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Metal contamination in traditionally used Medicinal plants: a serious threat in Murshidabad district, West Bengal, India

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Abstract

Murshidabad district is one of the most highly Arsenic (As) prone areas of West Bengal, India. The predominantly rural population of this district greatly depends on traditionally used medicinal plants for treatment of various ailments and subjected to risk of arsenic contamination. The present study revealed that some naturally grown medicinal plants in this district were found to have the alarming level of concentration of arsenic and other metals (Fe, Cu) contamination. So, there should be raised more consciousness on the toxic metal contamination of medicinal plants specifically, collected from contaminated sites.

Keywords: Arsenic, copper, iron, medicinal plants, Murshidabad

Introduction

A major portion of the World's population significantly rely on traditionally used medicinal plants as major healthcare provider, even today. Medicinal plants are viewed as an important source of natural products and generally posses an important position in the socio-cultural, spiritual and wellbeing field of provincial and tribal lives of India (Pala et al., 2010). Human information about therapeutic estimation of these plants go back most likely for in excess of five thousand years. Old Indians, Egyptians, Chinese and others utilized thousands assortments of plant and plant items (root, shoot, leaf, bark, fruit, and seed) for curing various kinds of ailments. From the study of Abu-Darwish, (2009) revealed that the use of aromatic medicinal herbs to relieve and treat many human diseases has been increased in worldwide because of their mild features and low side effects. According to World Health Organization, it has been accounted for that around 80% of the world's population and 80% population of the developing countries remains dependent on traditional medicine, especially herbal medicine (Issazadeh et al., 2012; Planning Commission, 2000). Besides treatment of many diseases medicinal plants serve as the main source of the raw material for many herbal formulations and popular dietary supplements. With increasing the awareness of salient feature of medicinal plants, world's herbal medicinal market increases drastically with annual growth rate between 5 and 15%, which in turn increases a trend of commercialization of medicinal plants in recent years (Joshi et al., 2004).

Now a day's atmosphere, soil and water are being polluted with chemicals and heavy metals (HMs) with the dynamic development of industrial sector along with the extensive use of pesticides and fertilizers. As we know, HMs cannot be destroyed biologically, they are only transformed from one oxidation state to another (Garbisu and Alkorta, 2001). Contamination of heavy metals represents one of the most pressing threats to water and soil resources as well as human health. They become concentrated as a result of anthropogenic activities and can enter plant, animal and human tissues via inhalation, diet, and manual handling. The condition is getting more critical, when the growing medicinal plants on contaminated sites used for curing diseases without any consideration of presence of such toxic HMs. Heavy metals are imperative environmental pollutants, and their toxicity is a problem of increasing significance for ecological, evolutionary, nutritional and environmental reasons. Metal concentrations in plants vary with plant species and with geological location. Plants uptake of heavy metals occurs passively from soil with mass concentration of water flow and it depends on soil physical parameters like pH, conductivity, texture, clay content. Arsenic (As) is a non essential nutrient of the plant and it present in a very negligible concentration. Though arsenic has no involvement in plant`s growth and metabolism, but still high level of As in plant tissue caused phytotoxicity and ultimately increased health risk to humans (Garg and Singla, 2011). Iron and Copper are well-known as essential micronutrients but they may become toxic to the plants at higher concentrations and consequently a threat to human health. Consumption of raw herbal drug collected from different medicinal plants, grown in polluted sites can cause serious human health risk. For example, higher levels of arsenic is carcinogenic and affects the central nervous system and elevated level of copper caused anorexia, fatigue, premenstrual syndrome, depression, anxiety, migraine headaches, allergies, childhood hyperactivity and learning disorders (Hussain et al., 2011; Baye and Hymete, 2013).

Presence of heavy metals in the soil is common due to geo-climatic conditions and plants accumulate those metals in their harvestable parts (via root uptake, foliar adsorption and deposition of specific elements in leaves). Uptake, accumulation and concentration of heavy metals in plants is influenced by various key factors including atmospheric depositions, concentration and bioavailability of heavy metals in soil, the nature of soil where herbs are grown, individual plant performance and manufacturing conditions of herbal drugs etc (Nwoko and Mgbeahuruike, 2011). It was reported that many medicinal plants accumulate various pollutants including heavy metals with elevated level. For example, Pyne and Santra, (2017) reported that mean As concentration in collected herbal plants was varied significantly at the five sampling site of Mursidabad and it was ranged between 0.027 mg kg^{-1} (Chatim) to 0.298 mg kg^{-1}(Gandal). So there must be a probability of transmission of arsenic and other heavy metals from soil to herbal plant as well as irrigated crops in metal contaminated site.

