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Assessment of Nitrate (NO_3^-) Levels and some Heavy Metals in Different Vegetables Available in Navsari Market

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Abstract Nitrate levels in food are very low (generally well below 10 ppm) and rarely exceed 100 ppm. Exceptions to this are vegetables that have been damaged, poorly stored or stored for extended periods, as well as pickled or fermented vegetables. The use of nitrogen (N)-fertilizer in agriculture has significantly increased over the past 30 years to meet the food and living requirements of the speedily growing population. Therefore, the use of nitrate in fertilizers causes a foremost predicament in ground water contamination.

Keywords Nitrate, Heavy metals, Vegetables, Navsari.

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Introduction

Pollution issue has a great effect on all life aspects and causes great threat to animals, plants, environment and human health. It was estimated that 80% of human cancers associated with carcinogens comes from food, water and air. The nitrate (NO_3^-) ions present in consumables or eatables; have been found to have carcinogenic effect on living beings. NO_3^- is a normal component of plant products. The acceptable dialy intake (ADI) of NO_3^- set by European commission's scientific committee for food (ECSCF) is 3.7 ppm body weight [1]. The higher concentration of this ion has been found to exert an adverse effect on living beings like methemoheamoglobinemia or bluebaby syndromes. Alternatively, a compound having high nitrates reacts in stomach to form N-nitroso compound having carcinogenic effects [2]. The nitrogenous fertilizers are the major sources of NO_3^- in the eatables. Many times the farmers use higher amounts of fertilizers either due to their ignorance or they want to increase production quickly when the prices of these products in markets are high. Plants cannot utilize all the added nitrogen, the excessive amounts might be leached down by irrigation water through the soil to reach ground water or it may dissolve in runoff water and flows into streams or lakes and rivers. Nitrogenous compounds also accumulate in plant tissues such as roots, tubers, leaves, stems and fruits or even in seeds [2]. Human dietary NO_3^- exposure should be controlled as they may be a health risk factor. Heavy metal contamination of vegetables

Table 1. Nitrate content (ppm fw) in vegetables in different months collected from Navsari market.

Months	Spinach (*Spinacia oleracea*)	Beetroot (*Beta vulgaris*)	Ivy gourd (*Coccinia grandis*	Indian bean (*Phaseolus vulgaris*)	Cabbage (*Brassica oleracea*)
Sep-13	86.15	137.71	39.15	63.01	40.79
Oct	77.41	126.95	74.20	66.47	38.21
Nov	90.90	118.13	40.43	71.43	40.39
Dec	92.08	117.58	43.78	74.43	41.85
Jan-14	88.71	90.08	55.86	79.17	45.06
Feb	80.35	82.50	62.84	85.22	49.02
Mar	82.11	59.94	36.56	52.83	44.27
Apr	70.37	87.35	68.68	55.97	39.55
May	60.08	88.98	33.97	61.17	32.55
Jun	63.61	99.72	35.59	75.29	51.23
Jul	69.00	89.90	31.95	55.69	42.71
Aug	86.51	87.38	37.82	33.22	55.53
Sep	68.58	85.67	109.69	49.09	68.90
Mean	78.14	97.84	51.58	63.31	45.39
SEm ± Month			0.17		
SEm ± Vegetable			0.10		
SEm ± Vegetable* month			0.39		
CD @ 5% Month			0.49		
CD @ 5% Vegetable			0.30		
CD @ 5% Vegetable* month			1.10		
CV %			2.04		

Table 2. Effect of storage and cooking on nitrate content (ppm fw) of different vegetables in different months collected from Navsari market.

Months	Spinach (*Spinacia oleracea*)	Beetroot (*Beta vulgaris*)	Ivy gourd (*Coccinia grandis*	Indian bean (*Phaseolus vulgaris*)	Cabbage (*Brassica oleracea*)
Fresh	100.14	121.05	67.54	73.86	55.28
Room Temp	87.64	105.34	52.12	66.94	49.76
Fridge	94.11	111.69	56.67	70.00	51.26
Boil	30.68	53.27	29.98	42.42	25.28
SEm			0.21		
CD @ 5%			0.60		
CV %			2.04		

cannot be under estimated as these food stuffs are important components of human diet. Vegetables are rich sources of vitamins, minerals and fibers and also have beneficial antioxidative effects. However, intake of heavy metal-contaminated vegetables may pose a risk to the human health. Heavy metal contamination of the food items is one of the most important aspects of food quality assurance [3—5]. This work is a survey type to find out the status of NO_3^- and heavy metals in most common vegetables available in the local market. This study will generate information to guide extension specialist, farmers and consumers about the risk of nitrate accumulation in vegetables.

