Study of Some Heavy Metals Distribution and Health Risk Assessment in Tube-well Water of Taunggyi Environs

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Abstract

The aim of this research is to determine the concentration of some heavy metals distribution in various tube-well water in Taunggyi environs. The concentration of some heavy metals such as lead (Pb), cadmium (Cd), arsenic (As), iron (Fe) and calcium (Ca) in tube-well water samples have been determined by using Atomic Absorption Spectroscopy (AAS). According to this research lead (Pb) and cadmium (Cd) concentration of all samples were found above the permissible limits of WHO standard. Arsenic (As) and iron (Fe) concentration were found below the permissible limits of WHO standard. The concentration of calcium (Ca) was found too much higher than WHO standard except sample (T1). The human health risk assessment was performed by determining the metal pollution index (MPI), daily intake of metals (DIM), health risk index (HRI) and total health risk index (THI) of the metal through human oral consumption. The daily intake of metal value for cadmium (Cd) in each sample and lead (Pb) in sample T3, T4 and T6 were more than recommended value. The health risk index of lead (Pb) in sample T4 was one, which was indication of potential health risk index. The health risk index of arsenic (As) in sample T4 and iron (Fe) in sample T3 were above one and thus pose a potential health risk. Health risk assessment for T3 and T4 samples indicated high risk. Therefore, the results of various tube-well water suggested that long-term use can be caused heavy metals contamination which was leading to health risk of consumers.

Keywords: Health risk assessment, metal pollution index, daily intake of metals, health risk index and total health risk index.

Introduction

Human life without water is just impossible. Water is not only require for metabolic systems in human body but also required for other associated activities with human life. Water is important for hormones, chemical messengers and nutrients to vital organs of the body. Different parts of our body have the following composition of water; 80% of brain, 83% of blood, 31% of bone and 79% of muscle. It is also an important component of the tissues of most other living things.

The five essential requirements for human existence are: (i) air, (ii) water, (iii) food, (iv) heat and (v) light. Contamination of these may cause serious health hazards not only to man but also to animal life. The use of water by man, plants and animal is universal. Without it, there, can be no life. Every living things require water (Chapman.,1996).

Man and animal cannot grow without water. The use of water is increasing rapidly with our growing population. Water maintains an ecological balance, balance in the relationship between living things and their environment in which they live. From the point of view of mankind, water is certainly the most important simple substance in the world. The earth can be regarded as a water planet, for it covers nearly two-thirds of the entire earth's surface.

Heavy metal or toxic metals are trace metals which are detrimental to human health. Once liberated into the environment through air, drinking water, food or countless varieties of man- made chemicals and products, heavy metals are taken into the body via inhalation, ingestion and dermal absorption (Sadar *et al.*, 2013). If heavy metal enter and accumulate in body tissues faster than the body's detoxification pathways can dispose of, then a gradual

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build-up of these toxins occurs. High concentration exposure is not a necessity to produce a state of toxicity in the body, as heavy metal accumulation occurs in body tissues gradually and over time, can reach toxic concentration level, much beyond permissible limits (Suruchi and Khanna, 2011).

Heavy metal contamination is a major problem of the environment especially of growing medium sized cities in developing countries primarily due to uncontrolled pollution levels driven by causative factor like industrial growth and heavy increases in traffic using petroleum fuels. Heavy metals are generally not removable even after the treatment at treatment plant and thus, cause risk of heavy metal contamination of the soil and subsequently to the food chain (Maigari *et al.*, 2016).

This research studied on some heavy metals distribution and health risk assessment in tube-well water from Taunggyi environs have been done by using Atomic Absorption Spectroscopy (AAS) method. The measurements by AAS results were compared with guidelines for water quality from WHO standards. Metal pollution index (MPI), daily intake of metals (DIM) and health risk index (HRI) and total health index (THI) are discussed in this research. Therefore this research is very important from the health physics point of view.

Objectives of the study

The objectives of the study were to determine the concentration of some heavy metal in tube-well water from Taunggyi environs by using AAS. Each of the tube-well water was collected from Taunggyi (Sample T1 and T2), Hopone (Sample T3), Aungban (Sample T4) , Nyaung Shwe (Sample T5) and Yatsauk (Sample T6). Sample preparation was performed by the automatic sampling system of AAnalyst 800 with PC control, determine the health risk by ingestion of water by the determination of their metal pollution index (MPI), daily intake of metals (DIM), health risk index (HRI) and total health risk index (THI) of the metal through human oral consumption.