Mandal et al., (1996) reported the presence of As is above the maximum limit as recommended by the WHO (0.01 mg/l)(WHO, 2001) in ground water in Murshidabad district of West Bengal, India. Traditionally, rural population of this district used various medicinal plants as Kavirajee directly for different primary health care. In these circumstances for getting desirable therapeutic benefits, it is necessary to improve quality standards for herbal medicines by examining and revising the maximum allowable values of heavy metals in medicinal plants. Thus the aim of this study is to investigate the arsenic, iron, copper contents in the useful parts of the medicinal plants and their transmission from soil.

Methodology

Study site

Five blocks of Murshidabad district (Beldanga I, Domkal, Hariharpara, Berhampore and Lalgola) has been chosen for the present study. The study sites are presented as per their location ID (Table 1 and Figure 1). According to the previous reports, the level of arsenic in groundwater in all these areas exceeding WHO permissible limit for drinking water (0.01 mg l^{-1})(WHO, 2001) and Food and Agricultural Organization permissible limit for irrigation water (0.10 mg l^{-1}) (FAO, 1985).

Sample collection

In the study area, different available medicinal plants like Basak, Kalmegh, Satamuli, Bhui amla, Kanak dhutra, Gandal, Shiuli, Aswagandha, Thankuni, White Dhutra, Tulsi, Neem, Hinche etc. were collected for the present study. The useful parts of these medicinal plants were collected, isolated in a substantial amount and stored in polythene bag to monitor the concentration of arsenic, iron and copper (Table 2).

Water samples has been collected in 100ml polythene bottles with replica (n=3) from the shallow pump, associated with the collected medicinal plants in the study area. Then the water samples were preserved with 1ml/L concentrated HNO_3.

Plant samples, based on their coverage at the site, together with the associated soil sample were collected from 0-10 cm depth and transferred it into air-tight polythene bags.

Sample preparation and treatment

The plant samples were washed thoroughly with tap water followed by de-ionized water for several times. Finally the samples were dried in hot air oven at 50^0 - 60^0C for 72h and stored in air tight polythene bags at room temperature with proper labeling. Most of the plant samples will cut into small pieces according to their useful medicinal parts (Das et al., 2004; Rahman et al., 2007).

The collected water samples are filtered through Whatman-40 filter paper and kept in polythene bottles at 4^0C prior to analysis.

The soil samples were immediately sun-dried after collection and later dried in hot air oven at 60^0C for 72h. After dried the soil samples are grind in a mortar and screened through 2.0mm pore sized sieve to get homogenized representative powdered sample. Finally the samples were stored in airtight polythene bags at room temperature.

Sample digestion

About 0.5 gram of each plant sample was acid digested using Perchloric acid ($HClO_4$), Sulphuric acid (H_2SO_4) and Nitric acid (HNO_3). Samples were kept on hot plate at 110^0 -120^0C and finally get clear solution. Then the solutions were cooled, diluted to 50 ml with double distilled water and filtered through Whatman-40 filter paper. This methods was used to analyze As, Fe, Cu content in plant samples (Nazir et al., 2015).

For Soil sample, 1 gram of each soil sample was acid digested using Perchloric acid ($HClO_4$), Sulphuric acid (H_2SO_4) and Nitric acid (HNO_3), to analyze Fe and Cu content. The content was then cooled, diluted to 50 ml with double distilled water, and filtered through Whatman filter paper for soil samples.

Another part of each soil sample was digested with di-acid mixture for analysis of arsenic concentration by SDDC method (Pereira et al., 2008; APHA, 1998).

