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Assessment of essential minerals and toxic trace metals in blended raw honey, soil, leaf and flower samples harvested from different locations of Kannad Taluka of Aurangabad District

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Abstract
The concentrations of eight essential minerals Ca, Cr, Co Cu, Fe, Mn, Ag, Zn and five toxic trace metals As, Cd, Pb, Hg and Ni were determined in blended raw honey, soil, leaf and flowers harvested from different locations of Kannad taluka. Result reveals that all honey samples from agricultural and road side area was contaminated with toxic trace metals. The honey samples harvested from forest area have no or lower concentrations of toxic trace metals than the permissible limits set by Indian standards (2010). The concentrations of these metals in honey samples investigated do not pose any serious concern to human health except honey harvested from road side area. Hence, the honey produced from Kannad taluka can be considered nutritionally safe and represents good quality. The present data also indicate that the levels of toxic trace metals in honey are comparatively more in roadway area than agricultural and forest areas. The essential minerals in soil, leaf and flower samples comparatively more in agricultural area than roadway and forest areas. The toxic trace metals are more in roadway sides than agricultural and forest areas.

Keywords: Heavy metals, human health, blended honey, permissible limits, Kannad taluka etc.

Introduction
Honey is the sweet substance produced by honeybees from the nectar of inflorescence, flower or from secretions on plants, which the bees collect, transform and store in honey combs [1]. The chemical composition of honey explains the numerous nutritional, healing and prophylactic properties. Honey contains sugar, proteins, vitamins, minerals, enzymes and some of bioactive components [2]. Heavy metals present above the admitted levels in raw honey by pollution standards are a threat to human health [3]. Nowadays, the international honey market trends are demanding good and more quality of honey. The raw materials for honey production were collected by different honeybee species from external environment; therefore it also contains pollutants [4]. Honeybees travel for their forage over several kilometers distance from the hives and they moderate effectively sample the environment for contaminants in plants, soil, and the atmosphere [5]. Honey reflects the chemical component of the many plants from which the bees collect their food and the content of trace elements that can specify the botanical origin of a specific honey [6, 7].
Pesticides and residues of antibiotics, minerals above permissible limits as well as toxic heavy metals are the possible honey contaminants. Therefore, the production of honey free from any harmful chemicals is utmost needed [8]. Mineral content primarily depends on the botanical origin and climatic as well as geographic conditions, but usually also on the type of soil where the honey plant grows [5].
The significant minerals present in honey originate from soil and later they are transported to trees through roots. The minerals make their way into the nectar and afterwards incorporated into the honey produced by bees [9]. Accordingly, the composition and the metal contents in honey, particularly major and minor metals are affected by the composition determined by geochemical and geological characteristics [10]. Since soil and plants are natural sources that have a great impact on the mineral composition of honey, information on the metal profile is suitable for categorizing honeys according to their floral and geographical provenance [11].

Honey samples derived from polluted sites from flowers that provide nectar and pollen pellets, are subject to contaminated by heavy metals from emissions of gases and particles [12]. The minerals present in bee products in levels above those permitted by legislation represent a threat to humans due to their negative and cumulative effects of contaminants on human health. The levels of various heavy metals viz., Pb, Cu, Cr, Zn, Fe and Cd in honey samples can indicate the degree of environmental pollution and the geographic origin of the honey [13]. Environmental monitoring indicates industry and agriculture as the most important sources of contamination, in which heavy metals are most contaminants.
Therefore, the aim of present study was to determine the concentration of eight essential minerals and five toxic trace metals in blended raw honey via soil, leaf, flowers and again in honey samples from three different locations of Kannad taluka of Aurangabad district (M.S.), India.

Materials and methods

Study area: Geographically, Kannad taluka of Aurangabad district is located at 20º 27' N 75º 13' E. The average altitude of this area is 633 meter above sea level. The total area of Aurangabad district is about 10.07 lakh hector is out of which 8.12 lakh hector is under agriculture and 0.12 lakh is forest area. Farmers are engaged in cultivation of traditional crops like sunflowers, mustard, maize, cotton, jawar, bajra, pulses, onion, other seasonable vegetables and also cultivating fruit plants like pomegranate, sweet orange etc. in the area provide and independent system in which the bees assist in carrying out cross pollination.

Procurement of honey samples

Honey samples of *Apis dorsata*, *Apis florea* and *Apis cerana indica* were collected from three different locations of Kannad region, Aurangabad (M.S.) India (Fig.1), during October 2015–September 2016. A total of 23 honey samples were collected (9 from agricultural area, 9 from road side area and 5 from forest area) in air tight sterilized plastic containers, labeled and brought to the laboratory. Location wise honey samples were blended in equal quantity as well as stored at 4-8°C until analysis.

Collection of Soil, Leaf, Flower and Honey Samples

Location wises soil, leaf, flower and honey samples were collected from three different locations of Kannad taluka of Aurangabad district, (M.S.) India (Fig. 1), during October 2015–September 2016 and were blended in equal quantity (powder of 20gm each).
The soil, leaf, flower and honey samples were collected from three different sites viz., agricultural (>20 meters from road side), road side (nearly 0-20 meters from road) and forest area are showed in map.

Sample Digestion

Digestion of soil, leaf, flower and honey samples

0.5g of each soil, leaf, flower and honey sample were digested with HNO_3 (99.9% from Merck) and perchloric acid (70% from Merck) mixture (5:1 ratio) on hot plate till the clear white fumes appeared. During the process 10 ml volume of acidic mixture was maintained. Digested samples were diluted to a final volume (50 ml) with double deionized water and solution was filtered through Whatman no. 41 filter paper. A blank digest was carried out in the same way. From each sample eight essential minerals and five toxic trace metals were determined using Flame Atomic absorption spectrometer (Model: S2, Make: Thermo, USA) with SOLAAR software. Readings for each element was taken in triplicate and mean value (mg/kg) of reading were considered.