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 (Isa Baba Koki *et al*., 2015).

Metal Pollution Index (MPI)

Metal Pollution Index (MPI) is computed to analyze the status of the heavy metal contamination in the environment. MPI is calculated according to the given equation;

$$MPI = (C1 \times C2 \times C3 \times \ldots\ldots\ldots \times Cn)^{1/n} \quad \ldots\ldots \qquad (2.1)$$

Where Cn is the concentration of the metals " n " in the sample (Isa Baba Koki *et al*., 2015).

Daily Intake of Metals (DIM)

The following equation is a simple representation of daily exposure route modified from USEPA (USEPA, 1992).

$$\text{DIM} = \frac{C_{metal} \times D_{water\,intake} \times C_f}{B_{averagebodyweight}} \quad \ldots\ldots (2.2)$$

DIM = 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 (WHO, 1993).

Health Risk Index (HRI)

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

$$\text{HRI} = \frac{DIM}{RfD} \quad \ldots\ldots (2.3)$$

DIM = 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 and greater the value above one, the greater is the risk level of the toxicants manifesting long-term health hazard effects increasing (Maigari *et al.*, 2016).

Total Health Risk Index (THI)

The total health risk index (THI) is the sum of the hazard quotients for all HMs, which was calculated by the equation,

$$\text{THI} = \Sigma\, \text{HQ} = \text{HQ}_{Pb} + \text{HQ}_{Cd} + \text{HQ}_{As} + \text{HQ}_{Fe} \quad \ldots\ldots (2.4)$$

Results and Discussion

Elemental analysis of the samples

Table (1). Comparison of tube-well water and WHO standard

Elements	T1 (mg/L)	T2 (mg/L)	T3 (mg/L)	T4 (mg/L)	T5 (mg/L)	T6 (mg/L)	WHO (mg/L)
Lead (Pb)	0.017	0.015	0.039	0.066	0.017	0.037	0.01
Cadmium(Cd)	0.009	0.008	0.008	0.009	0.011	0.009	0.003
Arsenic (As)	0.001	0.002	0.005	0.009	0.004	0.002	0.01
Iron (Fe)	0.075	0.082	0.130	0.075	0.114	0.074	0.3
Calcium (Ca)	0.022	24.08	20.61	17.62	30.81	20.15	0.05

T 1 = Tube-well Water from Taunggyi, T 2 = Tube-well Water from Taunggyi
T 3 = Tube-well Water from Hopone, T 4 = Tube-well Water from Aungpan
T 5 = Tube-well Water from Naung Shwe, T 6 = Tube-well Water from Yatsauk

Table (1) showed the comparison of tube-well water and WHO Standard and figure (1) showed the comparison of lead (Pb) level for tube-well water and WHO standard. The concentration of lead (Pb) in tube-well water was detected in the amount between 0.015mgL^{-1} in T2 and 0.066 mg L^{-1} in T4 . The lead concentration in all samples was too much higher than WHO standard the guideline value of 0.01 mg L^{-1} and was not suitable for portable use. These amount of lead (Pb) concentration containing in these water sample could be severely harmful for human health. The concentration of lead is dependent upon sources of pollution, lead content and characteristic of the system. Potential Health Effects from long-term exposure above the maximum contaminant lead level are decays in physical or mental development of infants. To reduce lead level, use only cold water for drinking and food preparation. Hot water is more likely to contain higher levels of lead (Pb) than cold water. Boiling the water not remove lead and may actually increase the concentration of lead.

Figure (2) showed the comparison of cadmium (Cd) level for tube-well water and WHO standard. Levels of cadmium (Cd) in tube-well water were found in the range between 0.008 mgL^{-1} in T2 and T3 and 0.011 mg L^{-1} in T5 . Thus, all samples of tube-well water were higher than WHO standard 0.003 mg L^{-1}.

Figure (3) showed the comparison of arsenic (As) level for tube-well water and WHO standard. The concentration of arsenic (As) in tube-well water was found in the range between 0.001 mg L^{-1} in T1 and 0.009 mg L^{-1} in T4. All samples were lower than WHO guideline value of 0.01 mg L^{-1} .

