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Original Research

Quality of Kelantan drinking water and knowledge, attitude and practice among the population of Pasir Mas, Malaysia

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ABSTRACT

Objectives: Information about the quality of drinking water, together with analysis of knowledge, attitude and practice (KAP) analysis and health risk assessment (HRA) remain limited. The aims of this study were: (1) to ascertain the level of KAP regarding heavy metal contamination of drinking water in Pasir Mas; (2) to determine the concentration of heavy metals (Al, Cr, Cu, Fe, Ni, Pb, Zn and Cd) in drinking water in Pasir Mas; and (3) to estimate the health risks (non-carcinogenic and carcinogenic) caused by heavy metal exposure through drinking water using hazard quotient and lifetime cancer risk.

Methods: Information on KAP was collected using a standardized questionnaire. Heavy metal analysis of drinking water samples was performed using graphite furnace atomic absorption spectrophotometry.

Results: The population of Pasir Mas has good knowledge (80%), a less positive attitude (93%) and good practice (81%) towards heavy metal contamination of drinking water. The concentrations of heavy metals analysed in this study were found to be below the permissible limits for drinking water set by the Malaysian Ministry of Health and the World Health Organization. The HRA showed no potential non-carcinogenic and carcinogenic risks from the intake of heavy metal through drinking water.

Conclusion: By investigating the quality of drinking water, KAP and HRA, the results of this study will provide authorities with the knowledge and resources to improve the management of drinking water quality in the future.

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Introduction

According to the World Health Organization (WHO), 89% of the world population consumes drinking water from improved drinking water sources.[1] Improved drinking water sources include piped treated water connections, public standpipes and protected dug wells.[2] However, improved drinking water sources can still be contaminated by heavy metals from various sources.[3,4] Bobaker et al. stated that heavy metal contamination of treated drinking water is associated with the quality of the water source, such as river water.[3] Another source of heavy metal contamination in treated drinking water is the use of chemicals, such as alum, in conventional water treatment systems.[5] Studies have shown that excess usage of alum in water treatment will result in high Al residues in drinking water.[6–8] Heavy metal leakage from pipeline materials could also contribute to heavy metal contamination.[9] Pipeline materials such as galvanized iron pipes, copper pipes, steel pipes, brass fittings and taps are prone to corrosion.[10,11] Heavy metals such as Pb and Cu are related to pipeline corrosion, which has been found to be higher in stagnated drinking water samples from the USA, Germany and Malaysia.[4,12,13] Another factor in the heavy metal contamination of drinking water is practices at home, such as poorly maintained filtration units and improper storage containers for drinking water.[14,15] Al, Cr and Ni were found to leach into drinking water from Al and stainless steel containers.[16,17] Previous studies have suggested practices such as flushing the tap before collecting drinking water, or using a filtration unit to reduce heavy metal contamination.[18,19]

Many studies have compared the heavy metal contamination of drinking water with local and WHO standards,[12,13,20,21] and found that the concentrations of most heavy metals in drinking water from Turkey, Pakistan, Jordan, Germany and Malaysia are below permissible limits. Nevertheless, comparisons with drinking water standards alone are not enough to indicate the health risks caused by heavy metal exposure through drinking water. Health risk assessment (HRA) can be used to obtain information on the risk of heavy metal exposure through drinking water for the population. According to the Environment Protection Agency (EPA), the HRA process involves calculation of the hazard quotient (HQ) and the lifetime cancer risk (LCR) using variables such as heavy metal concentration, ingestion rate, body weight, exposure duration and slope factor.[22] $HQ < 1$ indicates no non-carcinogenic health risk to humans. LCR is acceptable at ranges from 1 in 10,000 to 1 in 1 million ($10^{-6}<LCR<10^{-4}$). Exposure to heavy metals such as As, Cr, Cd and Pb can lead to both non-carcinogenic and carcinogenic effects such as skin lesions, liver and kidney problems, mental diseases, abdominal pain and cancer.[23] Apart from the estimation of health risk, knowledge, attitude and practice (KAP) are important elements in drinking water studies. The KAP tool is used when studying a specific population to collect information on what is known, believed and done in relation to a particular topic.[24] KAP has been used in studies regarding perceived quality of drinking water, perceived health risk related to drinking water, drinking water hygiene, and diseases in developing countries.[14,15,25,26] These studies found that using unimproved water sources, poor knowledge, poor household water treatment practices and poor handwashing practices were sources of heavy metal contamination of drinking water in Nigeria, Kenya and Pakistan.[15,25–27]

In Malaysia, several studies have applied HRA in drinking water studies.[8,13,28] No potential adverse effects of Pb and Al intake were found among the studied population. However, the literature on KAP related to heavy metal contamination of drinking water is limited. A study by Aini et al. found that the urban population (Seremban, Negeri Sembilan) practice good techniques to improve the quality of drinking water, by using filtration units at home and boiling drinking water.[14] However, Azlina et al. found a lack of knowledge regarding safe drinking water among the rural population (Kelantan).[29] Incorporation of HRA and KAP in drinking water studies will provide more knowledge about the exposure of heavy metals, and will improve KAP regarding heavy metal contamination of drinking water. Thus, this information will help to improve the management of drinking water quality by both authorities and communities.

The objectives of this study were: (1) to ascertain the level of KAP towards heavy metal contamination in drinking water in Pasir Mas; (2) to determine the concentrations of heavy metals (Al, Cr, Cu, Fe, Ni, Pb, Zn and Cd) in drinking water from Pasir Mas; and (3) to estimate the health risks of heavy metal exposure through drinking water for the Pasir Mas population.

Methods

Study site

Kelantan is a state located on the east coast of peninsular Malaysia. Pasir Mas is a district in north Kelantan, and borders Tumpat District to the north, Tanah Merah District to the south, Kelantan River and Kota Bharu District to the east, and Sungai Golok, Thailand to the West (Fig. 1). The main town in Pasir Mas District is Pasir Mas, which is situated at longitude 6.0333° N and latitude 102.1333°E. Pasir Mas District has a population of 177,487, of which 97.5% is Malay, 2% is Chinese and the other 0.5% is Indian and Bumiputera (indiginous people of South-east Asia).

Drinking water supplied to Pasir Mas originates from the Kelantan River, and is treated using a conventional water treatment system at Kelar water treatment plant.[30] Water from the Kelantan River is vulnerable to heavy metal pollution because of agricultural activity, sand mining and upstream logging activity.[31] Drinking water is distributed to Pasir Mas through a pipeline system consisting of mild steel and HDPE pipes.[32] The majority of the pipeline systems in Kelantan use mild-steel pipes, which have low resistance against corrosion.[33,34] Aside from the pipelines, fitting materials such as brass and copper also contribute to heavy metal contamination, as Pb and Cu leach out into the drinking water.[35]

Sample size

The sample size calculation was based on the proportion of drinking water monitoring suggested by WHO.[36] This suggested that ten samples per 10,000 population is required for a

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