Results and Discussion

Essential minerals and toxic trace metals in honey

Eight essential and five toxic trace metals were determined in blended raw honey harvested from different locations of Kannad taluka and the average values of obtained results with statistical analysis were summarized in Table No. 1 and 2. The results clearly shows that the mean values of eight essential minerals and five toxic trace metals varied from one location to another. These values are within the range of Codex standards [14] and Indian standards [15] recommended limits for human consumption
The results demonstrate that the concentrations of all studied essential minerals and toxic trace metals in blended raw honey samples varied from location to location and are related to the botanical and geographical origin of the samples.
The values of calcium content in honey were within the range of 3.77 to 11.33 mg/kg. The highest values (11.33 mg/kg) of calcium were recorded in honey from agricultural area and the lowest from road side area (3.77 mg/kg).
The mean values of chromium in blended honey from three different locations of Kannad taluka were within the range of 0.00-0.065 mg/kg. The honey from agricultural area shows the highest value (0.065mg/kg), while honey from forest area shows the lowest value (0.00 mg/kg).
The values of cobalt in honey samples harvested from different locations of Kannad taluka were within the range of 0.015-0.063 mg/kg. The honey harvested from agricultural area shows highest value (0.063 mg/kg), while honey from forest area shows the lowest value (0.015 mg/kg).
The mean values of copper in blended honey from three different locations of Kannad taluka were within the range of 0.021-0.029 mg/kg. The honey from agricultural area shows the highest value (0.029 mg/kg), while lowest values were reported at forest area (0.021 mg/kg).
The mean values of iron in blended honey from three different locations of Kannad taluka were within the range of 0.51-0.96 mg/kg. The honey from agricultural area shows the highest value (0.96 mg/kg), while honey from forest area shows the lowest value (0.51 mg/kg).
The values of Manganese in honey harvested from different locations of Kannad taluka were within the range of 0.021 to 0.06 mg/kg. The highest level of manganese was found in honey from agricultural area with values 0.06 mg/kg and lowest values were recorded in honey from forest area with values 0.021 mg/kg.
The values of silver in honey samples harvested from different locations of Kannad taluka were within the range of 0.023-0.068 mg/kg. The honey harvested from agricultural area showed the highest value (0.068 mg/kg), while honey from road side area showed the lowest value (0.023 mg/kg).
The mean values of zinc in blended honey from three different locations of Kannad taluka were within the range of 0.13-0.46 mg/kg. The honey from agricultural area shows the highest value (0.46 mg/kg), while from forest area shows the lowest value (0.13 mg/kg).
The obtained values of essential minerals (Ca, Cr, Co, Cu, Fe, Mn, Ag and Zn) were more or less similar to values obtained by [16] Nanda *et al.*, (2003) from North India, [17] Cantarelli *et al.*, (2008) from Turkey, [18] Juliana *et al.*, (2009) from Central

Bulgaria, [19] Adams *et al.*, (2010) from Ibadan, [3] Mbiri *et al.*, (2011) from Kenya, [20] Vincevica- Gaile *et al.*, (2012) from Latvia, [21] Liberato *et al.*, (2012) from Ceará State, Northeastern Brazil, [22] Maiyo *et al.*, (2014) Kenya, [23] Conti *et al.*, (2014) from Argentina, [24] Waykar and Baviskar (2015) from Maharashtra India, [25] Trstenjak *et al.*, (2017) from Croatia and [26] Boussaid *et al.*, (2018) from Tunisia.

The mean values of Arsenic in honey harvested from different locations of Kannad taluka were within the range of 0.0008-0.20 mg/kg. The honey harvested from agricultural area and road side area showed the highest value of As (0.099 and 0.20 mg/kg), while honey from forest area showed the lowest value (0.0008 mg/kg).

Industrial and agro-horticultural practices might be responsible for the higher values of As at these locations. In agricultural zones, the use of different types of pesticides and fertilizers are the main sources of arsenic. The values of As recorded were below than the Indian standards [15] recommended limits for human consumption. The recorded values of As in this study were lower than the values recorded in earlier studies. [3] Mbiri *et al*., (2011) reported the values of As in the range of 0.02-0.03 ppm in honey from Kenya, [27] Batelková *et al*., (2012) recorded the values of As in the range of 1.00-4.354 µg/kg in honey from South Moravian region (Czech Republic). [28] Bilandzic *et al*., (2012) reported the 11.1 µg/kg values of As in indigo bush honey and 502 µg/kg in rapeseed honey, Croatia, [20] Vincevica-Gaile *et al*., (2012) observed the 0.0031 mg/kg value of As in Latvia honey, [23] Conti *et al*., (2014) found the As concentration of Argentine honeys less than 0.01 µg/g. [29] Moniruzzaman *et al*., (2014) determined the concentration of As in Malaysian honeys ranges between 0.027 to 0.126 mg/kg. The recorded values of As in honey were higher than the values recorded by [24] Waykar and Baviskar (2015) 0.0283 to 0.54 mg/kg in honey from Maharashtra, India.

