# Heavy Metals Impact on Human Health from the Intake of Herbal Medicines

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**Abstract**

A growing interest in taking herbal medicines appears intensively popular amongst the people of Bangladesh. But the presence of toxic heavy metals in those health care products has been of great concern in recent years. In this context, the purpose of this study was to determine the heavy metal concentration in those products and estimation of their health effects. Fourteen herbal medicine samples, collected from the local markets of Savar, Dhaka were analyzed for Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb) and Zinc (Zn) by Atomic Absorption Spectrophotometer after acid digestion. The concentration of Cd, Cr, Cu, Pb and Zn were found in the range of 0.28-1.02 ppm, 14.98-35.18ppm, 0.37-6.24 ppm, 2.42-4.85 ppm and 1.89-52.37 ppm respectively. From the comparison of these results with WHO, US FDA, Canada, China, Singapore and Indian national standards it was observed that Cr and Cd in all the samples exceeded the recommended permissible limits except the permissible limit for Cd according to Chinese Pharmacopoeia which is 1 mg/kg for Cd. From non-carcinogenic assessment, Total Hazard Quotient (THQ) values of all samples were found below the acceptable boundary but Total Hazard Index (HI) was calculated 13.16 which was far above the standard (HI<1.0). The carcinogenic risks of Cd, Cr and Pb were also evaluated and for Cd and Cr the results were higher than the tolerable range ($>10^{-4}$ mg/kg/d). So, prescription should be strictly followed while taking these health care products.

***Keywords**:* Herbal medicines, Heavy metal analysis, Atomic absorption spectrophotometer, Health risk assessment, Carcinogenic risk

## 1. Introduction

Indian subcontinent has a glorious history of about 2500 years in herbal medicine practice and this territory is sometimes referred to as the birthplace of herbal drugs [1]. Though this practice of using natural drugs has gone through many changes in the course of its long history, it still remains the mainstay of medical relief to a large section of population of India and Bangladesh. Traditional medicine practice in Bangladesh is a very unique conglomerate of different ethnic-medical influences due to the relevancy to the country's socio-demographic and geographical characteristics. As Bangladesh is endowed with a very rich flora and because of the availability of numerous herbal plants in Bangladesh, the ancient practice of medicine here is solely dependent on plants. Many practitioners both registered and unregistered are prescribing millions of underprivileged and often educated class assuring cent percent recovery from several chronic diseases such as cardiovascular diseases, inflammatory diseases, arthritis, diabetes, cancer, sexually transmitted diseases, hormonal problems, skin diseases, infertility problem and others [2]. According to the Ministry of Health and Family Welfare of Bangladesh there are 92 ayurvedic educational institutions which are offering different degrees of medicine to about 4600 students each year. Currently 582 ayurvedic medicine companies are registered to manufacture different drugs [3] and the number of unregistered companies are countless. Millions of distributors and suppliers of these companies across the country are selling and promoting these drugs in different banners like Ayurvedic Drug, Herbal Drug, Homeopathic Drug, Unani Drug etc. In Bangladesh, there are over 12,000 ayurvedic hospitals, colleges and ayurvedic clinics.

Ayurveda is the most widely practiced system in terms of herbal medicine preparation [4]. Ayurveda is a traditional medical system used by a vast majority of our population and is used worldwide nowadays. Ayurvedic drugs, mostly composed of herbs, minerals, metals and animal products, are ancient Indian practices of alchemy where metals like lead, mercury, iron, zinc, arsenic, chromium, copper, cadmium etc. are processed and added to herbs as ashes which are believed to be safe for human health and it is claimed that the role of metals is to enhance the herbal product potency to act as the catalyst for the entrance into relevant cells.

In recent days, herbal medicines are being globally used with trust and confidence for their easy accessibility, low cost, restricted side effects and long-held belief in its effectiveness. Traditional medicines taken by 80% of the world's population are mainly derived from herbal plants and from their extracts [5] and the medicinal values of these plants are usually due to the presence of phytochemical content including alkaloids, tannins, flavonoids and phenolic compounds [2] and these plants are neurotoxic, pneumotoxic, genotoxic, hepatotoxic and cytotoxic.

