 0.57 mg/kg, of which 6 samples (4 %) revealed an As concentration higher than 0.8 mg/kg and corresponding to the standard diagnosis of chronic arsenic toxicity. Arsenic levels in hair were statistically significant to be correlated with As concentration in tubewell water after filtration.

Daily consumption of As amongst 40 % of adults was higher than the TDI level (1 µg/kg/day). The average cancer risk in adults from drinking filtered tubewell water amounted to 24 x 10-5. In other words, based on a population of 100 000 people consuming As-contaminated water, 24 persons are prone to have or develop cancer. This cancer risk would be 1.2 and 1.5 times higher after 5 and 10 years of drinking filtered water, respectively. By using filtered tubewell water over 70 years, the average cancer risk level amounts to 204 x 10-5. If tubewell water is used without filtering, the risk of cancer is 11.3 times higher. Different cancer risk scenarios are presented in Fig. 3.

Towards prevention and mitigation of health risks

Our study revealed a high As contamination level in tubewell water in Hanam, and a high risk of exposure to using As-contaminated water for drinking. Improved filtration measures or replacement of the current drinking water sources (e.g. by rain water, clean piped water etc) are recommended to prevent health risks of the local population. Risk awareness among the population, and especially amongst health workers, should be raised to prevent and mitigate the daily health effects posed by As contamination.

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