Health Risk Assessment of Heavy Metals in Purified Drinking Water in Hinthada Township, Ayeyarwady Region

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Abstract

The determination and monitoring of the characterizations of physico-chemical parameters and assessment of heavy metals in drinking water are essential tasks for environmental security of human society. In this paper, four samples of purified drinking water were collected from Hinthada Township, Ayeyarwady Region. The physico-chemical parameters of purified drinking water such as pH, turbidity, total dissolved solids, conductivity and hardness were studied. The results of this study were compared with the drinking water quality standard of World Health Organization (WHO)/Environmental Protection Agency (EPA). According to the results, physico-chemical parameters of purified drinking water were found within drinking standard value. The concentration of some heavy metals such as cadmium (Cd), lead (Pb), zinc (Zn), iron (Fe) and copper (Cu) in purified drinking water samples have been determined by using Atomic Absorption Spectroscopy (AAS). According to the results, lead (Pb) concentration of all samples were above and remaining metals were below the permissible limits of WHO standard. The human health risk assessment was performed by calculation chronic daily intake of metals (CDI) and health risk index (HRI) of the metal through human oral consumption. The daily intake of metal value for lead (Pb) in all samples were more than recommended value. The health risk index of lead (Pb) in all samples were greater than the value one, which was the indication of potential health risk index. The results of various purified drinking water suggested that long-term use can cause heavy metals contamination which is leading to health risk of consumers.

Keywords: Health risk assessment, chronic daily intake of metals, health risk index and AAS

Introduction

Myanmar is a developing country in Southeast Asia. The water infrastructure needs to be developed for the country's further economic development. Water plays a significant role in maintaining the human health and welfare. Clean drinking water is now recognized as a fundamental right of human beings. Human life without water is just impossible. Water is required not only for metabolic systems in human body but also for other associated activities in human life. After air, the important of water takes the second place as an essential requirement for living and non-living things.

The pH (Potential of Hydrogen) level of drinking water refers to how basic or acidic it is. The pH level is related to the hydrogen ions found in the water. The range goes from 0 to 14, with 7 being neutral. The pH level of less than 7 indicates acidity, whereas a pH level of greater than 7 indicates a base. The pH of water is a very important measurement concerning water quality. The pH is really a measure of the relative amount of free hydrogen and hydroxyl ions in the water. [18]

Turbidity is a measure of how clear the water is. Turbidity is the cloudiness or haziness of a fluid caused by suspended solids that are usually invisible to the naked eye. The measurement of turbidity is an important test when trying to determine the quality of water. In drinking water, the higher the level of turbidity, the higher the chance that those using it could develop gastrointestinal diseases. [19]

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Total Dissolved Solids (TDS) are inorganic compounds that are found in water such as salts, heavy metals and some traces of organic compounds that are dissolved in water. TDS in water is one of the leading causes of turbidity and sediments in drinking water. When the measures TDS of water, the presence of heavy metals cannot be exactly determined. TDS concentrations in drinking water can cause coronary heart disease, cancer, cardiovascular heart disease, and arteriosclerotic heart disease. [20]

Conductivity is a measure of the ability of water to pass an electrical current. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate and sulfate. Organic compounds like oil, phenol, alcohol, and sugar do not conduct electrical current. Conductivity is also affected by temperature: the warmer the water, the higher the conductivity. [21]

Hard water is water that has high mineral content. Hard water is formed when water percolates through deposits of limestone, chalk or gypsum which are largely made up of calcium and magnesium carbonates, bicarbonates and sulfates. Hard water is not seriously harmful to human health. However, water with a high level of hardness could cause serious problems. [21]

Samples Collection

Hinthada is located on the bank of the Ayeyarwady River in Ayeyarwady Region, Myanmar. It is located 17˚38′46″ North and 95˚27′37″ East. Sampling sites in collection of purified drinking water is shown in table (1).

Table (1) Sampling sites in collection of purified drinking water.