Figure (4) showed the comparison of iron (Fe) level for tube-well water and WHO Standard. Iron (Fe) concentration in tube-well water was detected in the range between 0.074 mg L^{-1} in T6 and 0.130 mg L^{-1} in T3. All samples were lower than WHO guideline value 0.3 mg L^{-1}.

Figure (5) showed the comparison of calcium (Ca) level for tube-well water and WHO standard. Levels of calcium (Ca) in tube-well water were found to detect in the range between 0.022 mg L^{-1} in T1 and 30.81 mg L^{-1} in T5. The concentration of calcium (Ca) in T1 was lower than WHO standard value 0.05 mg L^{-1}. The remaining samples T2 to T6 were extremely higher than WHO standard. Because of the plenty of limestone, concentration of calcium (Ca) in there samples is increased. Calcium (Ca) has been associated with increased risks of osteoporosis, kidney stones, stroke and hypertension. Most of these disorders have treatment but no cures. Calcium is unique among nutrients, in that the body's reserve is also functional increasing bone mass is linearly related to reduction in fracture risk.

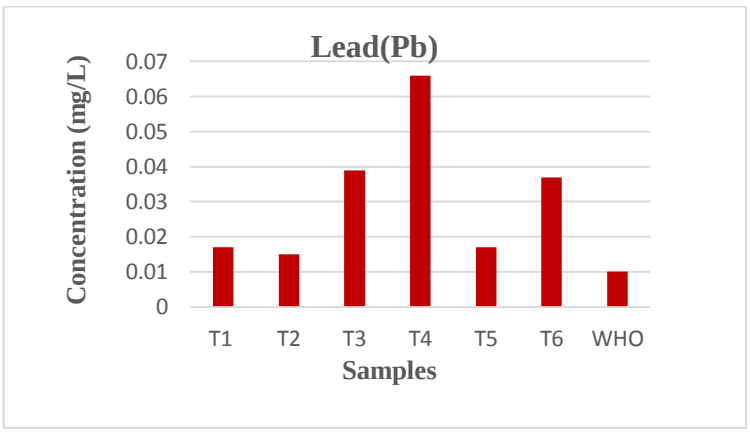

Figure (1). Comparison of lead (Pb) level for tube-well water and WHO standard.

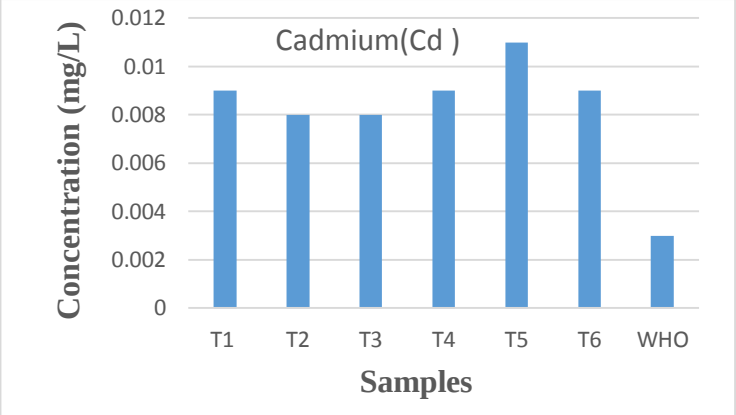

Figure (2). Comparison of cadmium (Cd) level for tube-well water and WHO standard.

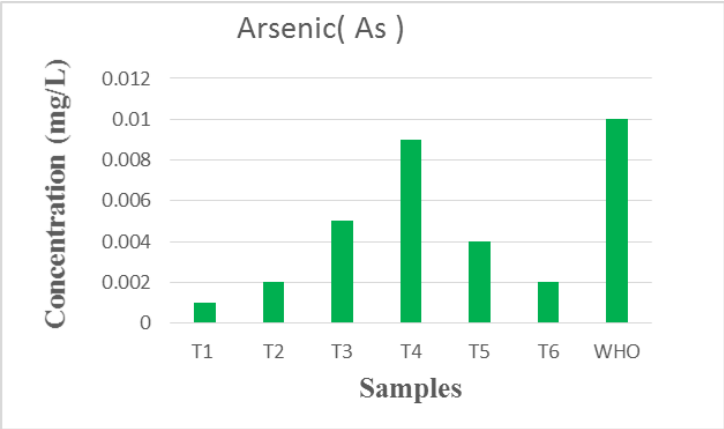

Figure (3). Comparison of arsenic (As) level for tube-well water and WHO standard.