The values of Cadmium in blended honey from different locations of Kannad taluka were within the range of 0.0006-0.01 mg/kg. The two distinctive locations (road side and agricultural area) show the higher values of Cd than the forest area. The high level of Cd recorded was attributed due to the agricultural, vehicular traffic in the studied area. The different chemical fertilizers and pesticides are the main sources of Cd [30]. [31] Tsukahara *et al.*, (2003) reported higher Cd level in industrial and extensive agricultural area. The values of Cd recorded were lower than the Indian standards [15] recommended limits for human consumption. The higher concentration of Cd was reported by [32] Frias *et al.*, (2008) 46.32 mgCd/kg from Tenerife honey. [33] Rahman *et al.*, (2014), studied the Cd concentration in branded and unbranded honeys from Khyber Pukhtounkhwa, Pakistan ranges between 0.12 -0.23 ppm. [3] Mbiri *et al.*, (2011) studied the concentration of Cd in Kenyan honey by atomic absorption and emission spectroscopy ranges between 0.02-0.03 ppm. [29] Moniruzzaman *et al.*, (2014) studied the concentration of Cd in Malaysian honeys ranges between 0.00 to 1.03 mg/kg. [28] Bilandzic *et al.*, (2014) reported the concentration of Cd in multifloral and unifloral honeys in Croatia ranges between 2.14 to 2.52 µg/kg. [23] Conti *et al.*, (2014) found the Cd concentration of Argentine honeys ranges between <0.01 to 0.03 µg/g. [34] Bilandzic *et al.*, (2012) reported the Cd concentration in different honey types from Koprivnica-Krizevci County, Croatia ranges between 1-5 µg/kg. [24] Waykar and Baviskar (2015) reported the concentration of Cd concentration in *Apis dorsata* honey from different locations of Paithan taluka of Aurangabad district ranges from 0.0044 to 0.0212 mg/kg. [25] Trstenjak *et al.*, (2017) reported the concentration of Cd in 200 Acacia honey samples obtained from different regions of Croatia ≤ 0.01mg/kg.

The mean values of lead (Pb) in blended honey from different locations of Kannad taluka were within the range of 0.00-2.82 mg/kg. The honey from road side area and agricultural area shows higher values of Pb than the forest area. The high values of Pb might be due to the small distance of bee colonies from the busy national highway. The vehicles release large quantity of smoke and dust which holds large amount of Pb from the burning of petrol in automobiles [35]. Honeybees travel considerable distances to collect nectar from different plants, and hence over the course of these lengthy journeys, have a high propensity to pick up unwanted materials and introduce these to the honey as a contaminant. This is likely to increase the amount of Pb in honey. The values of Pb recorded were higher than the Indian standards [15] recommended limits for human consumption.

The values of Pb recorded in this study were higher or lower than the values recorded by [36] Sahinler *et al.*, (2009), 1.29 mg/kg from Turkish. [33] Rahman *et al.*, (2014), studied the Pb concentration in branded and unbranded honeys from Khyber Pukhtounkhwa, Pakistan ranges between 0.11-1.34 ppm. [3] Mbiri *et al.*, (2011) studied the concentration of Pb in Kenyan honey by atomic absorption and emission spectroscopy ranges between 0.08-0.28 ppm. [29] Moniruzzaman *et al.*, (2014) studied the concentration of Pb in Malaysian honeys ranges between 0.00 to 1.017 mg/kg. [28] Bilandzic *et al.*, (2014) reported the concentration of Pb in multifloral and unifloral honeys in Croatia ranges between 301 to 810.3 µg/kg. [37] Conti *et al.*, (2014) found the Pb concentration of Argentine honeys ranges between 0.01 to 0.04 µg/g. [34] Bilandzic *et al.*, (2012) reported the Pb concentration in different honey types from Koprivnica-Krizevci county, Croatia ranges between 159- 2159 µg/kg. [24] Waykar and Baviskar (2015) reported the concentration of Pb concentration in *Apis dorsata* honey from different locations of Paithan taluka of Aurangabad district ranges from 0.00 to 0.0061 mg/kg. [26] Boussaid *et al.*, (2018), reported the concentration of Pb in six Tunisian honey samples from various floral origins ranges between 0.01-0.05 mg/kg. [25] Trstenjak *et al.*, (2017) reported the concentration of Pb in 200 Acacia honey samples obtained from different regions of Croatia ranges between0.04-0.08 mg/kg.

The mean values of mercury in honey harvested from different locations of Kannad taluka were within the range of 0.00-0.43 mg/kg. Honey harvested from road side area showed the highest value of Hg (0.43 mg/kg), while honey from forest area showed the lowest value (BDL).

The presence of mercury in honey may be caused by industrial activities like smelter pollution, emission from factories, non-ferrous metallurgy and agricultural activities [3]. The result demonstrates that the values of Hg recorded in honey were below than the Indian standards [15] recommended limits for human consumption. Several reports were available for Hg concentrations in honey samples.

[38] Akbari *et al*., (2012) found a mean value 3030 µg/kg of Hg in honey collected from Iran. [27] Batelková *et al*., (2012) found the values of Hg within the range of 5.06-11.31 µg/kg in honey from the South Moravian region (Czech Republic). Also they reported the Hg concentration in different honey types from Koprivnica-Krizevci County, Croatia ranges from 0.13-6.11 µg/kg.

[28] Bilandzic *et al*., (2014) reported the concentration of Hg in multifloral and unifloral honeys in Croatia ranges between 0.82 to 2.52 µg/kg. [33] Rahman *et al*., (2014) found the Hg values ranging from 0.00016-0.00071 ppm and 0.00012-0.00069 ppm in branded and unbranded honeys respectively. [24] Waykar and Baviskar (2015) determined the concentration of Hg in *Apis dorsata* honey from different locations of Paithan taluka of Aurangabad district ranges from 0.1 to 1.63 mg/kg.

The mean values of nickel in honey harvested from different locations of Kannad taluka were within the range of 0.0008-0.16 mg/kg. The honey harvested from road side area showed the highest value of Ni (0.16 mg/kg), while honey from forest area showed the lowest value (0.0008 mg/kg). The values of Ni recorded were below the recommended limits for human consumption. Honey samples showed lower values of Ni than those expressed in the other citations. [39] Matei *et al*., (2004) reported the concentration of nickel ranging from 0.90 to 2.50ppm in Romania honey. [20] Vincevica-Gaile *et al*., (2012) observed the 0.054 mg/kg of Ni content in heather/forest blossom honey from Latvia. [37] Conti *et al*., (2014) found the Ni concentration of Argentine honeys ranges from 0.01-0.07 µg/g. [33] Rahman *et al*., (2014) found the Ni values ranging from 0.00013-0.00241 ppm and 0.0015-0.00225 ppm in branded and unbranded honeys respectively, from Khyber Pukhtounkhwa Pakistan.