Heavy metals occur freely in soil, water and atmosphere and furthermore they originate from industrial processes and hence have gained importance as contaminants. Metals in herbal preparations are not only a result of accidental contamination but also introduced for their therapeutic properties; for example- mercury (Hg) was used in treatment of syphilis before the invention of penicillin, while compounds derived from copper have been used as

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remedies for rejuvenators, respiratory distress and skin disorder; Lead (Pb) was used in treatment of Kusta and hemorrhoids [6]. The transformation of medicinal herbs into drug dosage requires a number of steps including collection of raw materials, production, storage, transportation etc. and toxic heavy metals may get incorporated into these drugs from various sources and most of the time intentionally introduced. Moreover, plants can uptake heavy metals to certain extent from soil depending upon their inherent properties and these metals confined in plants finally enter the human body. Whatever the entry route is when these metals enter into a human body they disturb the normal functions of the central nervous system, liver, lungs, heart, kidney and brain, leading to hypertension, abdominal pain, skin eruptions, intestinal ulcer and different types of cancers [7]. Also, heavy metals like copper, zinc, cadmium, chromium and lead may have mutagenic effects even at a very low concentration [8]. Ayurvedic, herbal and other traditional medicines may have health benefits but several cases of significant adverse effects on human body including malfunction and malformation of organs have been reported due to metal toxicity. The first published case of heavy metal toxicity related to herbal medicines was reported in a patient in the UK in 1978 and from then to now on, numerous reports of heavy metal poisoning related to ayurvedic and other traditional medicines have been reported [9].

In addition, as many of these drugs do not go through the testing protocol set by the government and also due to the lack of in-house laboratory facilities to test the heavy metal content, many medicines are still sold with higher heavy metal contents beyond permissible limits. As heavy metals pose a hazard to human and animal health, it has been imperative to limit the metal toxicity in herbal medicines.

In the light of preceding discussion, an initiative was taken for quantitative determination of heavy metals in some commercially available herbal medicines usually consumed by the people of Savar municipality and assessment of their harmful health effects that might arise due to gradual accumulation of excess concentration of metals in the body from long term consumption of these medicines. Heavy metal concentration data to be obtained from this study would also act as the quality indicator of the medicines concerned as well as might be used for further research regarding this field.

## 2. Materials and Method

### *2.1 Sample Collection*

Savar upzila, an industrial region of Dhaka district, Bangladesh situated at 23.8583°N and 90.2667°E, was selected for sample collection. As this area is ragged with a high population density and has numerous pharmaceutical shops where herbal medicines manufactured by different registered and non-registered companies are sold and prescribed by the local practitioners and even sometimes by the shop owner himself, this area seemed to be the best choice for this present research work. Targeting the low earning garment workers specially women working in the nearby RMG industries who dwell nearby, this place has been a blessing city for herbal medicine shop owners. Fourteen (14) Medicinal products in the form of tablets and capsules manufactured by Hamdard Laboratories (WAQF) Bangladesh Limited, Ibn-Sina Pharmaceuticals Limited, Square Pharmaceuticals Limited, Astro Pharmaceutical Limited and Sanj Bangladesh were purchased from local medicinal shops and collected in air sealed plastic bags marked with a particular sample number and after collection the samples were brought to laboratory where these samples were preserved in desiccators until further processing. For uniform sampling, pharmaceutical shops were chosen at different spots spread over the whole upazila area.

### *2.2 Sample Preparation*

About 10 g of each sample was placed on a petri dish and dried in an oven at 80°C for 6-24 hours [10], then the dry cold samples were grained in an agate mortar and pestle, sieved and kept in air tight zipper bags and finally stored in a desiccator. For spectrophotometric treatment each powdered sample was digested. For the digestion process the glassware used was soaked in 10% nitric acid solution overnight to remove any metallic trace, thoroughly washed with tap water, rinsed with deionized water and dried at 105°C in an oven. All reagents used were prepared with analytical reagent grade chemicals. Deionized water ($EC \leq 0.2 \mu S/cm$) was used for the preparation of each chemical, sample solution and standards.