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Materials and Methods

The assessment of nitrate levels and some heavy metals in different vegetables available in Navsari market, district of Gujarat, India. The experiment was conducted for a period from September 2013 to September 2014 at Central Instrumentation Laboratory, Department of Soil Science and Agricultural Chemistry, Navsari Agricultural University, Navsari, AES-I of South Gujarat heavy rainfall zone. Vegetables observed in this experiment were root, stem, leafy and other vegetables viz. spinach (*Spinaciaoleracea*), beetroot (*Beta vulgaris*), little gourd (*Coccinia-grandis*), Indian bean (*Lablab purpureus*) and cabbage (*Brassica oleracea*). Vegetables were purchased from local market. Each type of vegetable was bought from five different vendors at random. After sampling each vegetable was rinsed with water to remove any soil or wind borne particles that may have been present on the vegetables. From the fresh vegetables, sub-samples were taken to study the effects of storage and cooking on nitrate-N concentration. For storage effect the vegetable sub-samples were stored in refrigerator and under room temperature for three days, while for cooking effect the vegetables were boiled separately for 10 min until cooked. After boiling all samples were drained on absorbent paper. The micronutrient (Fe, Mn, Zn and Cu) and toxic heavy metal content (Cr, Ni, Pb and Cd) was determined only from the fresh vegetables (un-stored and un-cooled) after

Table 3. Maximum allowable limit of heavy metal in vegetables established by standard regulatory bodies of (Food safety and standards authority of India) and (World health organization, WHO).

Elements	Limits (ppm)
Lead (Pb)	2.5
Zinc (Zn)	50
Copper (Cu)	30
Cadmium (Cd)	1.5
Chromium (Cr)	2.5
Iron (Fe)	425
Manganese (Mn)	500
Nickel (Ni)	67

wet digestion of the powdered samples. These samples were analyzed by atomic absorption spectrophotometer [6]. The alkaline extraction method was used to extract the NO_3^- from fresh, stored and cooked vegetables, the potentiometric determination of NO_3^- content in the sample was done by ion analyzer following EPA method 9210 A, with an ion selective electrode. All chemicals were analytical grade and the water was deionized prior to distillation. Allassays were carried out in triplicate. The results were expressed as mean values. Experimental results were subjected to univariate analysis of variance (ANOVA).

Results and Discussion

Among the five analyzed vegetables (spinach, beet root, ivy gourd, Indian bean and cabbage), the lowest nitrate level was determined in cabbage (45.39 ppm) and the highest in beetroot (97.84 ppm) followed by spinach (78.14 ppm) (Table 1). The accumulation of large amounts of nitrate in beetroot and spinach may be due to their low nitrate reductanse activity (NRA).

Nitrate concentration of spinach (*Spinaciao leracea*) leaves

The nitrate concentration of spinach leaves procured every month from September 2013 to September 2014 are summarized in Table 1 and from the data in the table, we found that the average nitrate concentration was in the range from 60.08 to 92.08 ppm respectively. The maximum nitrate concentration of 92.08 ppm was found to be in the sample pro-cured in the month of December, 2013 followed by the sample pro-

Table 4. Micronutrient content (ppm fw) in vegetables in different months collected from Navsari market.