[24] Waykar and Baviskar (2015) reported the concentration of Ni concentration in *Apis dorsata* honey from different locations of Paithan taluka of Aurangabad district ranges from 0.0036 to 0.0165 mg/kg. [25] Trstenjak *et al*., (2017) determined the concentration of Ni in 200 Acacia honey samples obtained from different regions of Croatia ranges from 0.16-0.98 mg/kg. [26] Boussaid *et al*., (2018) reported the concentration of Ni in six Tunisian honey samples from various floral origins ranged from 0.04-0.40 mg/kg. [40] Bouhlali *et al*., (2019) observed the concentration of Ni in eleven monofloral honey samples produced in Morocco in the range of 0.01 to 0.33mg/kg.

Significant variations in the concentration of Ni may be due to differences in the chemical composition of the soil at each location, as well as the existence of different kinds of plants. The role of different types of fertilizers may also contribute in this regard.

The result clearly indicates that there were significant differences in concentration of essential minerals and toxic trace metals between honey samples from three different locations of Kannad taluka. These variations might be due to the difference in the chemical composition of the soil at each location, use of different types of fertilizers and pesticides as well as the flora source of honey from which the bees consumes the nectar [11]. Plant absorbs these minerals from the water and soil and honey bees then suck the nectar from these plants which contain these minerals [41]. Also data shows that the levels of toxic trace metals are comparatively more in roadway area than agricultural and forest areas. Therefore honey harvested from road side area was not safe for human consumption because the values of Pb recorded were higher than the Indian standards [15] recommended limits. Honeybees fly up to 4 km distance in any direction in search of their food mainly nectar and can easily cover an area of approximately 50 km^2. The geological and chemical environment as well as habitat of these bees' greatly affects the quality and nutritional values of their honey.

Essential minerals and toxic trace metals in soil, leaf and flower sample

Eight essential minerals and five toxic trace metals were determined in blended soil, leaf and flower samples from three different locations of Kannad taluka and average values were summarized in table 1 and 2. The results clearly demonstrate that mean values of these essential minerals and toxic trace metals varied from one location to another.

Agricultural area: In agricultural area values of Ca, Cr, Co, Cu, Fe, Mn, Ag and Zn in soil samples are 1980.42, 8.29, 6.39, 34.41, 91.12, 5.41, 3.11 and 41.28 mg/kg respectively. In case of leaf samples values of Ca, Cr, Co, Cu, Fe, Mn, Ag and Zn are 170.15, 0.98, 2.14, 4.25, 13.19, 1.93, 0.99 and 9.05 mg/kg respectively. Values of Ca, Cr, Co, Cu, Fe, Mn, Ag and Zn in flower samples are 87.16, 0.21, 0.98, 0.96, 2.98, 0.91, 0.19 and 2.27 mg/kg respectively while values of Ca, Cr, Co, Cu, Fe, Mn, Ag and Zn in honey samples are 11.33, 0.065, 0.063, 0.029, 0.96, 0.06, 0.068 and 0.46 mg/kg respectively.

In agricultural area values of As, Cd, Pb, Hg and Ni in soil samples are 1.13, 0.26, 0.088, 0.33 and 2.03 mg/kg respectively. In case of leaf samples values of As, Cd, Pb, Hg and Ni are 0.69, 0.012, 0.009, 0.11, and 1.18 mg/kg respectively. Values of As, Cd, Pb, Hg and Ni in flower samples are 0.21, 0.0097, 0.0018, 0.099, and 0.057 mg/kg respectively while values of As, Cd Pb, Hg and Ni in honey samples are 0.099, 0.0078, 0.0007, 0.082 and 0.011 mg/kg respectively.

Forest area: In forest area values of Ca, Cr, Co, Cu, Fe, Mn, Ag and Zn in soil samples are 833.34, 0.00, 2.04, 7.47, 18.95, 3.01, 1.07 and 9.72 mg/kg respectively. In case of leaf samples values of Ca, Cr, Co, Cu, Fe, Mn, Ag and Zn are 99.05, 0.00, 1.02, 1.58, 2.98, 1.06, 0.72 and 2.03 mg/kg respectively. Values of Ca, Cr, Co, Cu, Fe, Mn, Ag and Zn in flower samples are 30.19, 0.00, 0.53, 0.81, 0.98, 0.076, 0.12 and 0.94 mg/kg respectively while values of Ca, Cr, Co, Cu, Fe, Mn, Ag and Zn in honey samples are 8.82, 0.00, 0.015, 0.021, 0.51, 0.021, 0.037 and 0.13 mg/kg respectively.

In forest area values of As, Cd, Pb, Hg and Ni in soil samples are 0.50, 0.00, 0.00, 0.00 and 0.98 mg/kg respectively. In case of leaf samples values of As, Cd, Pb, Hg and Ni are 0.17, 0.00, 0.00, 0.00 and 0.13 mg/kg respectively. Values of As, Cd, Pb, Hg and Ni in flower samples are 0.0043, 0.00, 0.00, 0.00 and 0.003 mg/kg respectively while values of As, Cd, Pb, Hg and Ni in honey samples are 0.0008, 0.0006, 0.00, 0.00 and 0.0008 mg/kg respectively.