1.0g of each of the powdered samples weighed in an analytical balance (CP 225D, Sartorius, Germany) was placed in a 125mL Erlenmeyer flask in which 10mL conc. $HNO_3$ acid (69%) was added for half an hour soaking. The sample was then heated carefully on a digital hot plate inside the fume hood at 70°C until the emission of brown nitrous oxide fume ceased. The sample was allowed to cool at room temperature and 2.5 mL conc. $HClO_4$ acid (70%) was added and again heated at 80°C until it was almost dry. After digestion when the solution became transparent and the total volume of the solution reduced near to dryness, the heating was stopped. The sample solution was then cooled by adding a very little amount of deionized water at the side of the flask and filtered using Whatman No. 42 ashless filter paper in a 25mL volumetric flask. The volume of the solution was made up to the mark with deionized water. The solution was filtered again using Whatman No.42 ashless filter paper and kept in a plastic sample bottle until analyzed by FAAS [10].

Three sets of samples for analysis of each heavy metal were prepared from each of the digested sample solutions through dilution. Five standards of suitable concentrations were prepared by diluting a particular volume (mL) taken from the standard solution of each metal for construction of the calibration curve. Precision test of the method was carried out for each metal using its standard of suitable concentration. For carrying out a recovery study (accuracy test) each properly diluted sample was spiked with three different concentrations of each metal's standard solution.

### *2.3 Aspiration of Samples and Standards into FAAS-Flame*

In order to determine the concentration of Cu, Zn, Cr, Cd and Pb by Flame Atomic Absorption Spectrophotometric (FAAS) method the samples were aspirated into the flame of the spectrophotometer under standard operating conditions described in the Table 1 for metals concerned.

**Table 1:** Operating condition for FAAS which are used in analysis of metals

| Parameter | Cd | Pb | Cr | Cu | Zn |
|---|---|---|---|---|---|
| Wavelength (nm) | 228.8 | 283.3 | 357.9 | 324.8 | 213.9 |
| HCl current (mA) | 8.0 | 10.0 | 10 | 6.0 | 8.0 |
| Acetylene flow rate (L/min) | 1.8 | 1.6 | 2.2 | 1.8 | 2.0 |
| Slit (nm) | 1.0 | 1.0 | 0.5 | 0.5 | 0.5 |

Standard solution of each metal was also aspirated using the same procedure stated above. The absorbance readings were recorded for all samples and standards and precision and recovery studies were also carried out sincerely. The Flame Atomic Absorption Spectrophotometer (SHIMADZU A6800) was used for heavy metal analysis under the present investigation.

### *2.4 Human Health Risk Assessment*

According to the definition of the United States Environmental Protection Agency (USEPA), Human health risk assessment is a process to estimate the nature and probability of adverse health effects on human beings who may be exposed to chemicals in contaminated environmental media, now or in the future. The non-carcinogenic (adverse effect on health but do not cause cancer) risk assessment can be done by evaluating Chronic Daily Intake (CDI), Hazard Quotient (HQ) and Hazard Index (HI) for oral ingestion. The carcinogenic risk is assessed by Total Cancer Risk (CR) for oral ingestion.

### *2.5 Chronic Daily Intake (CDI)*

Chronic Daily Intake (CDI) is a measure of the amount of a specific substance in food/ medicine/drinking water that can be ingested (orally) on a daily basis over a lifetime without an appreciable health risk. It can be expressed in mg/kg/day by the equation below [11]

$$CDI = (C_{HM} \times EDD)/BW$$

where, $C_{HM}$ is the heavy metal concentration in herbal medicines (mg/kg), EDD is estimated daily dose or average consumption rate of samples (kg/day per person), BW is the average body weight (kg).