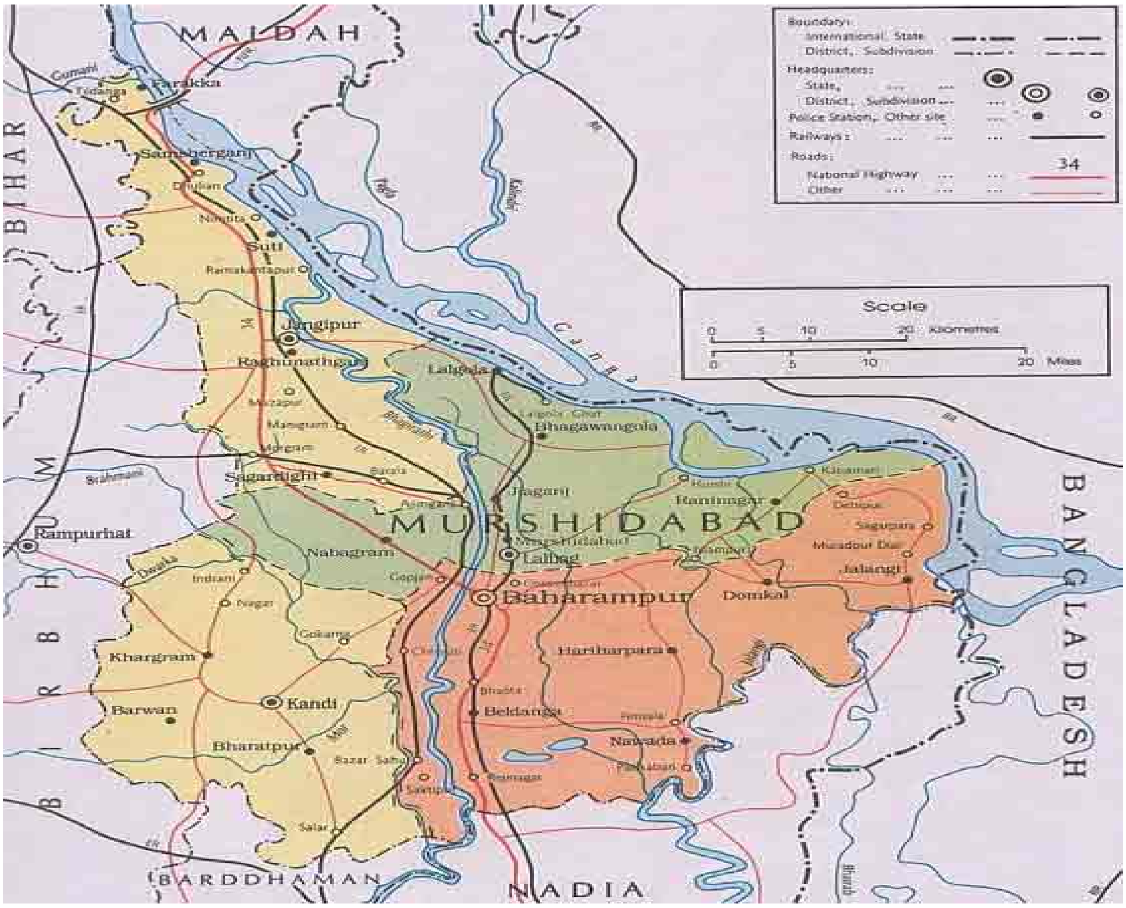

Fig. 1. Sampling site of Murshidabad district (Map source: Google search).

Sample analysis

Arsenic, Iron and Copper concentration of the digested plant samples were analyzed by hydride generation atomic absorption spectrophotometer (AAS) using external calibration (Welsch, 1990). Arsenic concentration of the digested soil and water samples were analyzed spectrophotometrically by silver diethyl dithio carbamate (SDDC) method (APHA, 1998). Iron and Copper concentration of the digested soil and water samples were analyzed by hydride generation atomic absorption spectrophotometric method.

Bioaccumulation factor was analysed by using this formula:

$$BAF = C_p/C_{soil}$$ ....eq(1) (Jena et al., 2007)

Where, C_p is the metal concentrations in aerial parts of the plant (mg kg^{-1})

C_{soil} is the metal concentrations in soil (mg kg^{-1})

Analytical Quality Control Data

The observed arsenic concentrations (mg/kg dry weight) of SRM from NIST, USA, were as follows: rice flour (SRM 1568A), 0.26 ± 0.09 (certified value 0.029 ± 0.03), San Joaquin soil (SRM 2709A) 16.1 ± 0.9 (certified value, 17.7 ± 0.8).

Statistical analysis

Correlation between the mean of metal concentration was also done by using SPSS 15.0.