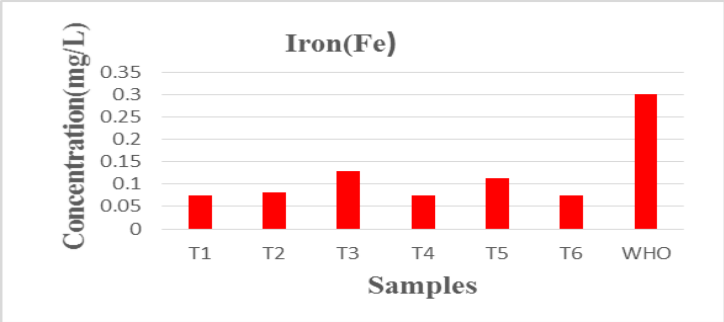

Figure (4). Comparison of iron (Fe) level for tube-well water and WHO standard.

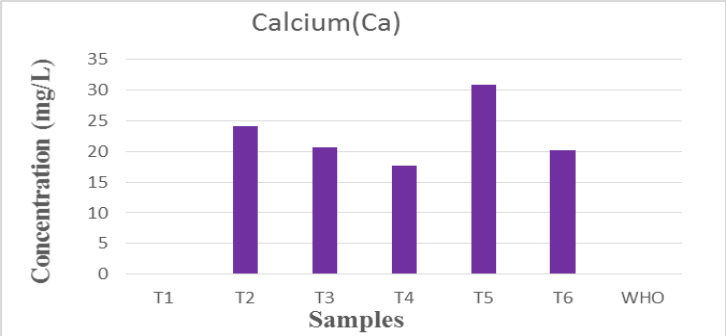

Figure (5). Comparison of calcium (Ca) level for tube-well water and WHO standard.

Metal Pollution Index (MPI)

Table (2) Metal Pollution Index

SAMPLE	MPI (mg/L)
T1	0.0118
T2	0.0543
T3	0.0839
T4	0.0933
T5	0.0765
T6	0.0630

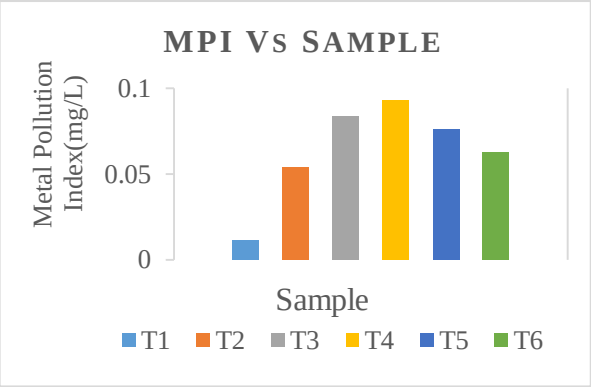

Figure (6) Comparison of MPI for tube-well water

Daily Intake of Metals (DIM)

Table (3) showed the daily intake of metals and the recommended value. Figures (7) and (8) showed the comparison of DIM for lead and cadmium in tube-well water and recommended value. The daily intake of metal value for lead (Pb) in sample T3, T4 and T6 were more than the recommended value. The daily intake of metal value for cadmium (Cd) in each sample was more than the recommended value.

Table (3). Daily Intake of Metals

Sample	T1	T2	T3	T4	T5	T6	Recommended Value
Pb	0.00093	0.00082	0.00213	0.00360	0.00093	0.00202	0.0012
Cd	0.00049	0.00044	0.00044	0.00049	0.00060	0.00049	0.0001
As	0.00054	0.00011	0.00027	0.00040	0.00022	0.00011	0.0014
Fe	0.00409	0.00447	0.00709	0.00409	0.00621	0.00404	-
Ca	0.00120	1.31345	1.12418	0.96100	1.68054	1.09900	-