### *2.6 Target Hazard Quotient (THQ)*

Target Hazard Quotient (THQ) is defined as a ratio of the potential exposure to a substance and the level at which no adverse effects are expected. A hazard quotient value of 1.00 or lower means adverse non cancer effects are unlikely, and thus can be considered to have negligible hazardous effects. According to USEPA (2011), THQ for oral ingestion for an adult can be calculated by the following equation [12].

$$THQ_{oral} = \frac{C_{HM} \times EDD \times EF \times ED}{AT \times BW \times R_f D_{(oral)}}$$

Where, $C_{HM}$ = Heavy Metal concentration in a sample (mg/kg)

EDD = Estimated Daily Dose (Kg), EF = Exposure Frequency (350 Days/year), ED = Exposure Duration (30 Years), AT = Average Time (10,500 Days), BW = Average Body Weight (70 Kg), $R_fD_{oral}$ = Oral Reference Dose (mg/kg/d), where $R_fD_{oral}$ of Cu = 0.0371, Zn = 0.30, Cd = 0.0005, Cr = 0.003 and Pb = 0.0014 mg/kg/d [13, 14].

### *2.7 Hazard Index*

Hazard Index (HI) can be expressed as the sum of Target Hazard Quotient for toxic substances that can affect the same target organ or organ system and is given by the following equation. The HI value should be lower than 1.00 to avoid adverse effects on health [15].

$$HI_{ing} = \sum THQ_{oral}$$

### *2.8 Carcinogenic Risk for Oral Ingestion*

Carcinogenic health risks that may be induced by a toxic metal is expressed by its cancer slope factor (CSF) which converts the estimated exposure through inhalation or ingestion via intake of metals into incremental risk of an individual developing cancer over time. The acceptable or tolerable range of carcinogenic risks ($CR_{ing}$) varies from 1.0E-06 to 1.0E-04 (USEPA 2011). The equation is as follows [15]:

$$CR_{oral} = CDI \times CSF$$

The oral carcinogenic slope factors for Pb, Cd and Cr are 0.0085, 6.3 and 0.5 mg/kg/day respectively.

### *2.9 Evaluation of the Metal-Contaminated Status of Herbal Medicine*

A single-factor pollution index (SFPI) method was used to evaluate the heavy metal contamination status of herbal medicine [16]. The equation for expressing pollution index (Pi) is as follows:

$$P_i = C_i/S_i$$

Where Pi is the certain heavy metal pollution index, $C_i$ is the measured value of certain metal concentration (mg/kg), and $S_i$ is the evaluation standard. The values of the evaluation standard for Cd, Pb, Cu, Zn and Cr in herbal medicines are 0.30, 10.0, 40.0, 50.0 and 2.0 mg/kg respectively according to FAO/WHO standards [17].

## 3. Results and Discussion

### *3.1 Heavy Metal Concentration and Pollution Index in Herbal Medicines*

A calibration curve was constructed by plotting concentrations of the standards of each element versus the corresponding absorbance readings. Based on the calibration curve the concentrations of all heavy metals were measured. The concentration of heavy metals i.e. Cu, Zn, Cd, Cr and Pb measured in fourteen (14) herbal medicine samples by FAAS method is tabulated in Table-2. Permissible limits of heavy metal concentration in herbal medicines according to some international reference standards for the respective metal has also been added. Pollution Index values of heavy metals in all samples were described in Table 3.

All the pharmaceutical natural health products (14 products) were tested to determine the heavy metal contents on the samples. The results of heavy metal concentration in herbal medicines and the standards for heavy metals in finished or commercialized natural healthcare products were represented in Table 2.