Result and discussion

Metal concentration in plants

Sampling ID with the latitude and longitude of the sampling stations are shown in Table 1.The commonly available medicinal plants with their medicinal use of the study area are given in Table 2. In this study, total seventeen medicinal plant(MP) samples of thirteen plant species was collected and analyzes of total As, Fe, Cu content in the useful parts (viz., leaf, shoot, root and stem), which varies significantly with different geographical location, were shown in Table 3 and Figure 2. Results found that minimum and maximum amount of As content was found in Aswagandha (0.043mg/kg) in Hariharpara and Kalmegh (0.35mg/kg) compare to others. Arsenic accumulation in all the seventeen MPs species was relatively higher at site E compare to site A, B, C and D. At the same time minimum and maximum concentration of Fe was found in Aswagandha (0.22 mg kg^{-1}) and Hinche (1.46 mg kg^{-1}), whereas Satamuli (0.033 mg kg^{-1}) and Tulsi (0.88 mg kg^{-1}) contains the minimum and maximum amount of Cu content in plants respectively. Profiling on heavy metals concentration in MPs, Tripathy et al., (2011) reported that significant As accumulation was present in all the collected terrestrial MPs, which showed arsenic level beyond the permissible limit. They have studied that As accumulation was present at much higher concentration in aquatic plants than terrestrial plants. In a previous study by Pyne and Santra, (2017)in Murshidabad, highest and lowest mean arsenic concentration was found in Gandal shoot (*Paederia scandens)*, 0.298 mg kg^{-1} and Chatim (*Alstonea scholaris*) 0.027 mg kg^{-1}respectively.

It has been observed that the Fe uptake in plant body is much higher than arsenic and copper. Yoon et al., (2006) was examined over 36samples of 17 plant species among 10 locations and they observed that Copper concentration in plants was varied from 6 to 460 mg kg^{-1}). Among their tested samples *P. Nodiflora, Cynodon dactylon* also contained a significant amount of Cu (310-432 mg kg^{-1}).

Close examination of average metal contents of the data obtained showed that some plants like *A. paniculata* tend to accumulate relatively large amount of As, which is somehow in line with many findings**.** It has been revealed from the study of all the plants are a good source of minerals (Ca, Mg, Na, K, Cu, Fe, Zn) (Ghosh and Singh, 2015). From their study, concentration of potential toxic heavy metals exhibit that arsenic concentration was found below the permissible limit in *A. paniculata,* (0.93 ± 0.08 mg kg^{-1}) and also in other plant material. According to the result, plant samples are moderately contaminated with As and the level is below than safe limit. The maximum permissible limit of As for food or edible tissue is 1mg kg^{-1}dry weight and for raw herbs is 3 ppm as per Ayurvedic Pharmacopoeia of India (WHO, 1989; Anonymous, 2009).Similar results were also reported by many researchers in previous studies (Singh et al., 2014 ; Begum et al., 2017). The study indicates that the arsenic concentration in plant samples vary with sampling location which could be for soil factors, that influence the amount of As availability for plant uptake (Mahimairaja et al., 2005).They include redox potential, pH, the contents of organic matter, iron, manganese, phosphorus and calcium-carbonate, and soil microbes.

Metal concentration in soil and water sample

Soil samples collected from different sites showed significant amount of studied metal concentration. In case of plants, high arsenic amount was found in Site E. The minimum and maximum amount of As was found in 0.022 mg kg^{-1} (soil field of Basak at Beldanga I) and 0.27 mg kg^{-1}(soil field of Gandal at Hariharpara). Thus in general, the order of As in soil is, Site E> Site C> Site D>Site B> Site A. Table 4and Figure 3 explain the variation of metal concentration in soil. The variation in the soil As level may be due to differences in the baseline soil arsenic, the level of As in the ground water and the amount of irrigation in the area (Lu et al., 2009).From the study of Pyne and Santra,(2017)the range of As in soil 2.23-5.31 mg kg^{-1} and in water 0.20-0.37mg lt^{-1} in Murshidabad district.

In present study the accumulation of arsenic in soil was lower than the reported global average of 10.0 mg kg^{-1} and was much below than the maximum acceptable limit for agricultural soil of 20.0 mg kg^{-1} as recommended by the European Community (Das et al., 2002). Roychowdhury et al., (2002), reported that arsenic affected areas of Murshidabad, West Bengal, India, found that accumulation of arsenic in various food composites (leafy vegetables, rice, wheat, turmeric powder) ranged between <0.0004 and 0.693 mg kg^{-1}Several reports have been published about arsenic accumulation of soil due to the irrigation with arsenic- contaminated ground water in West Bengal (Chakraborti et al., 2002; Samal, 2005; Bhattacharya et al., 2009). The highest content of Asin soil of West Bengal 19.4 mg kg^{-1}, was reported by Roychowdhury et al., (2005).