Vegetables			Fe					Mn		
Months	S	B	G	I	C	S	B	G	I	C
Sep-13	12.93	2.13	1.33	1.66	3.23	1.89	0.40	0.52	0.38	0.46
Oct	11.82	2.91	1.15	1.88	3.03	3.49	2.14	1.97	1.23	1.20
Nov	4.35	1.77	1.71	2.52	6.27	1.56	1.31	1.19	1.87	1.03
Dec	6.08	4.39	3.58	2.32	6.29	1.72	0.54	0.21	0.39	0.29
Jan-14	2.21	9.97	3.19	3.61	2.13	0.50	0.54	0.06	0.37	0.28
Feb	2.08	1.55	1.26	1.33	0.33	2.39	0.63	0.19	0.13	0.06
Mar	22.70	1.61	1.17	1.12	0.20	2.03	1.04	0.39	0.76	0.65
Apr	8.01	3.25	2.22	1.81	1.28	1.20	0.35	0.027	0.03	0.17
May	5.32	2.61	2.09	1.91	1.32	5.32	2.61	2.09	1.92	1.32
Jun	12.37	1.15	2.04	1.43	0.81	1.02	0.26	0.21	0.31	0.29
Jul	11.27	1.25	1.39	2.11	0.55	0.55	0.57	0.30	0.32	0.45
Aug	8.06	3.30	2.27	1.86	1.33	1.24	0.39	0.06	0.07	0.21
Sep	5.60	2.52	2.30	1.89	1.37	1.24	0.057	0.08	0.08	0.22
Mean	8.68	2.95	1.98	1.95	2.16	1.73	0.84	0.56	0.55	0.50
SEm ± M	0.31					0.01				
SEm ± V	0.19					0.07				
SEm ± V*M	0.71					0.02				
CD @ 5% M	0.88					3.21				
CD @ 5% V	0.55					2.00				
CD @ 5% V*M	1.96					7.20				
CV %	34.35					5.31				

Table 4. Continued.

Vegetables			Zn					Cu		
Months	S	B	G	I	C	S	B	G	I	C
Sep-13	0.34	0.29	0.32	0.42	0.20	0.16	0.17	0.16	0.15	0.16
Oct	0.63	0.63	0.68	0.68	1.15	0.29	0.25	0.22	0.30	0.20
Nov	0.43	0.18	0.30	0.47	0.25	0.25	0.37	0.26	0.34	0.26
Dec	0.58	0.20	0.35	0.35	0.35	0.20	0.14	0.14	0.25	0.13
Jan-14	0.66	0.85	0.10	0.50	0.14	0.30	0.29	0.25	0.33	0.30
Feb	0.36	0.14	0.26	0.33	0.19	0.13	0.12	0.08	0.14	0.31
Mar	0.43	0.14	0.26	0.48	0.21	0.21	0.19	0.18	0.27	0.24
Apr	0.54	0.09	0.26	0.24	0.24	0.24	0.20	0.23	0.38	0.30
May	0.55	0.11	0.28	0.30	0.27	0.25	0.21	0.20	0.40	0.30
Jun	0.59	0.19	0.36	0.47	0.44	0.47	0.19	0.21	0.32	0.21
Jul	0.37	0.17	0.38	0.46	0.37	0.16	0.28	0.37	0.52	0.57
Aug	0.58	0.14	0.31	0.29	0.29	0.29	0.24	0.27	0.43	0.34
Sep	0.22	0.35	0.34	0.32	0.32	1.25	0.44	0.43	0.59	0.51
Mean	0.48	0.27	0.32	0.40	0.34	0.32	0.24	0.23	0.35	0.30
SEm ± M	0.03					0.01				
SEm ± V	0.02					0.01				
SEm ± V*M	0.08					0.04				
CD @ 5% M	0.10					5.25				
CD @ 5% V	6.33					3.25				
CD @ 5% V*M	0.22					0.11				
CV %	38.80					25.47				

cured in month of November, 2013 at 90.90 ppm and in January, 2014 at 88.71 ppm. The minimum nitrate concentration of 60.08 ppm was found to be in the sample procured from in the month of May, 2014. The nitrate content of the sample procured in the month of December, 2013 showed an increase of 53.26% over the sample of summer month. It may be due to a complex interaction between the growing seasons, production method and location inrelation to the amount of sunlight. In low light intensity and low temperature condition, the accumulated nitrate is not rapidly reduced as in other places with high temperature and bright sunshine [7]. Nitrate consumption through vegetables can is kept low by harvesting them at the proper time.

Nitrate concentration in beet root (*Beta vulgaris*)

Nitrate concentrations in beet root procured in different months are summarized in Table 1. The nitrate content ranged from 59.94 to 137.71 ppm fresh weight of the sample. In this study, the average nitrate content of beet root was found to be highest in the month of September 2013 with a value of 137.71 ppm which was followed by the month of October 2013 at 126.95 ppm. The average nitrate content of 59.94 ppm was found to be the minimum in the month of March, 2014.