**Table 2:** Summary of heavy metal contents in herbal pharmaceuticals product and its comparison with several international standards [17, 18]

| Serial No. | Sample ID | Cu (mg/kg) | Zn (mg/kg) | Cd (mg/kg) | Cr (mg/kg) | Pb (mg/kg) |
|---|---|---|---|---|---|---|
| 1 | T-1 | 1.52 | 1.89 | 0.39 | 16.76 | BDL* |
| 2 | T-2 | 1.33 | 3.42 | 0.35 | 19.63 | BDL* |
| 3 | T-3 | 4.05 | 6.46 | 0.21 | 16.63 | 1.14 |
| 4 | T-4 | 5.23 | 7.57 | 0.20 | 22.83 | BDL* |
| 5 | T-5 | 4.00 | 16.68 | 0.42 | 35.18 | 3.06 |
| 6 | C-6 | 3.01 | 10.39 | 0.18 | 15.59 | 0.43 |
| 7 | C-7 | 0.37 | 6.81 | 0.37 | 17.27 | BDL* |
| 8 | C-8 | 1.10 | 5.01 | 0.63 | 17.18 | BDL* |
| 9 | C-9 | 1.18 | 5.23 | 0.41 | 15.49 | 0.56 |
| 10 | C-10 | 2.23 | 10.04 | 0.58 | 17.26 | 0.51 |
| 11 | C-11 | 6.24 | 52.37 | 1.03 | 22.24 | 0.57 |
| 12 | C-12 | 2.59 | 16.98 | 0.54 | 21.08 | BDL* |
| 13 | C-13 | 1.79 | 11.3 | 0.67 | 18.62 | BDL* |
| 14 | C-14 | 0.41 | 4.26 | 0.63 | 14.98 | BDL* |
| Minimum | | 0.37 | 1.89 | 0.18 | 14.98 | 0.43 |
| Maximum | | 6.24 | 52.37 | 1.03 | 35.18 | 3.06 |
| Average | | 2.50 | 11.32 | 0.47 | 19.34 | 1.05 |
| Canada | | – | – | 0.3 | 2.0 | 10 |
| FAO/WHO | | 40 | 50 | 0.3 | 2.0 | 10 |
| HSA Singapore | | 150 | – | 0.05 | – | 20 |
| Chinese Pharmacopoeia | | 20 | – | 1 | – | 10 |
| USFDA/WHO | | 20 | 50 | 0.3 | – | 10 |
| India | | – | – | 0.3 | – | 10 |

*BDL = Below Detection Limit. MDL (minimum detection limit) for Pb is ≤0.005 mg/kg.

In this study, the concentrations of Cu, Cd, Cr, Pb and Zn in different natural healthcare products were determined to identify any potential risk due to the accretion of these heavy metals leading to toxicity. All the fourteen (14) herbal medicines contained Cu, Cd, Cr and Zn at some levels but concentrations of Pb were below its detection limit for most of the samples (Table 2). There are several regulatory bodies that set specific allowable limits for heavy metal content in herbal and traditional preparations based on different guidelines and these allowable limits vary among these regulatory bodies (Tables 2). Cadmium concentrations in all samples (0.18-1.03 mg/kg) except one (C-11) were detected below the safety limit (1.0 mg/kg) approved by Chinese Pharmacopoeia. But almost all of the samples showed levels of Cd above the safety limits (0.05-0.3 mg/kg) set by Canada, FAO/WHO, USFDA and India. Cadmium toxicity could induce tissue injury [19], epigenetic changes in DNA expression [20], hypertension,