Road side area: In road side area values of Ca, Cr, Co, Cu, Fe, Mn, Ag and Zn in soil samples are 1231.19, 1.81, 2.01, 25.18, 47.02, 4.3, 2.41 and 34.12 mg/kg respectively. In case of leaf samples values of Ca, Cr, Co, Cu, Fe, Mn, Ag and Zn are 72.3, 0.33, 0.98, 3.19, 8.02, 1.21, 0.56 and 5.98 mg/kg respectively. Values of Ca, Cr, Co, Cu, Fe, Mn, Ag and Zn in flower samples are 23.14, 0.12, 0.09, 0.84, 2.03, 0.85, 0.097 and 1.33 mg/kg respectively while values of Ca, Cr, Co, Cu, Fe, Mn, Ag and Zn in honey samples are 3.77, 0.06, 0.05, 0.026, 0.87, 0.046, 0.023 and 0.42 mg/kg respectively.

In road side area values of As, Cd, Pb, Hg and Ni in soil samples are 1.98, 0.47, 4.91, 0.96 and 9.03 mg/kg respectively. In case of leaf samples values of As, Cd, Pb, Hg and Ni are 0.84, 0.031, 3.87, 0.79 and 2.03 mg/kg respectively. Values of As, Cd, Pb, Hg and Ni in flower

samples are 0.38, 0.017, 2.98, 0.58 and 0.98 mg/kg respectively while values of As, Cd, Pb, Hg and Ni in honey samples are 0.20, 0.01, 2.82, 0.43 and 0.16 mg/kg respectively.

The present values of essential minerals and toxic trace metals in blended soil, leaf and flower samples were more or less similar to values obtained by [42] Khan *et al.*, (2011) from Pakistan, [43] Ekmekyapar *et al.*, (2012) from Turkey, [44] Formicki *et al.*, (2013) from Southern Poland, [45] Christiana and Samuel, (2013) from Nigeria, [22] Maiyo *et al.*, (2014) from Kenya, [46] Altunatmaz *et al.*, (2017) from Turkey, [25] Trstenjak *et al.*, (2017) from Croatia, [47] Rao *et al.*, (2017) from Chhattisgarh, India, [48] Paul *et al.*, (2018) from Nigeria and [49] Aldgini *et al.*, (2019) from Jordan. It is considered that the proportion of mineral contents in honey largely depends on its botanical origin, but also on the climatic conditions, and the composition of soil on which the honey plant was growing [5]. Moreover, it is also believed that the characteristic soil composition of a particular region can be seen in the mineral content of honey plants or the mineral content of its nectar and pollen [50]. It was observed that honey, soil, leaf and flower samples obtained near roadway sides had elevated levels of lead due to exhaust emission of motor vehicles.

Table 1: Concentration of essential minerals in raw honey, flower, leaf and soil samples harvested from three different locations of Kannad taluka of Aurangabad district (mg/kg).