Nitrate concentration in ivy gourd (*Coccinia grandis*)

The data presented in Table 1 showed the average nitrate concentrations in the range of 31.95 to 109.69 ppm. Among the different months of collection, the maximum recorded average nitrate concentration of 109.69 ppm originated from the sample procured from in the month of September 2014. This was then followed by the month of October 2013 at 74.20 ppm. The minimum average nitrate concentration of 31.95 ppm was found to be in the sample procured in July, 2014.

Nitrate concentration in bean (*Phasealus vulgaris*)

The nitrate concentration of bean procured every month from September 2013 to September 2014 are summarized in Table 1 and from the data in the table, we found that the average nitrate concentration was

in the range from 33.22 to 79.17 ppm respectively. The maximum nitrate concentration of 79.17 ppm was found to be in the sample pro-cured in the month of January, 2014 followed by the sample procured in month of June, 2013 at 75.29 ppm. The minimum nitrate concentration of 33.22 ppm was found to be in the sample procured from in the month of August, 2014.

Nitrate concentration in cabbage (*Brassica oleracea*)

Nitrate concentration in cabbage procured in different months are summarized in Table 1. The nitrate content ranged from 32.55 to 68.90 ppm fresh weight of the sample. In this study, the average nitrate content of cabbage was found to be highest in the months of September 2014 with a value of 68.90 ppm which was followed by the month of August 2014 at 55.53 ppm. The average nitrate content of 32.55 ppm was found to be the minimum in the month of May, 2014. It was observed from the data that samples collected in winter showed higher nitrate content as compared to the summer. This may be due to low activity of enzyme nitrate reductase in winter season. However, in all the months, the nitrate content in any vegetable sample did not cross the ADI limit of 3.65 ppm body wt per day set by the scientific committee for food (SCF).

The influence of food processing on nitrate levels in vegetables

Nitrate contents in fresh vegetables, vegetables stored at room temperature and in the refrigerator and cooked vegetables were shown in Table2. Storage conditions does not significantly affect the nitrate content but boiling reduces nitrate content since nitrate-N is soluble and predisposed to readily leach into the cooking liquids. The highest nitrate-N loss after boiling was found for spinach (69.36%), followed by beet root (55.99%), ivy gourd (55.61%), cabbage (54.27%) and bean (42.57%). Moreover, by cooking vegetables in water (with low nitrate concentration), at least 50% of accumulated nitrate can be removed. Since ascorbic acid and tocopherols inhibit the formation of N-nitrocompounds, an increase in the content of these vitamins and a reduction in nitrate content can attach added value to vegetable products (already rich in carotenoids, selenium, dietary fiber, plant sterols, glucosinolates and indoles, isothiocyanates, flavonoids, phenols) reported [8].

Heavy metal content in vegetables

The mean concentrations of heavy metals in various vegetable species collected from the study area were compared with the standard set for vegetables [9]. Maximum allowable limit of heavy metal in vegetables established by standard regulatory bodies are represented in Table 3.

The mean levels of Fe observed in different vegetable were shown in Table 4. The iron content of spinach was found to range between 2.21–22.70 ppm in January 2014 and March 2014 respectively. The mean Fe content of beet root ranged between 1.15–9.97 ppm, in the June 2014 and January 2014 respectively, Fe content in ivy gourd was found to mean range between 1.15–3.58 ppm in October 2013 and December 2013 respectively. However, the Fe content in bean was found mean range between 1.12–3.61 ppm in March 2014 and January 2014 respectively, while in cabbage the Fe content was mean ranged between 0.20–6.29 ppm in March 2014 and December 2014 respectively. On other hand the amounts of Fe in the leafy vegetables were higher as compared to those in the other investigated vegetables especially the reasonable explanation of this situation that the Fe uptake can be promoted and accumulated in the leaves as a result of leaves are considered food making factories in plants. Our results were much higher than different samples of vegetables and reported a high concentration (7.9–24.8 ppm) of Pakistan [10]. The mean levels of Mn observed in different vegetable were shown in Table 4. The Mn content of spinach was found to be range between 0.50–5.32 ppm in January 2014 and May 2014 respectively. The mean Mn content of beet root ranged between 0.057–2.61 ppm, in the September 2014 and May 2014 respectively, Mn content in ivy gourd was found to mean range between 0.027–2.09 ppm April 2014 and May 2014 respectively, However, the Mn content in bean was found to be mean ranged between 0.03–1.92 ppm in April 2014 and May 2014 respectively,

while in cabbage the Mn content was mean ranged between 0.06–1.32 ppm in February 2014 and May 2014 respectively.