**Table 3:** Single-factor pollution index method for heavy metals in herbal medicines

| Sample ID | Pollution Index (Pi) of Heavy Metals with Remarks | | | | |
|---|---|---|---|---|---|
| | Cu | Zn | Cd | Cr | Pb |
| T-1 | 0.076 (safe) | 0.038 (safe) | 1.300 (mild contamination) | 8.380 (serious contamination) | – |
| T-2 | 0.067 (safe) | 0.068 (safe) | 1.167 (mild contamination) | 9.815 (serious contamination) | – |
| T-3 | 0.203 (safe) | 0.129 (safe) | 0.700 (safe) | 8.315 (serious contamination) | 0.114 (safe) |
| T-4 | 0.262 (safe) | 0.151 (safe) | 0.667 (safe) | 11.415 (serious contamination) | – |
| T-5 | 0.200 (safe) | 0.334 (safe) | 1.400 (mild contamination) | 17.590 (serious contamination) | 0.306 (safe) |
| C-6 | 0.151 (safe) | 0.208 (safe) | 0.600 (safe) | 7.795 (serious contamination) | 0.043 (safe) |
| C-7 | 0.019 (safe) | 0.136 (safe) | 1.233 (mild contamination) | 8.635 (serious contamination) | – |
| C-8 | 0.055 (safe) | 0.100 (safe) | 2.100 (moderate contamination) | 8.590 (serious contamination) | – |
| C-9 | 0.059 (safe) | 0.105 (safe) | 1.367 (mild contamination) | 7.745 (serious contamination) | 0.056 (safe) |
| C-10 | 0.112 (safe) | 0.201 (safe) | 1.933 (mild contamination) | 8.630 (serious contamination) | 0.051 (safe) |
| C-11 | 0.312 (safe) | 1.047 | 3.433 (moderate contamination) | 11.120 (serious contamination) | 0.057 (safe) |
| C-12 | 0.130 (safe) | 0.340 (safe) | 1.800 (mild contamination) | 10.540 (serious contamination) | – |
| C-13 | 0.090 (safe) | 0.226 (safe) | 2.233 (moderate contamination) | 9.310 (serious contamination) | – |
| C-14 | 0.021 (safe) | 0.085 (safe) | 2.100 (moderate contamination) | 7.490 (serious contamination) | – |
| Average | 0.125 (safe) | 0.226 (safe) | 1.574 (mild contamination) | 9.669 (serious contamination) | 0.105 (safe) |

diabetes, and insulin resistance [21]. Moreover, excess cadmium may inhibit transport pathways and heme synthesis [22]. All herbal medicine samples contained Cr in the range of 14.98-35.18 mg/kg. The average concentration in all samples (19.34mg/kg) were found about 10 times higher than the safety limits of Canada and FAO/WHO which are set to 2.0 mg/kg. Although Cr is required for human physiological functions at an approximate concentration of 0.3 ppm, its higher accumulation can cause blood glucose reduction, alimentary and cardiovascular and renal disorders etc. [23]. The concentrations of other metals like Cu, Zn and Pb in all medicine samples ranged from 0.37-6.24, 1.9-52.4 and 0.43-3.06 mg/kg and their average concentrations were 2.50, 11.32 and 0.50 mg/kg respectively which were found below the tolerable limits of different international standards (Table 2). As the major components of these herbal preparations are plants, the presence of heavy metals in herbal medicines is quite relevant. Some of the identified metals (Zn, Cu and Cr) have significant biological roles in the body [17].

According to the values of $P_i$, it was divided into five levels: safe ($Pi \leq 0.7$), guard line ($0.7 < Pi < 1.0$), mild contamination ($1.0 < Pi < 2.0$), moderate contamination ($2.0 < Pi < 3.0$), and serious contamination ($Pi \geq 3.0$) [24]. It can be seen from Table 3, the $P_i$ of different herbal medicines are indicated safe for Cu, Zn and Pb. In the case of Cd, the pollution index showed mild contamination and for Cr it is serious level of contamination (Table 3).

Statistical analyses like Pearson's correlation were performed to clarify the connections among heavy metals in natural healthcare products [25] and to identify the imperative elements involved in guiding the circulation of metal contaminants [26]. Pearson's correlation matrix was calculated for heavy metals concentrations in herbal medicine samples to see if some of the metals were interrelated with each other.