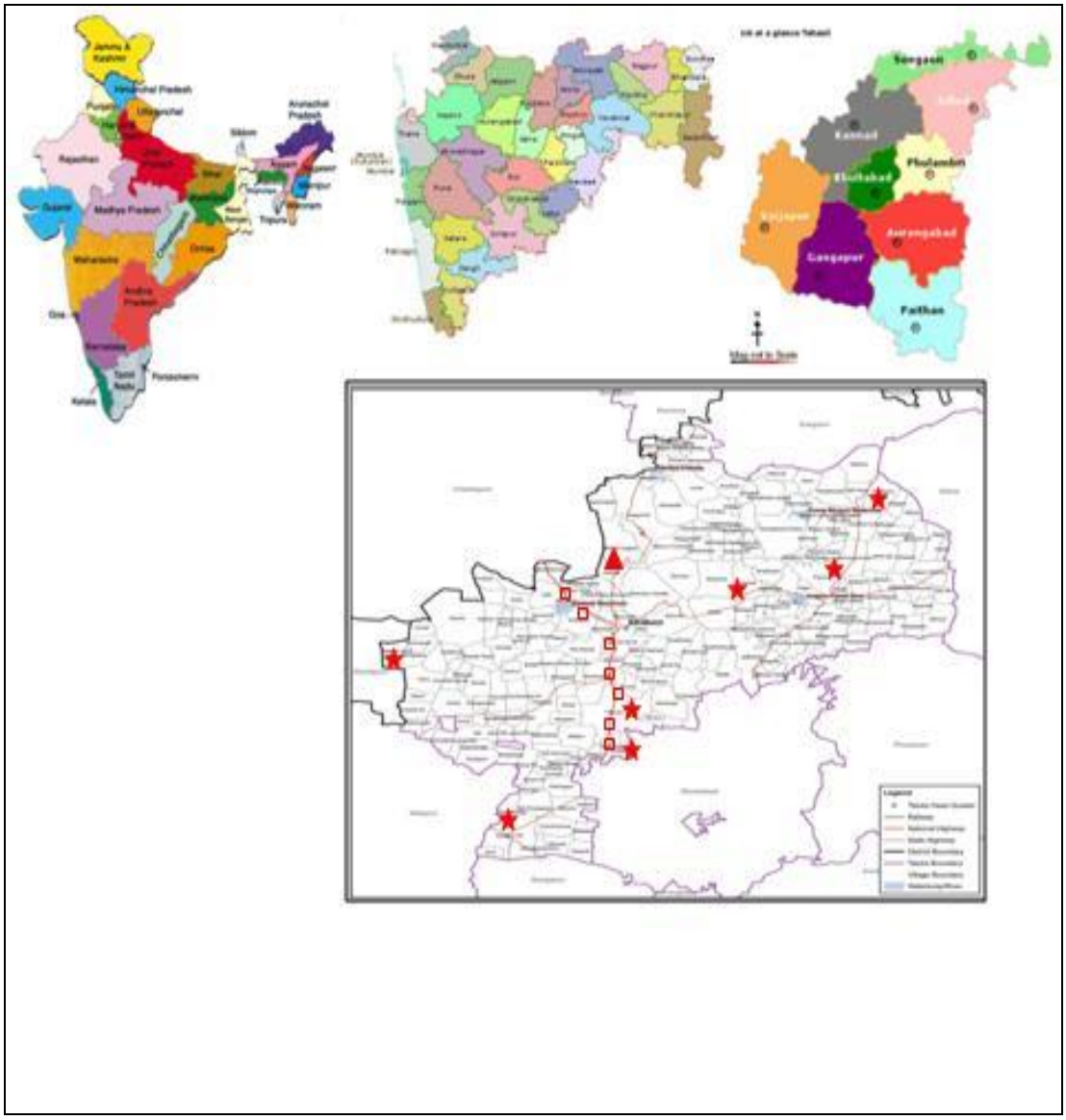
Site of Collection	Samples	Ca	Cr	Co	Cu	Fe	Mn	Ag	Zn
Agricultural Area	H	11.33±0.08	0.065±0.004	0.063±0.003	0.029±0.003	0.96±0.006	0.06±0.003	0.068±0.003	0.46±0.002
	F	87.16±0.9	0.21±0.03	0.98±0.02	0.96±0.01	2.98±0.02	0.91±0.03	0.19±0.002	2.27±0.02
	L	170.15±1.45	0.98±0.008	2.14±0.04	4.25±0.05	13.19±0.09	1.93±0.02	0.99±0.009	9.05±0.03
	S	1980.42±2.43	8.29±0.06	6.39±0.09	37.41±0.91	91.12±2.11	5.41±0.07	3.11±0.02	41.28±0.57
Forest Area	H	8.82±0.05	BDL	0.015±0.001	0.021±0.002	0.51±0.002	0.021±0.001	0.037±0.003	0.13±0.001
	F	30.19±0.7	BDL	0.53±0.01	0.81±0.02	0.98±0.01	0.0076±0.002	0.12±0.001	0.94±0.01
	L	99.05±1.21	BDL	1.02±0.01	1.58±0.01	2.98±0.03	1.06±0.01	0.72±0.005	2.03±0.02
	S	833.34±1.16	BDL	2.04±0.02	7.47±0.06	18.95±0.31	3.01±0.02	1.07±0.01	9.72±0.04
Road Side Area	H	3.77±0.04	0.06±0.003	0.05±0.003	0.026±0.002	0.87±0.004	0.046±0.002	0.023±0.001	0.42±0.002
	F	23.14±0.5	0.12±0.02	0.09±0.0001	0.84±0.004	2.03±0.03	0.85±0.02	0.097±0.0001	1.33±0.02
	L	72.3±1.03	0.33±0.006	0.98±0.03	3.19±0.02	8.02±0.03	1.21±0.02	0.56±0.004	5.98±0.05
	S	1231.19±1.29	1.81±0.02	2.01±0.01	25.18±0.51	47.02±0.59	4.30±0.03	2.41±0.03	34.12±0.88
Codex Alimentarius Standards, 2003 (Conc. of honey in mg/Kg)		50	-	0.09	0.02-0.08	0.5-1.5	0.005	-	0.5

BDL- Below Detection Limit, H- Honey, F- Flower, L- Leaf and S- Soil.

Table 2: Concentration of toxic trace metals in raw honey, flower, leaf and soil samples harvested from three different locations of Kannad taluka of Aurangabad district (mg/kg).

Site of Collection	Samples	As	Cd	Pb	Hg	Ni
Agricultural Area	H	0.099±0.005	0.0078±0.0002	0.0007±0.0001	0.082±0.003	0.011±0.001
	F	0.21±0.007	0.0097±0.0001	0.0018±0.0001	0.099±0.006	0.057±0.003
	L	0.69±0.005	0.012±0.001	0.009±0.0002	0.11±0.002	1.18±0.01
	S	1.13±0.001	0.26±0.007	0.088±0.001	0.33±0.001	2.03±0.01
Forest Area	H	0.0008±0.0001	0.0006±0.0001	BDL	BDL	0.0008±0.0002
	F	0.0043±0.0001	BDL	BDL	BDL	0.003±0.0001
	L	0.17±0.001	BDL	BDL	BDL	0.13±0.01
	S	0.50±0.004	BDL	BDL	BDL	0.98±0.02
Road Side Area	H	0.20±0.003	0.01±0.001	2.82±0.03	0.43±0.002	0.16±0.003
	F	0.38±0.003	0.017±0.001	2.98±0.02	0.58±0.003	0.98±0.005
	L	0.84±0.006	0.031±0.001	3.87±0.03	0.79±0.005	2.03±0.02
	S	1.98±0.004	0.47±0.005	4.91±0.02	0.96±0.002	9.03±0.6
Indian Standards, IBS, 2010 (Conc. of honey in mg/Kg)		<1.1 ppm	<1.5 ppm	<2.5 ppm	<1 ppm	
International Standards, FSI, 1998 (Conc. of honey in mg/Kg)						0.02-2.5

BDL- Below Detection Limit, H- Honey, F- Flower, L- Leaf and S- Soil.



Map showing the locations of honey sample collection.

= Road side area

= Forest Area (Gautala)

= Agricultural Area

Fig 1: Location Map

Conclusion

It was concluded that the values of essential minerals and toxic trace metals in blended honey, soil, leaf and flower samples were significantly different from locations to locations and large quantities of minerals are present in the soil than leaf, flower and honey samples. The essential minerals (Ca, Cr, Co, Cu, Fe, Mn, Ag and Zn) in soil, leaf and flower samples comparatively more in agricultural area than roadway and forest areas as well as toxic trace metals (As, Cd, Pb, Hg and Ni) are more in roadway sides than agricultural and forest areas. Uses of micronutrients (B, Zn, Fe, Mn, Cu, Mo and Cl) in agro practices may have impact on changing the mineral contents in soil, leaf and flowers. Also soil, leaf and flower samples obtained near roadway traffic shows large amount of toxic trace metals due to vehicular traffic. These essential minerals and toxic trace metals are might be incorporated in honey through soil, leaf and flowers.