Minimum and maximum amount of Fe was found in 53.6 mg kg^{-1}(Gandal plant soil at Hariharpara) and 160.50mg kg^{-1}(Neem plant soil at Berhampore), whereas minimum and maximum concentration of Cu was found in Neem plant soil at Berhampore (8.30 mg kg^{-1}) and in Neem soil at Domkal (34.3 mg kg^{-1}) respectively(Table-4 and Figure 3).Similarly Fe concentration was found in order of Site E>Site A>Site B>Site D> Site C and Cu concentration in Site B> Site E> Site C> Site A> Site D respectively.

The range of As, Fe, Cu concentration in water sample shown in Table-5.Results revealed minimum and maximum concentration of As was 0.054-0.28 mg kg^{-1}. Arsenic adsorbed on Fe/Mn/oxides/hydroxides is released into ground water due to decrease of the redox state in the aquifer (Nickson et al., 2000). The heavy withdrawal of groundwater may be the reason why iron pyrites decompose (Das et al., 1996 and Chowdhury et al., 1999) and release arsenic into water.

The correlation analysis among the metal concentration of collected plant and soil sample were shown in Table-6, illustrated that there is selective accumulation found in plant samples. A negative correlation was found between Fe and As content of soil, whereas Cu is positively correlate with As but are not statistically significant. Apart from the result, Fe content in plant sample negatively correlate with As whereas positive correlation was found between Cu and As, but these are not statistically significant. So it can be said that the source of these metals are not dependent on each other.

Bioaccumulation factor was analyzed by using eq(1). The bioaccumulation factor (BAF) from soil to component parts of medicinal plants expressed as the ratio of concentration of metal divided by concentration of metal in soil. If the BAF>1 then the plants can be accumulators, BF=1 is no influences and if the BAF<1 then the plant can be excluder (Jena et al., 2007 and Ma et al., 2001). The bioaccumulation factors (BAF) of As, Fe, Cu in different medicinal plants are shown in Table 8. From our investigation it expressed that most of the investigated plant samples are accumulator of arsenic as because their BAF value is greater than 1 (range 0.46-2.64).The differences in As bioavailability might be also partially the consequences of various soil pH at these localities. The highest As BAF was found in Basak (2.64) at Beldanga 1. Similarly highest amount of BAF of Fe and Cu was found in Hinche (0.021) and Kalmegh (0.041).

Conclusion

This study was conducted to understand the accumulation of arsenic, iron, copper in frequently used herb or medicinal plant of the local habitant of Murshidabad district of West Bengal. The quality of soil and the extent of contamination of

Table 1. Sampling station and ID of study area.

Sampling Location	Location Id	Latitude	Longitude
Beldanga I	A	24.045° N	88.444° E
Domkal	B	24.225° N	88.822° E
Hariharpara	C	24.093° N	88.550° E
Berhampore	D	24.215° N	88.386° E
Lalgola	E	24.638° N	88.388° E

Table 2. General description and economical importance of Medicinal plants used in the study area

Plant species	Common Name	Family	Medicinal uses	Parts used
Paederia scandens	Gandal	Rubiaceae	Asthma, diarrhea, blood dysentery, night blindness, piles, blood purification	Root and leaf
Centella asiatica	Thankuni	Mackinlayaceae	Headache, body ache, insanity asthma,leprosy, ulcer, eczemas, wound healing, antitumor	Leaf
Withania somnifera	Aswagandha	Solanaceae	Antifever, leucoderma, dropsi, fistula, leprosy	Root, leaf, fruit
Datura stramonium	White dhutra	Solanaceae	Sedative, antihairfall, anti dandruff, Parkinson's disease, breathing trouble	Leaf, fruit, seed
Phyllanthus fraternus	Bhui amla	Euphorbiaceae	Bronchitis, problem of renal tube, anemia, gonorrhea, blood dysentery	Whole plant
Justicia adhatoda	Basak	Acanthceae	Cough and cold, leucoderma, indigestion, asthma, chronic bronchitis, diarrhea	Leaf, bark, root, flower
Andrographis paniculata	Kalmegh	Acanthaceae	Influenza, ulcer, skin disease, liver problem, cough, dysentery	Whole plant, leaf, root
Asparagus racemosus	Satamuli	Liliaceae / Asparagaceae	Night blindness, blood dysentery, cough and cold, sperm disorderness	Root and leaf
Enydra fluctuens	Hinche	Compositae	Chiken pox,bronchitis, liver problem, leucoderma, gonorrhea, skin disease	Shoot and leaf
Azadirachta indica	Neem	Meliaceae	Leprosy, urinal problem, blood purifier, skin disease, eczemas, ulcer, diabetes	Root, shoot, bark, leaf, fruit, seed

Nyctanthes arbortristis	Shiuli	Verbenaceae	High fever, malaria, gastro-intestinal problem	Root, bark, leaf, seed
Ocimum tenuiflorum	Tulsi	Lamiaceae	Blood puriifier, cold and cough, gastrities, skindisease	Leaf, seed, whole plant

Table 3. Accumulation of Arsenic, Iron and Copper in plant body.