**Table 4:** Correlation coefficient study of heavy metals in medicines

| Factors | Cu | Zn | Cd | Cr | Pb |
|---|---|---|---|---|---|
| Cu | 1.00 | - | - | - | - |
| Zn | 0.69 | 1.00 | - | - | - |
| Cd | 0.10 | 0.69 | 1.00 | - | - |
| Cr | 0.52 | 0.37 | 0.06 | 1.00 | - |
| Pb | 0.40 | 0.22 | -0.10 | 0.75 | 1.00 |

The variables having coefficient value (r)>0.5 are considered significant. From this correlation (Table-4), it was found that all heavy metals were positively correlated with each other. And there was a strong positive relation between Zn-Cu (r = 0.69), Cr-Cu (r = 0.69), Cd-Zn (r = 0.52) and Pb-Cr (r = 0.75). The significant relationship between heavy metals suggests similar sources of input (human or natural) for these metals in the herbal medicines [27].

### *3.2 Non-Carcinogenic Health Risk Assessment*

In this study, the non-carcinogenic health risk was evaluated by Chronic Daily Intake (CDI), Target Hazard Quotient (THQ) and Hazard Index (HI). The average assessed CDI values of Cu, Zn, Cd, Cr and Zn from consuming herbal medicine for a typical adult of 70 kg body weight in Bangladesh was 3.22E-04, 1.45E-03, 6.07E-05, 2.49E-03 and 1.34E-04 respectively which were well below the acceptable limit (Cu: 0.060, Zn: 0.011, Cd: 0.04, Cr: 0.035 and Pb: 0.21 mg/kg/day). Target Hazard Quotient (THQ) values obtained for all metals in all samples (Table-5) that had fallen under 1 indicated that the consumption of herbal medicine might not cause non-carcinogenic health risk to the human body. The calculated Hazard Index (HI) values obtained for all samples are described in the Table-5. It was found that four samples had shown HI values above 1. HI was also calculated for Cd and Cr which had values 1.63 and 11.13 mg/kg/d respectively which were also higher than the acceptable limit. Total Hazard Index measured for oral ingestion was found to be 13.16 which indicated that the collected herbal medicine samples might cause severe non-carcinogenic health risk upon long term consumption.

**Table 5:** Target Hazard Quotient and Hazard Index in the samples

| Sample ID | Unit | Cu ($THQ_{oral}$) | Zn ($THQ_{oral}$) | Cd ($THQ_{oral}$) | Cr ($THQ_{oral}$) | Pb ($THQ_{oral}$) | $HI = \Sigma THQ_{oral}$ |
|---|---|---|---|---|---|---|---|
| T-1 | (mg/kg/d) | 5.05E-03 | 7.77E-04 | 9.62E-02 | 6.89E-01 | – | 0.791 |
| T-2 | (mg/kg/d) | 4.42E-03 | 1.41E-03 | 8.63E-02 | 8.07E-01 | – | 0.899 |
| T-3 | (mg/kg/d) | 1.35E-02 | 2.65E-03 | 5.18E-02 | 6.83E-01 | 4.02E-02 | 0.791 |
| T-4 | (mg/kg/d) | 1.74E-02 | 3.11E-03 | 4.93E-02 | 9.38E-01 | – | 1.008 |
| T-5 | (mg/kg/d) | 1.33E-02 | 6.85E-03 | 1.04E-01 | 1.45E+00 | 1.08E-01 | 1.677 |
| C-6 | (mg/kg/d) | 1.00E-02 | 4.27E-03 | 4.44E-02 | 6.41E-01 | 1.51E-02 | 0.714 |
| C-7 | (mg/kg/d) | 1.23E-03 | 2.80E-03 | 9.12E-02 | 7.10E-01 | – | 0.805 |
| C-8 | (mg/kg/d) | 3.66E-03 | 2.06E-03 | 1.55E-01 | 7.06E-01 | – | 0.867 |
| C-9 | (mg/kg/d) | 3.92E-03 | 2.15E-03 | 1.01E-01 | 6.37E-01 | 1.97E-02 | 0.763 |
| C-10 | (mg/kg/d) | 7.41E-03 | 4.13E-03 | 1.43E-01 | 7.09E-01 | 1.80E-02 | 0.882 |
| C-11 | (mg/kg/d) | 2.07E-02 | 2.15E-02 | 2.54E-01 | 9.14E-01 | 2.01E-02 | 1.230 |
| C-12 | (mg/kg/d) | 8.61E-03 | 6.98E-03 | 1.33E-01 | 8.66E-01 | – | 1.015 |
| C-13 | (mg/kg/d) | 5.95E-03 | 4.64E-03 | 1.65E-01 | 7.65E-01 | – | 0.941 |
| C-14 | (mg/kg/d) | 1.36E-03 | 1.75E-03 | 1.55E-01 | 6.16E-01 | – | 0.774 |
| $HI = \Sigma THQ_{oral}$ | (mg/kg/d) | 0.116 | 0.065 | 1.630 | 11.126 | 0.221 | $\Sigma HI = 13.159$ |