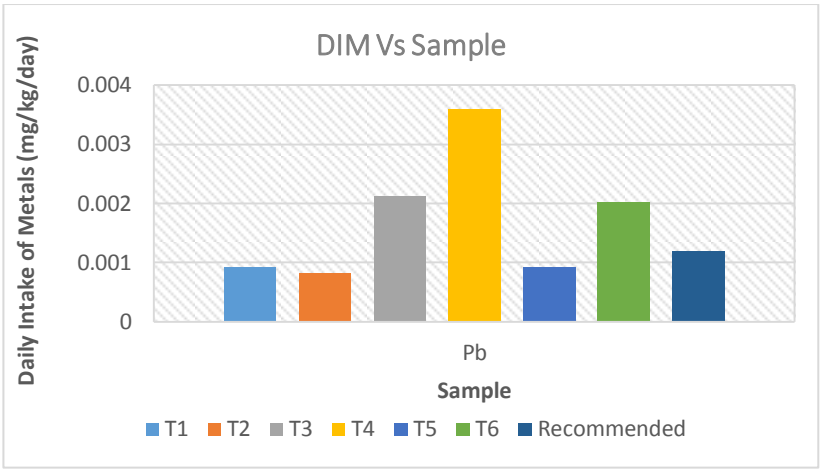

Figure (7). Comparison of DIM for lead in tube-well water and recommended value.

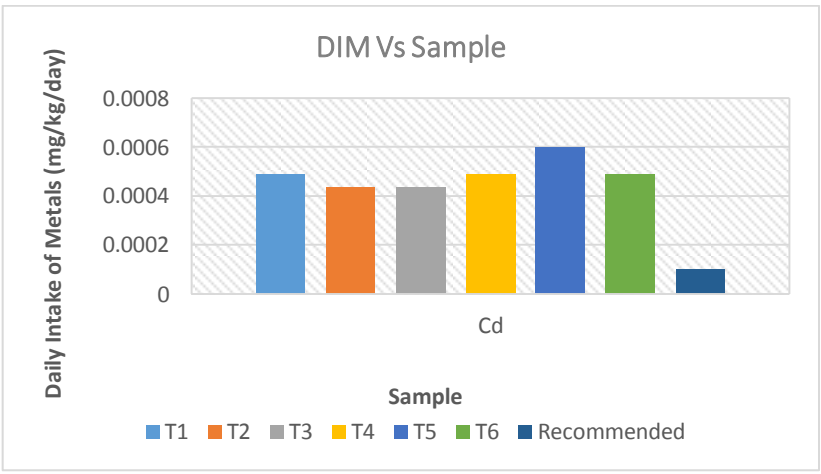

Figure (8). Comparison of DIM for cadmium in tube-well water and recommended value.

Health Risk Index (HRI) and Total Health Risk Index (THI)

Table (4) showed the health risk index (HRI) and total health risk index (THI) of the samples. Figures (9) to (3.11) showed the comparison of HRI for lead (Pb), arsenic (As) and iron (Fe) level in tube-well water. The health risk index of lead (Pb) in sample T4 was one which was indication of potential health risk. The health risk index of arsenic (As) in sample T4 and iron (Fe) in sample T3 were above one and thus pose a potential health risk.

Table (4). Health Risk Index (HRI) and Total Health Risk Index (THI)

Sample	T1	T2	T3	T4	T5	T6
Pb	0.257	0.227	0.590	1	0.257	0.560
Cd	0.490	0.436	0.436	0.490	0.600	0.490
As	0.180	0.363	0.906	1.633	0.726	0.363
Fe	0.584	0.638	1.012	0.584	0.887	0.576
THI	1.511	1.664	2.944	3.707	2.470	1.898

*Indication of potential health risk (HRI) ≥ 1.

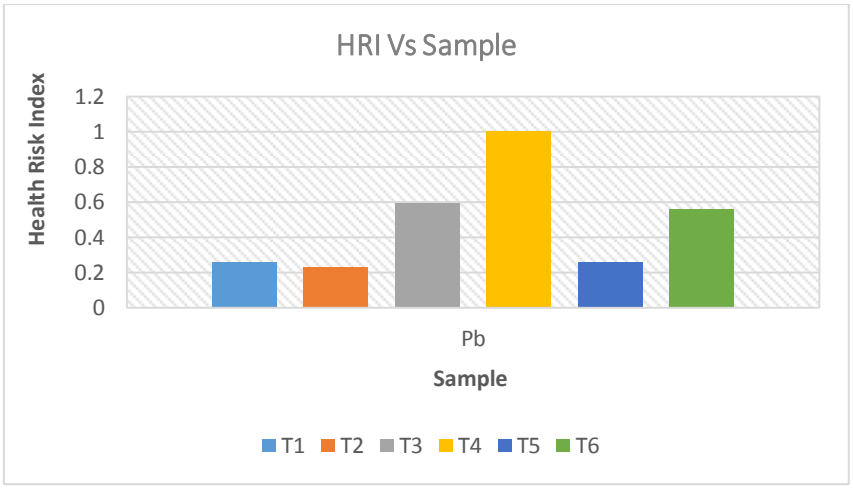

Figure (9) Comparison of HRI for lead (Pb) level in tube-well water.