Sampling site (Block)	Medicinal plant (Common name)	Arsenic concentration in ppm (Mean±SD)	Iron concentration in ppm (Mean±SD)	Copper concentration in ppm (Mean±SD)
	Basak	0.058 ±0.002	0.78±0.020	0.126±0.009
A	Kalmegh	0.115±0.001	0.456±0.019	0.118±0.019
	Satamuli	0.09±0.015	0.237±0.017	0.033±0.014
	Siuli	0.153±0.002	0.303±0.019	0.26±0.011
B	Neem	0.074±0.001	0.27±0.020	0.159±0.01
	Kanak dhutra	0.095±0.015	0.296±0.009	0.079±0.014
	Gandal	0.29±0.01	0.582±0.015	0.14±0.02
C	White Dhutra	0.084±0.013	0.421±0.016	0.91±0.013
	Aswagandha	0.043±0.014	0.222±0.012	0.182±0.017
	Thankuni	0.128±0.021	0.49±0.019	0.17±0.015
	Neem	0.21±0.020	0.342±0.017	0.48±0.01
	Hinche	0.081±0.001	1.46±0.02	0.103±0.008
D	Kalmegh	0.28±0.014	0.481±0.002	0.46±0.02
	Tulsi	0.147±0.008	0.846±0.016	0.88±0.016
	Kalmegh	0.35±0.02	0.454±0.018	0.26±0.007
E	Bhui amla	0.158±0.003	0.462±0.02	0.053±0.012
	Neem	0.137±0.004	0.353±0.021	0.28±0.005

*A=Beldanga I, B= Domkal, C= Hariharpara, D= Berhampore, E= Lagola

Table 4. Accumulation of Arsenic, Iron and Copper in Soil samples.

Block	Soil samples of related MP(s)	Arsenic concentration in ppm (Mean ± SD)	Iron concentration in ppm (Mean ± SD)	Copper concentration in ppm (Mean ± SD)
	Basak	0.022±0.006	88.2±1.9	16.3±1.5
A	Kalmegh	0.095±0.001	74.6±2.1	10.8±1.00
	Satamuli	0.088±0.004	110.5±2.4	21.6±1.1
	Siuli	0.063±0.011	66.5±2.0	12.69±1.3
B	Neem	0.16±0.012	98.6±1.8	34.3±1.4
	Kanak dhutra	0.084±0.007	101±2.2	22±1.0
C	Gandal	0.27±0.01	53.6±2.4	25.9±1.4
	White Dhutra	0.045±0.004	70±2.0	11.17±1.3

	Aswagandha	0.077±0.006	85.8±2.9	20.6±1.4
	Thankuni	0.1±0.009	97.6±2.8	17.8±1.9
	Neem	0.11±0.01	160.5±1.8	8.3±0.09
	Hinche	0.085±0.012	70.4±2.4	12.1±1.1
D	Kalmegh	0.2±0.014	55.6±2.1	11.2±1.1
	Tulsi	0.079±0.007	55.8±2.1	9.17±0.9
	Kalmegh	0.21±0.001	78±3.1	18.45±2.2
E	Bhui amla	0.12±0.012	125.2±1.9	35.7±2.34
	Neem	0.0710.006	74±1.6	9.68±1.8

*A=Beldanga I, B= Domkal, C= Hariharpara, D= Berhampore, E= Lagola

Table 5. Range of Arsenic, Iron and Copper content in Water samples.

Block	Range of As content (ppm)	Range of Fe content (ppm)	Range of Cu content (ppm)
A	0.054-0.22	0.06-0.64	0.038-0.047
B	0.065-0.24	0.074-0.83	0.035-0.078
C	0.058-0.18	0.057-0.37	0.004-0.064
D	0.068-0.18	0.075-0.079	0.0-0.002
E	0.091-0.28	0.0-0.093	0.001-0.004

*A=Beldanga I, B= Domkal, C= Hariharpara, D= Berhampore, E= Lagola

Table 6. Correlation study between metals in plant and Soil samples.