Sample	Location	Description
P1	Kanaung Su Quarter	Purified Drinking Water
P2	Thone Pin Kwin Quarter	Purified Drinking Water
P3	Natmaw Quarter	Purified Drinking Water
P4	Nyaung Pin Zaye Quarter	Purified Drinking Water

Materials and Methods

Physico-chemical parameters of purified drinking water such as pH, turbidity, total dissolved solids, conductivity and hardness were determined in Ecological Laboratory. The concentration of some heavy metals such as cadmium (Cd), lead (Pb), zinc (Zn), iron (Fe) and copper (Cu) in purified drinking water samples was determined by using Atomic Absorption Spectroscopy (AAS) in University Research Center (URC).

Health Risk Assessment

Health risk assessment is considered as the characterization of the potential adverse health effects of human as a result of exposures to environmental hazards (USEPA, 2012). Health risk assessment modes were developed basically in Europe and United States. The risk assessment is a multi-step procedure that comprises of data collection, exposure assessment, toxicity assessment and risk characterization. [4]

Chronic Daily Intake of Metals (CDI)

The following equation is a simple representation of daily exposure route modified from USEPA. [12]

$$CDI = \frac{Cmetal \times Dwater\ intake \times Cf}{Baveragebodyweight} \quad .....(1)$$

CDI = Chronic Daily Intake of Metals (mg/kg/day)

C_{metal} = The heavy metal concentration in water (mg/L)

$D_{waterintake}$ = Average daily intake rate of water is 3 litre / day

C_f = Concentration Factor

* The average body weight was taken as 55kg for adults according to WHO guideline, 1993.[14]

Health Risk Index (HRI)

Value of Health Risk Index (HRI) depends on the Chronic Daily Intake of Metals (CDI) through water and the reference dose (RfD).

$$HRI = CDI / RfD \quad ..... (2)$$

CDI = Chronic Daily Intake of Metals (mg/kg/day)

RfD = The reference dose (mg/kg/day)

Health risk assessment of the toxicants was interpreted based on the values of health risk index. HRI<1 means no risk but the greater the value above one, the greater the risk level of the toxicants manifesting long-term health hazard effects. [5]

Results and Discussion

Results and Discussion for some physico-chemical parameters

In this paper, the measured some physico-chemical parameters such as pH, turbidity, total dissolved solids, conductivity and hardness, the data given in table (2).

According to the results, pH levels of the samples were found in the amount between 6.9 (in P2) and 7.7 (in P3). In all samples, the pH level was found within drinking standard value. Levels of turbidity in all samples were detected less than 10 FAU and it showed lower than drinking standard value. In all samples, the total dissolved solids levels were found lower than drinking standard value 500 mg/L (in EPA standard). Levels of conductivity and hardness in all samples were detected lower than drinking standard value.

Table (2) Some physico-chemical parameters that contained in purified drinking water samples

Quality Parameter	P1	P2	P3	P4	Drinking Standard
pH	7.4	6.9	7.7	7	6.5 - 8.5
Turbidity	5 FAU	5 FAU	5 FAU	5 FAU	10 FAU
Total Dissolved Solids	5 mg/L	15 mg/L	10 mg/L	11.5 mg/L	500mg/L
Conductivity	0.01 mS/cm	0.02 mS/cm	0.01 mS/cm	0.2 mS/cm	2.5 mS/cm
Hardness	2 mg/L	2 mg/L	2 mg/L	2 mg/L	60 mg/

Results and Discussion for the concentration of some heavy metals

In this research, the concentration of some heavy metals in purified drinking water such as cadmium (Cd), lead (Pb), zinc (Zn), iron (Fe) and copper (Cu) in water samples were determined by using Atomic Absorption Spectroscopy (AAS). According to the results, lead (Pb) concentration of all samples were found above the permissible limits of WHO standard and remaining metals were found below the permissible limits of WHO standard. Lead is a dangerous element; it is harmful even in small amounts. Lead enters the human body in many ways. Table (3) showed that some heavy metals contained in purified drinking water samples. Figure (1) showed the comparison of lead (Pb) and zinc (Zn) concentrations that contained in purified drinking water samples and WHO standard.

