Study on Health Risk Assessment in Ground Water from Kamma Environs, Magway Region

Naing Naing Oo[1], Myint Myint Win[2], Zaw Htet Aung[3], Win Win Thein[4]

Abstract

This research is to determine the concentration of some heavy metals and health risk assessment in various ground water in Kamma Environs, Magway Region. The concentrations of some heavy metals such as lead (Pb), cadmium (Cd), arsenic (As) and chromium (Cr) in ground water samples have been determined by using Atomic Absorption Spectroscopy (AAS). According to this research, lead (Pb) and cadmium (Cd) in all samples were exceeded as higher limitation level than WHO standard values. Levels of arsenic (As) and chromium (Cr) in all samples were lower than WHO standard values. The underground water in this research area should not be portably used. The human health risk assessment was performed by determining the metal pollution index (MPI), daily intake of metals (DIM) and health risk index (HRI) of the metal through human oral consumption. Health risk assessment for all samples indicated high risk. The results of various ground water can cause heavy metal contamination which is leading to health risk of consumers.

Key words: Health risk assessment, metal pollution index, daily intake of metals.

INTRODUCTION

Groundwater is located below the earth's surface within soil and rock layers. Surface water is the source of river, lake, wetland, or ocean. Groundwater is located underground in large aquifers and must be pumped out of the ground after drilling a deep well. There are many sources of replenishment of groundwater supplies, including groundwater depletion and melting snow.

The surface of the water is covered by lakes, rivers and ponds. It is found in rivers and streams and is consumed in public water supply. The water is usually not very high in minerals. It contains many different contaminants, such as animal wastes, pesticides, insecticides, industrial wastes, algae and many other organic materials.

Groundwater is an important part of the water cycle. Groundwater is the part of the rainfall, which seeps into the water until it reaches a rocky surface. Water is stored in the ground in the spaces between rock particles. Groundwater is slowly moving underground. It generally moves to the downward angle (because of gravity), and eventually to rivers, streams, lakes, and oceans. It can seep into the lakes and oceans.

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

[1] Associate Professor, Dr, Department of Physics, Hinthada University.
[2] Lecturer, Dr, Department of Physics, Pakokku University.
[3] Lecturer, Dr, Department of Physics, Hinthada University.
[4] Professor & Head, Dr, Department of Physics, Hinthada University.

treatment plant and thus, cause risk of heavy metal contamination of the soil and subsequently to the food chain. (Maigari A. U. et al., 2016)

This research studied some heavy metals and health risk assessment in groundwater from Kamma Environs, Magway Region that 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) are discussed in this research. This research is very important from the health physics point of view.

Measurement of AAS

AAS is based on the absorption of virtually monochromatic light by a cloud of atoms of the detecting samples. The light is produced by emission from the same kind of atoms as those being determined. This means that exactly the same wavelength of light is produced as that being absorbed, and hence a high temperature flames and graphite furnace. Atomic absorption using flame atomizers was rapidly accepted as a simple technique which gave high sensitivity, accuracy and precision.

Generating free atoms using an atomizer may be flame or a thermal atomizer. The absorption is measured at one of several wavelength characteristics of the element being determined. Absorption by free atoms at other wavelengths is essentially zero. The wavelength is selected using a monochromator and is measured by using a photomultiplier.

The flame warms up and auto-alignment of main console unit is reached within 10 minutes to achieve the stated specification. Fuel adjustment, air adjustment and initial adjustment are PC's control. If something is wrong in operating setting input, AA Winlab soft-ware appears the setting error and closes the running operations. All alignment and operating systems [selecting the atomizer, setting up the burner system, changing a burner head, changing the nebulizer, igniting the flame, emergency shutdown, the drain trap system, gas(fuel) controls] are PC's controlled on the analyst 7000 Atomic Absorption Spectrometer (Perkin Elmer). (Bernhard, W., 1976 and Perkin Elmer Instrument Manual, 2001)

Sample Collection

The objectives of the study were to determine the concentration of some heavy metals in groundwater from Kamma Environs, Magway Region by using AAS. The specific places from which the water samples were collected are Kamma Environs. Five samples were collected in this work and each collected water sample was immediately stored in separate air tight narrow necked bottle. In this research, sample G1 was collected in Kamma village, sample G2 was collected in Chaung Sone village, sample G3 was collected in Ohn Taw village, sample G4 was collected in Kyat Pyae village and sample G5 was collected in Sone Kone village. Sample preparation was performed by the automatic sampling system of AAnalyst 7000 with pc control, and determined the health risk by ingestion of water by the determination of their metal pollution index (MPI), daily intake of metals (DIM) and health risk index (HRI) 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). 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;