	Avg As Conc.(plant)	Avg As Conc.(soil)	Avg Fe Conc.(plant)	Avg Fe Conc.(soil)	Avg Cu Conc.(plant)	Avg Cu Conc.(soil)
Avg As Conc.(plant)	1					
Avg As Conc. (soil)	0.73	1				
Avg Fe Conc.(plant)	-0.09	-0.07	1			
Avg Fe Conc. (soil)	-0.07	-0.04	-0.35	1		
Avg Cu Conc.(plant)	0.42	-0.101	0.24	-0.27	1	
Avg Cu Conc. (soil)	-0.28	0.006	-0.21	0.06	-0.52	1

Table 7. Bioaccumulation Factor (BAF) of metals from soil to plant.

Block	Plant Sample	BAF_{As}	BAF_{Fe}	BAF_{Cu}
	Basak	2.64	0.009	0.008
A	Kalmegh	1.21	0.006	0.01
	Satamuli	1.02	0.002	0.002
B	Siuli	2.43	0.004	0.02

	Neem	0.46	0.002	0.005
	Kanak dhutra	1.13	0.003	0.004
	Gandal	1.07	0.01	0.005
C	White Dhutra	1.87	0.006	0.08
	Aswagandha	0.558	0.003	0.008
	Thankuni	1.28	0.005	0.01
	Neem	1.9	0.002	0.06
D	Hinche	0.95	0.021	0.008
	Kalmegh	1.4	0.008	0.041
	Tulsi	1.86	0.02	0.1
E	Kalmegh	1.67	0.005	0.014
	Bhui amla	1.32	0.003	0.001
	Neem	1.92	0.004	0.03

