Journal of Epidemiology and Global Health (2015) 5, 297–310

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Drinking water studies: A review on heavy metal, application of biomarker and health risk assessment (a special focus in Malaysia)

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Received 11 December 2014; received in revised form 6 February 2015; accepted 3 April 2015
Available online 2 May 2015

KEYWORDS
Biomarker;
Drinking water;
Health risk assessment;
Heavy metal;
Exposure

Abstract Malaysia has abundant sources of drinking water from river and groundwater. However, rapid developments have deteriorated quality of drinking water sources in Malaysia. Heavy metal studies in terms of drinking water, applications of health risk assessment and bio-monitoring in Malaysia were reviewed from 2003 to 2013. Studies on heavy metal in drinking water showed the levels are under the permissible limits as suggested by World Health Organization and Malaysian Ministry of Health. Future studies on the applications of health risk assessment are crucial in order to understand the risk of heavy metal exposure through drinking water to Malaysian population. Among the biomarkers that have been reviewed, toenail is the most useful tool to evaluate body burden of heavy metal. Toenails are easy to collect, store, transport and analysed. This review will give a clear guidance for future studies of Malaysian drinking water. In this way, it will help risk managers to minimize the exposure at optimum level as well as the government to formulate policies in safe guarding the population.

Contents

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http://dx.doi.org/10.1016/j.jegh.2015.04.003

1. Introduction

Malaysia uses 99% water supply for domestic use from surface water, while another 1% of the supply from groundwater [1]. Total internal Malaysia water resources are estimated about 580 km^3/year and 30% water withdrawal is for municipal uses [2]. Water supply mainly from surface water and groundwater was treated and distributed to consumers as tap water, bottled drinking water and bottled mineral water which were used as drinking water [3—5]. In Malaysia, main sources of drinking are tap water, bottled drinking water and bottled mineral water [1,6—8]. Water supply from surface water is widely used as drinking water in Malaysia, such as water withdraw from Sungai Langat, Sungai Selangor, Sungai Kinta in West Coast Peninsular Malaysia [3,9]. Water supply from groundwater is also used as drinking water in a few states of Malaysia such as Kelantan, Terengganu, Pahang, Perlis, Kedah, Sabah, and Sarawak [10].

Municipal water consisting of untreated surface water and groundwater needs to be treated, before the water is made potable. A total of 488 water treatment plants (WTP) are operated in Malaysia to treat municipal water before the water is supplied to consumers [11]. Treatment plants in Malaysia have the ability to produce 15,536 Million Litre per Day (MLD) drinking water to consumers [11]. Majority of water treatment plants are using conventional water treatment system, while only a few water treatment plants are using advanced technologies such as Actiflo Clarification System, Ultra Membrane Filtration, Dissolved Air Floatation (DAF) and Ozone [3,12]. Conventional water treatment is divided into three stages namely pre-treatment, pre-chlorination and post-treatment [13]. Pre-treatment stage includes filtration and aeration process to remove particles such as sands, colour, odour and taste [13]. Pre-chlorination phase is functioned to remove smaller particles by pre-chlorination, coagulation (use alum), flocculation (use polymer), sedimentation and filtration (rapid sand gravity) process [3,13]. Among water treatment plants which are using conventional water treatment systems are at Langat Batu 10 and Cheras Batu 11 WTP (Selangor), Kelar and Kampung Puteh WTP (Kelantan) and Ulu Kinta and Hilir Perak WTP (Perak) [3,9,12]. Usage of advanced technology such as Actiflo Clarification System and Dissolved Air Floatation is to improve clarification process which is similar to coagulation and sedimentation purpose in conventional system [3]. Another advanced technology is Ultra Membrane Filtration which uses transmembrane pressure to remove Cr, Cd, Zn, Cu, Ni and Pb with removal percentage ranging from 92% to 100% [3,14]. Lastly, the post-treatment stage involves disinfection, post lime, fluoride and balancing reservoir to remove bacteria and stabilize water hardness [13]. Ozone technology is used as disinfection to replace chlorination process [15]. List of water treatment plants which are utilized advanced technology are summarized in Table 1. Despite effective heavy metal removal using advanced technologies, small number of this technology used in Malaysia might be due to high technology operation and maintenance with expensive running cost [16].

Treated water from water treatment plant is distributed to consumer as tap water using pipeline system which is provided by water body such as Syarikat Bekalan Air Selangor Sdn. Bhd. (SYABAS) and Syarikat Air Negeri Sembilan Sdn. Bhd. (SAINS) for Selangor and Negeri Sembilan state. Pipeline system used is according to guidelines prepared by National Water Services Commission [13]. There are wide variety of pipes used in Malaysia such as Galvanized Iron (GI), Ductile Iron (DI), Mild Steel (MS), Stainless Steel (SS), asbestos (ABS) and plastics (HDPE and PVC). GI type is the oldest type of pipe that has been used in Malaysia [17]. However, due to low resistant to corrosion, most of states in Malaysia have already replaced this type of pipe with HDPE, SS, DI, and MS pipe [17—19]. In West Coast Peninsular Malaysia and