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

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)

$$DIM = \frac{C_{metal} \times D_{water\,intake} \times C_f}{B_{averagebodyweight}} \quad \ldots\ldots (2)$$

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. (WHO, 2011)

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).

$$HRI = \frac{DIM}{RfD} \quad \ldots\ldots (3)$$

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 A. U. et al., 2016)

RESULTS AND DISCUSSION

Investigation of heavy metals such as lead (Pb), cadmium (Cd), arsenic (As) and chromium (Cr) concentration contained in groundwater from Kamma Environs are given in Table (1).

According to AAS result, Figure (1) shows that concentration of lead (Pb) in groundwater was detected in the amount between 0.490 mg/L (G1) and 0.646 mg/L (G5). In all samples, the concentration of lead was found extremely higher than WHO standard, 0.015 mg/L. Thus, these water samples can be utilized as domestic water but not suitable for potable use. Lead may enter in water and soils through corrosion of leaded pipelines from water transporting system through corrosion of lead paints. Lead can accumulate in human body over some time and cause serious damage to brain, kidney, nerves and red blood cells. Hot water is more likely to contain higher levels of lead than cold water. Boiling water cannot remove lead and may actually increase the concentration of lead.

Figure (2) shows that concentration of cadmium (Cd) in groundwater was detected in the range between 0.081 mg/L (G4) and 0.141 mg/L (G5). All samples were higher than the WHO standard value 0.003 mg/L. These amounts of (Cd) concentration containing in these water samples could be severally harmful in human health. High level of cadmium (Cd) can increase risks to kidney damage.

According to Figure (3), levels of arsenic (As) in underground water were found to be between 0.0011 mg/L (G3) and 0.0072 mg/L (G2). All samples were lower than the WHO standard value 0.01 mg/L. Long-term exposure to high levels of arsenic in drinking water can cause discoloration of the skin, nausea, diarrhea, decreased production of blood cells,

Figure (4) shows that concentration of Chromium (Cr) in the samples was detected in the amount between 0.009 mg/L (G4) and 0.024 mg/L (G2). All samples were lower than WHO standard value of 0.05 mg/L. Chromium is called an essential trace element because a very small amount of chromium is necessary for human health. Too much chromium from supplements can also damage the liver, kidneys and nerves.

Table (1) Lead, Cadmium, Arsenic and Chromium concentrations contained in the groundwater samples.

Element	G1 (mg/L)	G2 (mg/L)	G3 (mg/L)	G4 (mg/L)	G5 (mg/L)	WHO (mg/L)
Lead(Pb)	0.490	0.505	0.555	0.583	0.646	0.015
Cadmium(Cd)	0.120	0.120	0.119	0.081	0.141	0.003
Arsenic(As)	0.0026	0.0072	0.0011	0.0014	0.0023	0.010
Chromium(Cr)	0.013	0.024	0.016	0.009	0.012	0.050

G1 = groundwater from Kamma village.

G2 = groundwater from Chaung Sone village.

G3 = groundwater from Ohn Taw village.

G4 = groundwater from Kyat Pyae village.

G5 = groundwater from Sone Kone village.