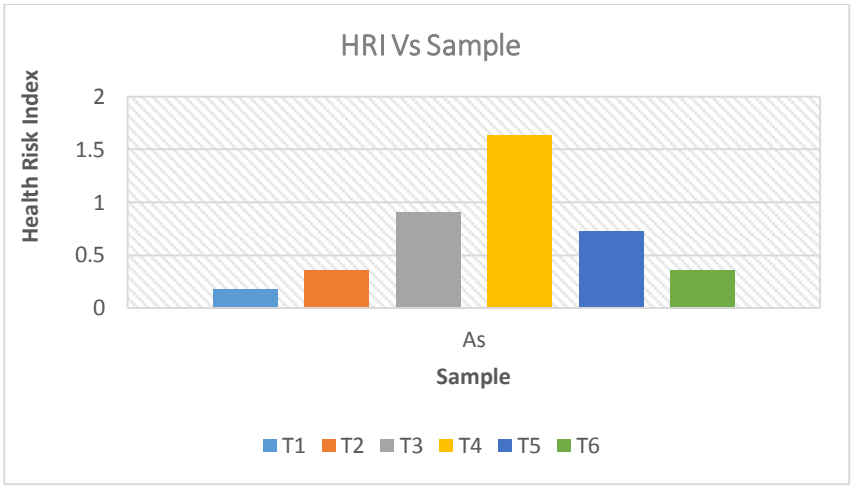

Figure (10) Comparison of HRI for arsenic (As) level in tube-well water.

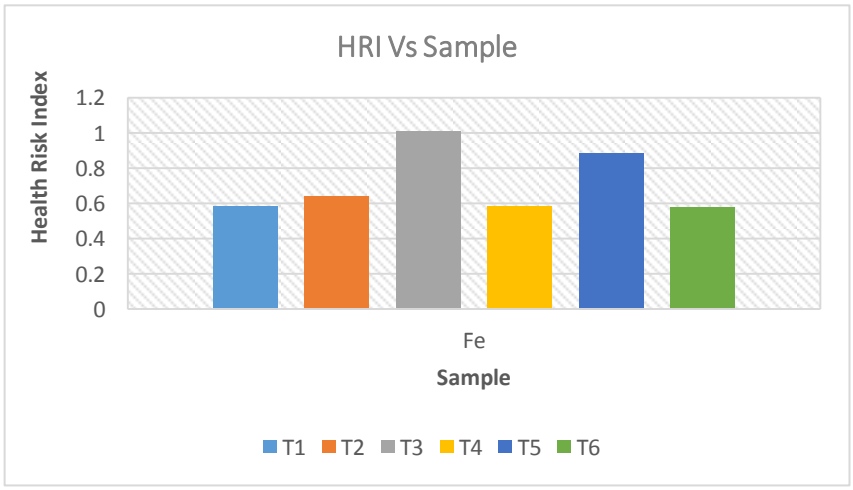

Figure (11) Comparison of HRI for iron (Fe) level in tube-well water.

Conclusion

This research studies on some heavy metal distribution and the proximation of health risk assessment in Tube-well water in Taunggyi environs. The concentration of lead and cadmium in all samples were found above the permissible limits of WHO standard. Level of calcium in all samples except sample T1 were extremely higher than WHO standard. The higher concentration of calcium in these samples is because of plenty of limestone. Calcium is not toxic, but higher amount can increase the risk of kidney stones, gallstone.

The daily intake of cadmium (Cd) in each sample and lead (Pb) in sample T3, T4 and T6 were more than the recommended value. The health risk index of lead (Pb) in sample T4 was one, arsenic (As) in sample T4 and iron (Fe) in sample T3 were above one thus pose a potential health risk. Therefore, caution should be taken in long-term use.

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