The mean levels of Zn observed in different vegetables were shown in Table 4. The Zn content of spinach was found to range between 0.22–0.66 ppm in September 2014 and January 2014 respectively. The mean Zn content of beet root ranged between 0.09–0.85 ppm, in the April 2014 and January 2014 respectively, Zn content in ivy gourd was found to mean range between 0.10–0.68 ppm in January 2014 and October 2013 respectively. However the Zn content in bean was found to be mean ranged between 0.24–0.64 ppm in April 2014 and October 2013 respectively, while in cabbage the Zn content was mean ranged between 0.14–1.15 ppm in January 2014 and October 2013 respectively. The mean levels of Cu observed in different vegetable were shown in Table 4. The Cu content of spinach was found to range between 0.13–1.25 ppm in January 2014 and September 2014 respectively. The mean Cu content of beet root ranged between 0.12–0.44 ppm, in the February 2014 and September 2014 respectively, Cu content in ivy gourd was found to mean range between 0.08–0.43 ppm in February 2014 and September 2014 respectively. However the Cu content in bean was found to be mean ranged between 0.14–0.59 ppm in February 2014 and September 2014 respectively, while in cabbage the Cu content was mean ranged between 0.13–0.57 ppm in December 2013 and July 2014 respectively. Concentration of Cu (2.25–5.42 ppm) in vegetables grown in wastewater areas of Varanasi, India to be within the safe limit [11].

The mean levels of Cr and Ni content observed in different vegetables were shown in Table 5. The Cr content of spinach was found to range between 0.06–3.0 ppm in September 2014 and March 2014 respectively. The mean Cr content of beet root ranged between 0.27–2.30 ppm, in the February 2014 and September 2014 respectively, Cr content in ivy gourd was found to mean range between 0.18–2.10 ppm in September 2013 and September 2014 respectively. However the Cr content in bean was found to be mean ranged between 0.35–2.53 ppm in February 2014 and March 2014 respectively, while in cabbage the Cr content was mean ranged between 0.11–2.45 ppm in Feb-

Table 5. Heavy metals content (ppm fw) in vegetables in different months collected from Navsari market. M: Month, V: Vegetable, S: Spinach (*Spinaciaoleracea*), B: Beetroot (*Beta vulgaris*), G: Ivy gourd, (*Cocciniagrandis*), I: Indian bean (*Phaseolus vulgaris*), C: Cabbage (*Brassica oleracea*), ND: Not detected.

Vegetables			Cr					Ni		
Months	S	B	G	I	C	S	B	G	I	C
Sep-13	0.73	0.67	0.18	0.7	0.74	0.72	0.17	0.36	0.58	0.36
Oct	0.99	1.45	0.86	1.57	1.64	0.28	0.29	0.23	0.26	0.08
Nov	0.51	0.89	0.57	0.68	0.36	0.41	1.00	0.53	0.50	0.43
Dec	0.55	1.61	1.06	1.73	1.79	N.D	N.D	N.D	N.D	N.D
Jan-14	1.33	1.28	1.17	1.49	1.33	N.D	N.D	N.D	N.D	N.D
Feb	0.37	0.27	0.18	0.35	0.11	0.26	0.23	0.24	0.31	0.11
Mar	3.00	2.16	2.04	2.53	2.45	N.D	N.D	N.D	N.D	N.D
Apr	2.18	1.77	2.01	2.02	2.07	N.D	N.D	N.D	N.D	N.D
May	1.69	1.52	1.61	1.46	1.05	N.D	N.D	N.D	N.D	N.D
Jun	1.06	0.60	0.71	0.74	1.13	0.37	0.12	0.01	0.20	0.17
Jul	1.02	0.56	0.64	0.71	1.08	0.03	0.05	0.02	0.03	0.02
Aug	2.24	1.83	2.06	2.07	2.13	N.D	N.D	N.D	N.D	N.D
Sep	0.06	2.30	2.10	2.11	2.17	N.D	N.D	N.D	N.D	N.D
Mean	1.21	1.30	1.16	1.39	1.38	0.15	0.15	0.10	0.14	0.09
SEm ± M	0.004					0.01				
SEm ± V	0.002					0.01				
SEm ± V*M	0.009					0.04				
CD @ 5% M	1.21					5.33				
CD @ 5% V	7.55					3.30				
CD @ 5% V*M	2.72					0.11				
CV %	1.30					57.5				

Table 5. Continued.