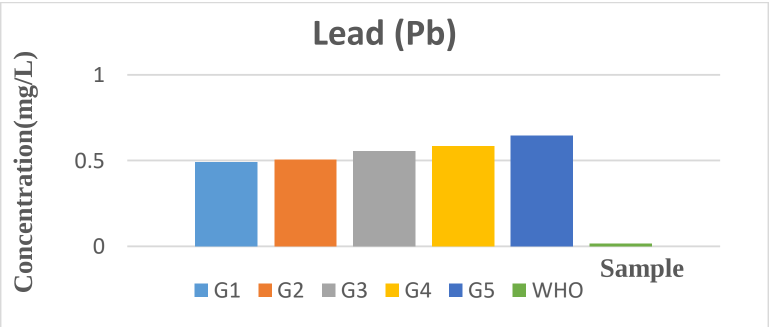


Fig .1 Comparison of lead (Pb) level for groundwater and WHO standard

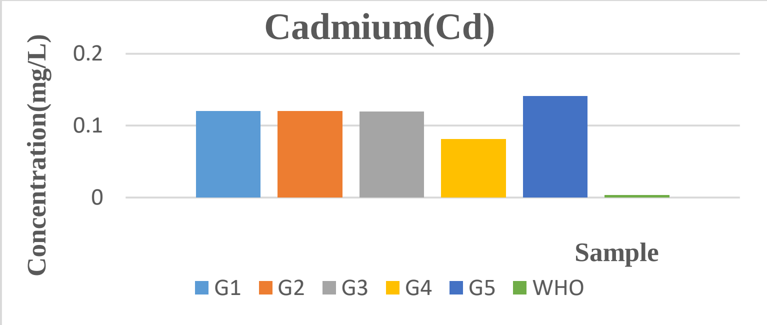


Fig .2 Comparison of cadmium (Cd) level for groundwater and WHO standard

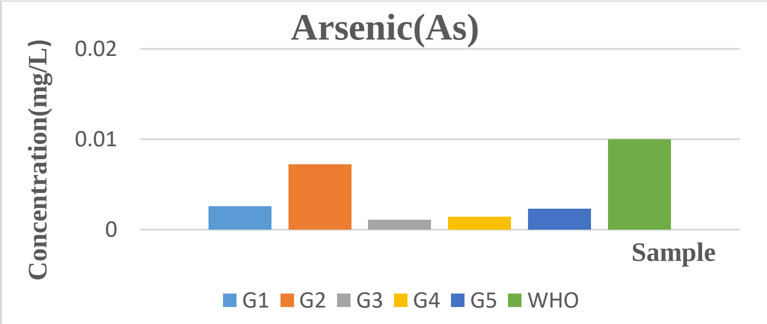


Fig .3 Comparison of Arsenic (As) level for groundwater and WHO standard

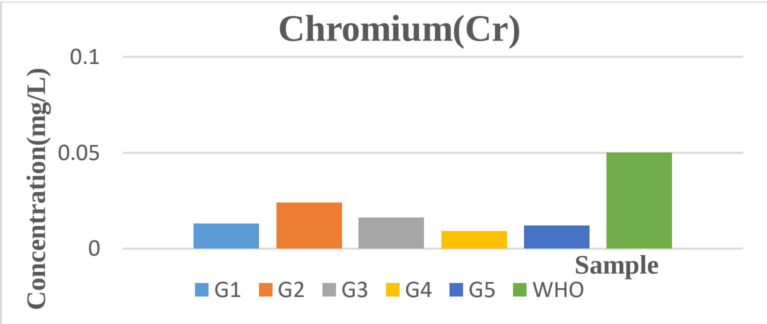


Fig .4 Comparison of Chromium (Cr) level for groundwater and WHO standard

Metal Pollution Index (MPI)

The maximum and minimum values of metal pollution index in all samples are shown in sample G2 and G4.

Table (2) Metal pollution Index (MPI)

Samples	MPI(mg/L)
G1	0.0375
G2	0.0445
G3	0.0328
G4	0.0278
G5	0.0398

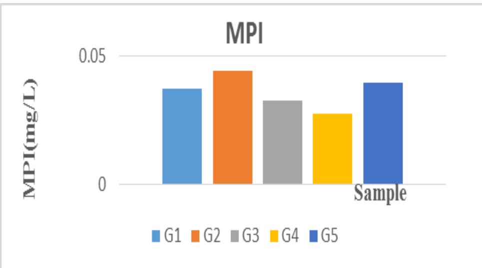


Fig .5 Comparison of Metal Pollution Index

Daily Intakes of Metals (DIM)

Figure (6) shows the comparison of DIM for lead and cadmium in groundwater and recommended value. The daily intakes of metal values for lead (Pb) and cadmium (Cd) in all samples were more than the recommended value, and those of arsenic (As) and chromium (Cr) in all samples were lower than the recommended value as seen in the following figure.

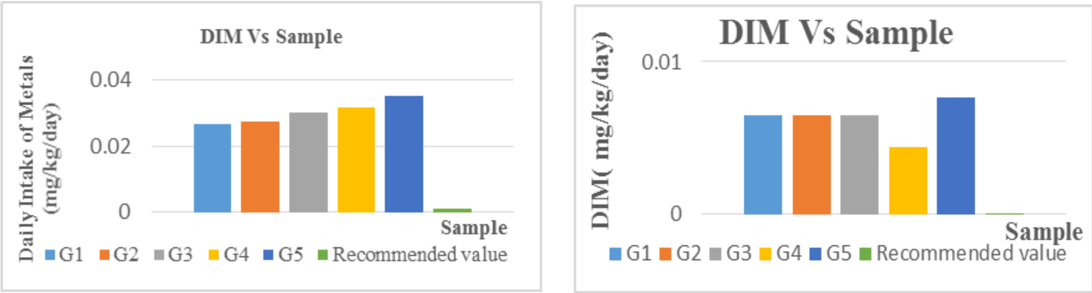


Fig .6 Comparison of DIM for lead (Pb) and cadmium (Cd) in groundwater and the recommended value

Health Risk Index (HRI)

Table (3) shows the health risk index (HRI) of the all samples. The health risk indices of lead (Pb) and cadmium (Cd) in all samples was greater than one which was the indication of potential health risk in figure (7). The health risk indices of arsenic (As) and chromium (Cr) in sample G2 were the above one and thus posed a potential health risk in figure (8).