### *3.3 Carcinogenic Health Risk Assessment*

The carcinogenic health risk of heavy metal for oral intake was represented in Table-6.

**Table 6:** Carcinogenic risk assessment for oral ingestion in collected medicine samples

| Sample ID | Cd ($CR_{oral}$) | Cr ($CR_{oral}$) | Pb ($CR_{oral}$) |
|---|---|---|---|
| T-1 | 3.03E-04 | 1.03E-03 | – |
| T-2 | 2.72E-04 | 1.21E-03 | – |
| T-3 | 1.63E-04 | 1.03E-03 | 1.19E-06 |
| T-4 | 1.55E-04 | 1.41E-03 | – |
| T-5 | 3.26E-04 | 2.17E-03 | 3.21E-06 |
| C-6 | 1.40E-04 | 9.61E-04 | 4.51E-07 |
| C-7 | 2.87E-04 | 1.06E-03 | – |
| C-8 | 4.89E-04 | 1.06E-03 | – |
| C-9 | 3.18E-04 | 9.55E-04 | 5.87E-07 |
| C-10 | 4.50E-04 | 1.06E-03 | 5.34E-07 |
| C-11 | 8.00E-04 | 1.37E-03 | 5.97E-07 |
| C-12 | 4.19E-04 | 1.30E-03 | – |
| C-13 | 5.20E-04 | 1.15E-03 | – |
| C-14 | 4.89E-04 | 9.23E-04 | – |
| Acceptable range | | 1.0(E-06 to 04) | |

Carcinogenic Risk (CR) lower than $10^{-6}$, above $10^{-4}$ and lying in between $10^{-6}$ and $10^{-4}$ are considered to be negligible and acceptable respectively [28]. In this study, average of CR in Cd, Cr and Pb was 3.67E-04, 1.19E-03 and 1.10E-06 respectively and it was quite evident that Carcinogenic Risk for Cd and Cr in all the samples was higher and all of the samples showed risk above the permissible range, whereas for Pb, it was inside the safety limit.

## 4. Conclusion

The contamination of herbal medicines by heavy metals has been of great concern because of their toxic and cumulative reactions. The overall analysis of the fourteen herbal medicines commonly consumed in Savar, Dhaka showed the presence of heavy metals Cu, Zn, Cd, Cr and Pb in various levels and their increasing order of concentrations were Cd<Pb<Cu<Zn<Cr. As, the contents of the heavy metals in all tested samples were not below the internationally accepted permissible limits, their unconditional use could have cumulative effect, which in turn might lead to their toxicity in the human body. Also, from non-carcinogenic evaluation; although CDI and THQ values were under the permissible limits but HI value was found to be 13.125 indicating acute non-carcinogenic hazard. The Hazard Index values calculated in the samples were found in the increasing order of C-6<C-9<C-14<T-1<T-3<C-7<C-8<C-10<T-2<C-13<T-4<C-12<C-11<T-5. Moreover, the herbal medicinal products evaluated in this study exhibited carcinogenic risk for both Cd and Cr which could be very alarming. From this study a preliminary idea was obtained about some heavy metals' health hazard impact on human beings from the consumption of these medicines. Further study in this field can reveal more in this regard.

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