*A=Beldanga I, B= Domkal, C= Hariharpara, D= Berhampore, E= Lagola

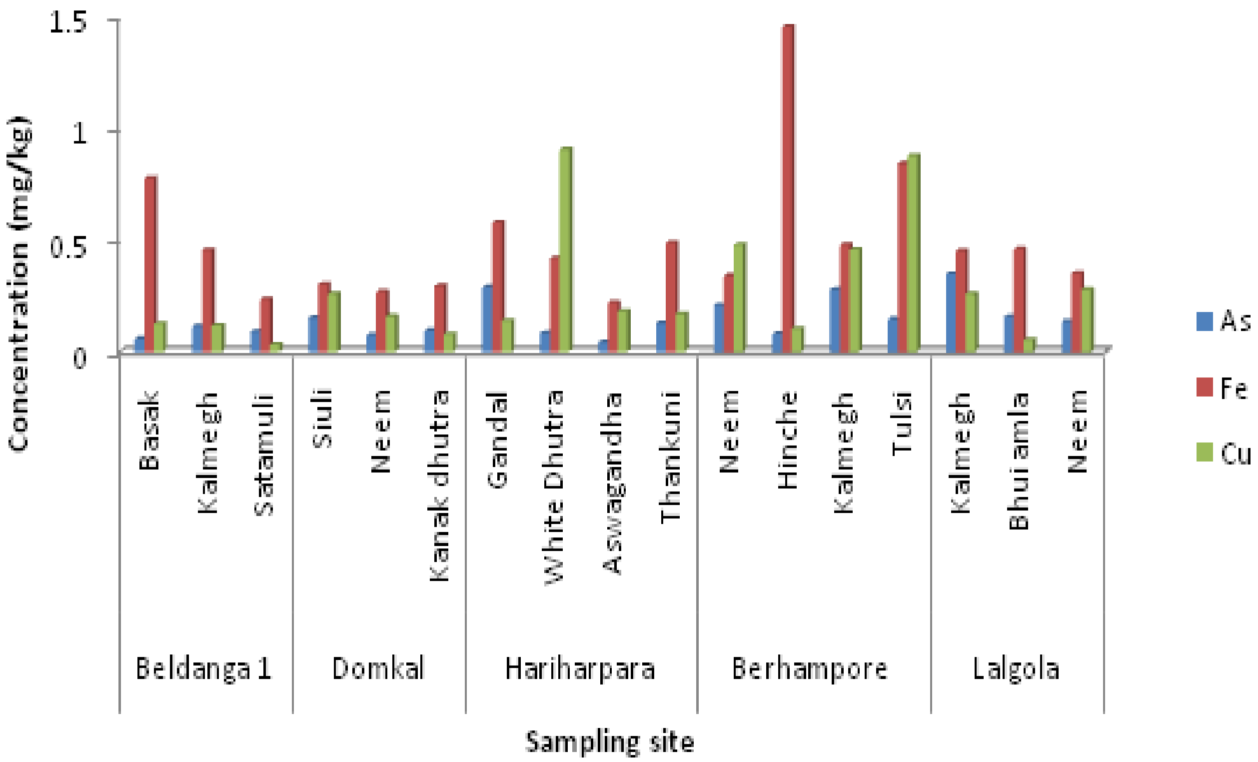

Fig. 2. Accumulation of metals in plant samples of the selected sampling site.

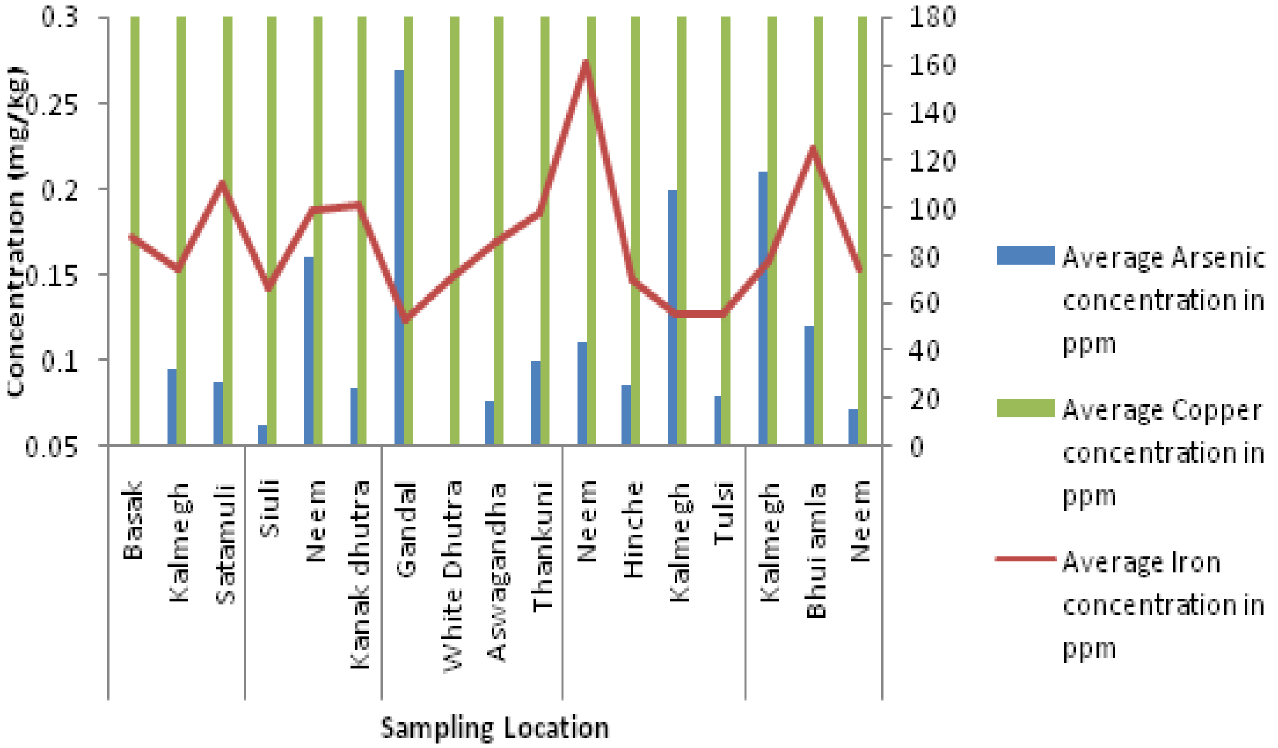

Fig. 3. Distribution of metals in soil samples of the selected sampling site.

soil exert major and significant impact on the accumulated levels of the toxic metals such as As, Fe, Cu which could cause health risks through diet. All the seventeen investigated medicinal plants showed moderate arsenic concentration. Significant As accumulation in medicinal plants was found beyond the WHO permissible limit. However other nutrient elements (Fe, Cu) were found within the acceptable and safe limits including medicinal plants. Lastly it can be concluded that the chronic intake nonessential arsenic in collected medicinal plants (or herbs) may impart health on human beings and animal life.

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