Table (3) Some heavy metals that contained in purified drinking water samples

Element	P1 (mg/L)	P2 (mg/L)	P3 (mg/L)	P4 (mg/L)	WHO Standard (mg/L)
Cadmium (Cd)	ND	ND	ND	ND	0.003
Lead (Pb)	0.186	0.391	0.284	0.386	0.01
Zinc (Zn)	0.008	ND	ND	0.011	0.1
Iron (Fe)	ND	ND	ND	ND	0.3
Copper (Cu)	ND	ND	ND	ND	1.0

ND = Non-Detectable in mg/L range.

Figure (1). Comparison of Lead (Pb) and Zinc (Zn) concentrations that contained in purified drinking water samples and WHO standard

Chronic Daily Intake of Metals (CDI)

Table (4) showed the chronic daily intake of metals in purified drinking water samples and the recommended value. Figure (2) showed the comparison of CDI for lead (Pb) in purified drinking water and recommended value. The chronic daily intake of metal value for lead (Pb) in all samples were more than the recommended value.

Table (4) Chronic Daily Intake of Metal

CDI (mg/kg/day)	P1	P2	P3	P4	Recommended Value
Lead (Pb)	0.0101	0.0213	0.0154	0.0210	0.0012

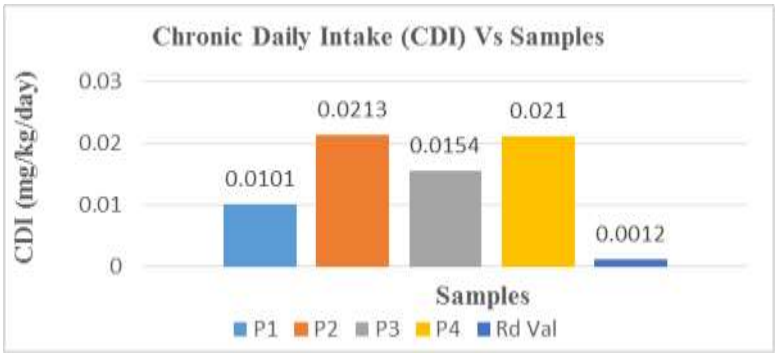

Figure (2) Comparison of CDI for lead (Pb) in purified drinking water and recommended value

Health Risk Index (HRI)

Table (5) showed the health risk index (HRI) in purified drinking water samples for lead (Pb). Figure (3) showed the comparison of HRI for lead (Pb) in purified drinking water. The health risk index of lead (Pb) in all samples were greater than the value one which was the indication of potential health risk.

Table (5) The health risk index (HRI)

HRI	P1	P2	P3	P4
Lead (Pb)	2.805	5.961	4.277	5.833

*Indication of potential health risk (HRI) ≥ 1

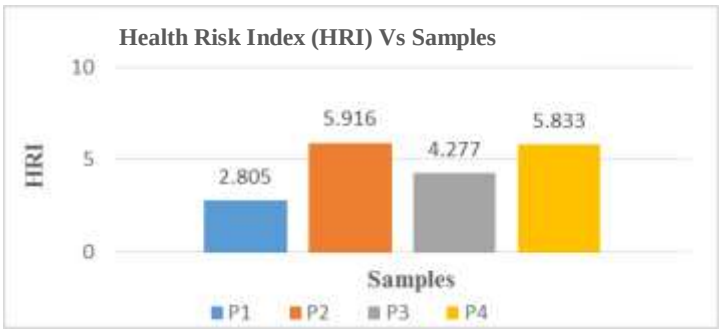

Figure (3) The comparison of HRI for lead (Pb) in purified drinking water samples

Conclusion

In this paper, some physico-chemical characterizations of purified drinking water in Hinthada were studied. According to analysis of the physico-chemical parameters results, the pH levels, turbidity levels, total dissolved solids, conductivity and hardness in all samples were found within standard drinking water. So, the purified drinking water samples in this research areas have drinkable level. But this research studies on some heavy metal distribution and the proximation of health risk assessment in purified drinking water. The concentration of lead in all samples were found above the permissible limits of WHO standard. The chronic daily intake (CDI) of lead (Pb) in all samples were more than the

recommended value. The health risk index (HRI) of lead (Pb) in all samples were above the value one that poses a potential health risk. Therefore, caution should be taken in long-term useof there purified drinking water in Hinthada Township. To get acceptable concentration level of lead (Pb) in sample P1 purified drinking water, it should be reduced one third of the result value.

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