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References

1. Codex Alimentarius. Draft revised standard for standard for honey (at step 10 of the Codex procedure). Alinorm. 2001;1(25):19-26.
2. Al-mamary M, Al- meeri A, Al-habori M. Antioxidant activities and total phenolics in different types of honeys. Nutritional Research. 2002;22(9):1041-1047.
3. Mbiri A, Onditi A, Oyaro N. Determination of essential and heavy metals in Kenyan Honey by atomic absorption and emission spectroscopy. JAGST. 2011;13(1):107-115.

4. Roman A. Bees and their products as pollution bioindicator in the copper (LGOM) and lime-cement (Opole) industry areas. In *Zeszyty Naukowe Akademii Rolniczej we Wrocławiu*. Seria. Zootechnika. 1997;5(2):175-193.
5. Przybyłowski P, Wilczyńska A. Honey as an environmental marker. Food Chemistry. 2001;74(3):289-291.
6. Celli G, Maccagnani B. Honey bees as bioindicators of environmental pollution. Bulletin of Insectology. 2003;56(1):137-139.
7. Bogdanov S. Contaminants of bee products. Apidologie. 2006;37:1-18.
8. McKee B. Prevention of residues in honey: a future perspective. Apiacta. 2003;38:173-177.
9. Stankovska E, Stafilov T, Šajn R. Monitoring of trace elements in honey from the Republic of Macedonia by atomic absorption spectrometry. Environmental Monitoring and Assessment. 2008;142(1-3):117-126.
10. Fernández-Torres R, Perez-Bernal JL, Bello-Lopez MA, Callejon-Mochon M, Jimenez-Sanchez JC, Guiraúm-Pérez A. Mineral content and botanical origin of Spanish honeys. Talanta. 2005;65(3):686-691.
11. Pohl P. Determination of metal content in honey by atomic absorption and emission spectrometries. Trend Anal Chem. 2009;28(1):117-128.
12. Magalhaes MS. Mel e pólen de abelhas *Apis mellifera* como bioindicadores de poluição ambiental por metais pesados. 68 f. Dissertação (Mestrado em Ecologia de Biomas Tropicais)-Universidade Federal de Ouro Preto, Ouro Preto, 2010.
13. de Abreu Franchini RA, de Souza CF, Colombara R, Costa Matos MA, Matos RC. Rapid determination of hydrogen peroxide using peroxidase immobilized on Amberlite IRA-743 and minerals in honey. Journal of agricultural and food chemistry. 2007;55(17):6885-6890.
14. Codex Alimentarius Commission. Revised Codex standard for honey. Codex Stan 12-1981 (1987) Rev 1, (2001) Rev. 2003;2:1.
15. IBS. (Indian Bureau of Standards). FSSAI Advisory on Standards for Honey and Prohibition of Antibiotics. 2010.
16. Nanda V, Sarkar BC, Sharma HK, Bawa AS. Physico-chemical properties and estimation of mineral content inhoney produced from different plants in northern India. J. Food Composition and Analysis. 2003;16(5):613-619.
17. Cantarelli MA, Pellerano RG, Marchevsky EJ, Camina JM. Quality of honey from Argentina: Study of chemical composition and trace elements. Argentine Chemical Society. 2008;96:33-41.
18. Juliana RA, Lilyana YD, Maria LA. Palynological, physical and chemical data on honey from the Kazanlak region (Central Bulgaria). Phytologia Balcanica. 2009;15:107-114.
19. Adams BA, Osikabor B, Olomola A, Adesope AA. Comparative study of elements composition of some honey samples in Ibadan Metropolis. J. Agriculture and Social Research (JASR). 2010;10(2):54-58.
20. Vincevica-Gaile Z, Klavins M, Rudovica V, Viksna A. Potentially Toxic Metals in Honey from Latvia: Is there Connection with Botanical Origin? Recent Researches in Environment. Energy Systems and Sustainability, 2012, pp. 158-163.
21. Liberato M, Morais S, Magalhaes C, Magalhaes I, Cavalcanti D, Silava M. Physicochemical properties and mineral and protein content of honey samples from Ceará State, Northeastern Brazil. Food Sci. Technol, Campinas. 2012;33(1):38-46.
22. Maiyo WK, Kituyi JL, Mitei YJ, Kagwanja SM. Heavy metal contamination in raw honey, soil and flower samples obtained from Baringo and Keiyo Counties, Kenya. International Journal of Emerging Science and Engineering (IJESE). 2014;2(7):5-9.
23. Conti ME, Finoia MG, Fontana L, Mele G, Botrè F, Iavicoli I. Characterization of Argentine honeys on the basis of their mineral content and some typical quality parameters. Chemistry Central Journal. 2014;8(1):44.
24. Bhalchandra W, Baviskar RK. Essential and toxic trace metals in raw honey of *Apis dorsata* harvested from different locations of Paithan taluka of Aurangabad district. The Ecoscan; 2015;vii, 1-6.
25. Trstenjak UN, Puntarić D, Levanić D, Gvozdić V, Pavlek Ž, Puntarić A, Vidosavljević M. Pollen, Physicochemical and Mineral Analysis of Croatian Acacia Honey Samples: Applicability for Identification of Botanical and Geographical Origin. Journal of Food Quality, 2017.
26. Boussaid A, Chouaibi M, Rezig L, Hellal R, Donsì F, Ferrari G, *et al*. Physicochemical and bioactive properties of six honey samples from various floral origins from Tunisia. Arabian Journal of Chemistry. 2018;11(2):265-274.
27. Batelková B, Èelechovská O, Vorlová1 L, Bartáková K. Polycyclic aromatic hydrocarbons and risk elements in honey from the South Moravian region (Czech Republic). Acta vet. Brno. 2012;8:169-174
28. Bilandžić N, Gačić M, Đokić M, Sedak M, Šipušić ĐI, Končurat A, *et al*. Major and trace elements levels in multifloral and unifloral honeys in Croatia. Journal of Food Composition and Analysis. 2014;33(2):132-138.
29. Moniruzzaman M, Chowdhury MA, Rahman MA, Sulaiman SA, Gan SH. Determination of mineral, trace element, and pesticide levels in honey samples originating from different regions of Malaysia compared to Manuka honey. BioMed research international. 2014.
30. Nirel PM, Pasquini F. Differentiation of copper pollution origin: agricultural and urban sources. Novatech, 2010, pp. 1-7.
31. Tsukahara T, Ezeki T, Moriguchi J, Furuki K, Shimbo S, Matsuda-Inoguchi N. *et al.* Rice as the most influential source of cadmium intake among general Japanese population. Sci. Total Environ. 2003;305:41-51.
32. Frias I, Rubio C, Weller DA. Metals in fresh honeys from Tenerife Island, Spain. Bull Environ Contam Toxicol. 2008;80(2):30-33.
33. Rahman K, Imdadullah M, Hussain A, Rahman H, Ali J. Contaminants Analysis of Different Branded and Unbranded Honey of khyberpukhtounkhwa Pakistan. Life Science J. 2014;11(3s)
34. Bilandžić N, Đokić M, Sedak M, Varenina I, Kolanović BS, Končurat A, *et al*. Content of five trace elements in different honey types from Koprivnica-Krievcicounty. Slovenian Veterinary Research. 2012;49(4):167-175.
35. Reddy BT, Rao PV, Venkata RC, Bhaskar CH, Babu JP. Assessment of heavy metal study on ground water in and around Kapuluppada Msw Site,Visakhapatnam, AP. International J. Science and Nature. 2012;2:468-471.
36. Sahinler N, Guel A, Akyol E. Heavy metals, trace elements and biochemical composition of different honey