Table (3) Health Risk Index (HRI)

Element	G1	G2	G3	G4	G5
Lead (Pb)	7.416	7.639	8.417	8.833	9.778
Cadmium (Cd)	6.5	6.5	6.5	4.4	7.7
Arsenic (As)	0.333	1.333	0.333	0.333	0.333
Chromium (Cr)	0.7	1.3	0.9	0.5	0.7

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

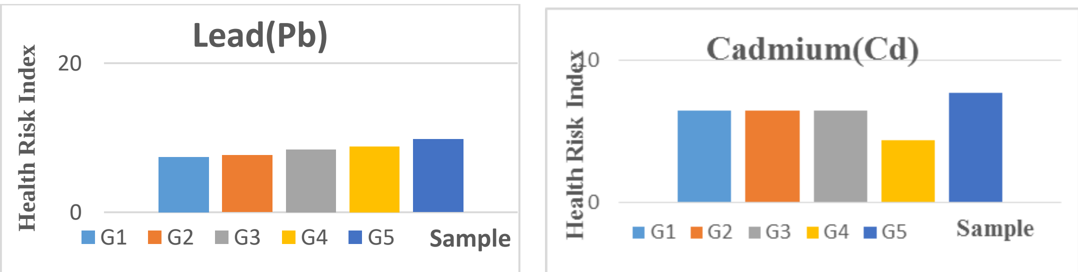
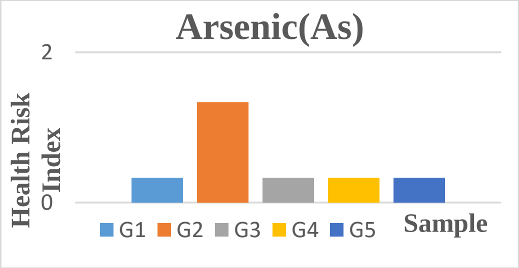


Fig .7 Health Risk Indices of lead (Pb) and Cadmium (Cd) in groundwater



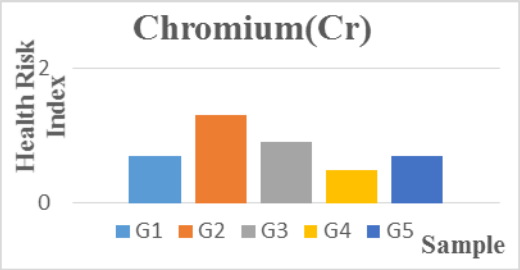


Fig .8 Health Risk Indices of Arsenic (As) and Chromium (Cr) in groundwater

CONCLUSION

The main goal of this research work is to assess the health risk in groundwater in Kamma Environs. The concentration of lead (Pb) and (Cd) in all samples was found above the permissible limits of WHO standard. Levels of arsenic (As) and chromium (Cr) in all samples were agreed within the permissible limits of the standard proposed by WHO. The maximum and minimum values of metal pollution index in all samples were shown in samples G2 and G4.

The daily intakes of lead (Pb) and cadmium (Cd) in all samples were more than the recommended value. The health risk indices of lead (Pb) and cadmium (Cd) in all samples were greater than the one, which was the indication of potential health risk index. The health risk indices of arsenic (As) and chromium (Cr) in sample G2 were above one and thus posed a potential health risk. Health risk assessments for all samples indicated the high risk. These indicated that all heavy metal concentrations in study areas are deteriorated by heavy metal pollution and will cause problems for human health. Hence, the preventive steps of control should be taken with necessary treatment to use the water in these places for several different purposes.

Acknowledgements

We would like to express our profound gratitude to Dr Theingi Shwe (Rector, Hinthada University), Dr Yee Yee Than (Pro-Rector, Hinthada University) and Dr Cho Kyi Than (Pro-Rector, Hinthada University), for their kind permission to do this research. Our heart-felt thanks also go to our parents and the teachers from kindergarten to University.

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