produce in Turkey. Asian J. Chemistry. 2009;21:1887-1896.
37. Conti ME, Finoia MG, Fontana L, Mele G, Botrè F, Iavicoli I. Characterization of Argentine honeys on the basis of their mineral content and some typical quality parameters. Chemistry Central J. 2014;8:44.
38. Akbari B, Gharanfoli F, Khayyat MH. Determination of heavy metals in different honey brands from Iranian markets. Food Additives and Contaminants: Part B: Surveillance. 2012;5(2):105-111.
39. Matei N, Birghila S, Simona D, Petre C. Determination of C vitamin and some essential trace elements (Ni, Mn, Fe, Cr) in bee products. Acta Chim. Slov. 2004;51:169-175.
40. Bouhlali ED, Bammou M, Sellam K, El Midaoui A, Bourkhis B, Ennassir J, *et al*. Physicochemical properties of eleven monofloral honey samples produced in Morocco. Arab Journal of Basic and Applied Sciences. 2019;26(1):476-487.
41. Devillers J, Dore JC, Marenco M. Chemometrical analysis of 18 Metalic and Nonmetallic elements found in honeys sold in France. J. Agric. Food Chem. 2002;50(21):5998-6007.
42. Khan KY, Khan MA, Niamat R, Munir M, Mazari HF, Seema N, *et al*. Element content analysis of plants of genus *Ficus* using atomic absorption spectrometer. African journal of pharmacy and pharmacology. 2011;5(3):317-321.
43. Ekmekyapar F, Sabudak T, Seren G. Assessment of heavy metal contamination in soil and wheat (*Triticum aestivum* L.) plant around the Corlu–Cerkezkoy highway in Thrace region. Global Nest J. 2012;14(4):496-504.
44. Formicki G, Greń A, Stawarz R, Zyśk B, Gał A. Metal Content in Honey, Propolis, Wax, and Bee Pollen and Implications for Metal Pollution Monitoring. Polish Journal of Environmental Studies. 2013;22(1).
45. Christiana O, Samuel K. Investigation of heavy metal levels in roadside agricultural soil and plant samples in Adogo, Nigeria, Academia Journal of Environmental Sciences. 2013;1(2):031-035.
46. Altunatmaz SS, Tarhan D, Aksu F, Barutcu UB, ME. Mineral element and heavy metal (cadmium, lead and arsenic) levels of bee pollen in Turkey. Food Science and Technology. 2017;37:136-141.
47. Rao P, Thomas T, Hasan A, David A. Determination of Heavy Metals Contamination in Soil and Vegetable Samples from Jagdalpur, Chhattisgarh State, India. Int. J. Curr. Microbiol. App. Sci. 2017;6(8):2909-2914.
48. Paul SH, Usman AA, Gana IN, Manase A, Adeniyi OD, Olutoye MA. Comparative study of mineral and nutritional composition of a multifunctional flora composite formulated from seven medicinal plants and their applications to human health. Engineering Technology. Open Access Journal. 2018;1(5):1-13.
49. Aldgini HM, Al-Abbadi AA, Abu-Nameh ES, Alghazeer RO. Determination of metals as bio indicators in some selected bee pollen samples from Jordan. Saudi Journal of Biological Sciences. 2019;26(7):1418-1422.
50. Porrini CA, Sabatini S, Girotti S, Ghini P, Medrzycki A, Grillenzoni F. Honey bees and bee products as monitors of the environmental contamination. Apiacta. 2003;38:63-70.