Vegetables			Pb					Cd		
Months	S	B	G	I	C	S	B	G	I	C
Sep-13	1.86	1.84	1.43	1.51	0.49	0.10	0.12	0.14	0.18	0.15
Oct	1.96	1.29	1.27	1.68	1.06	0.10	0.10	0.13	0.11	1.09
Nov	0.54	1.71	1.14	1.56	0.51	0.11	0.06	0.02	0.02	0.05
Dec	0.93	1.28	0.82	1.51	0.96	N.D	N.D	N.D	N.D	N.D
Jan-14	1.68	1.88	1.99	1.54	2.04	N.D	N.D	N.D	N.D	N.D
Feb	1.29	0.65	1.18	1.21	1.27	N.D	N.D	N.D	N.D	N.D
Mar	1.37	0.49	1.3	1.21	1.70	N.D	N.D	N.D	N.D	N.D
Apr	0.02	0.02	0.03	0.02	0.02	N.D	N.D	N.D	N.D	N.D
May	0.30	0.15	0.17	0.22	0.09	N.D	N.D	N.D	N.D	N.D
Jun	0.34	N.D	N.D	N.D	N.D	0.50	0.17	0.07	0.23	0.27
Jul	N.D	N.D	N.D	N.D	N.D	0.18	0.14	0.03	0.15	0.22
Aug	0.07	0.07	0.07	0.06	0.06	0.04	0.04	0.04	0.04	0.04
Sep	0.23	0.07	0.08	0.08	0.07	0.04	0.03	0.04	0.05	0.05
Mean	0.79	0.72	0.71	0.81	0.60	0.08	0.05	0.03	0.06	0.14
SEm ± M	0.01					0.015				
SEm ± V	0.01					0.009				
SEm ± V*M	0.04					0.033				
CD @ 5% M	0.05					0.42				
CD @ 5% V	3.36					0.26				
CD @ 5% V*M	0.12					0.94				
CV %	10.30					76.89				

ruary 2014 and March 2014 respectively. The Ni content of spinach was found to be ranged between 0.03–0.72 ppm in July 2014 and September 2014. The Ni was not detected in the month of December 2013, January 2014, March-May 2014 and August-September-2014. The present concentration of metals was compared with permissible limits given by FAO/WHO. Cr is nonessential metals causing advarse health effects even at very low concentrations. Investigation of high doses of chromium can cause irregular heartbeat, stomach distress, itching and flushing in human. In addition chromium can cause ulceration, liver and kidney damage [12, 13].

The mean levels of Pb observed in different vegetables were shown in Table 5. The Pb content of spinach was found to be ranged between 0.02–1.96 ppm in April 2014 and October 2013. The Pb was not detected in the month of July 2014 but in June 2014 in spinach was found 0.34 ppm. The mean levels of Cd observed in different vegetables were shown in Table 5. The Cd content of spinach was found to be ranged between 0.04–0.11 ppm in August 2014 and June 2014. The Cd was not detected in the month of December 2013 to May 2014. Found higher than the maximum permissible levels of Cd and Pb concentrations in vegetables collected from six sampling sites around Dabaoshan mine located at Shaoguan city, Guangdong, Southern China [14].

The results indicate that, spinach absorbed and accumulated the Fe, Mn, Zn and Cu metal better than any of the other vegetables in the study. The higher levels of heavy metal contamination found in some vegetables could be closely related to the pollutants in irrigation water, farm soil and pesticides or alternatively could be due to pollution from traffic on the highways.

Conclusion

In conclusion, the results reported here confirm that the average nitrate content of beet root (97.84 ppm) to be maximum followed by spinach (78.14 ppm). It was also observed from the data that samples collected in winter showed higher nitrate content as compared to the summer. However, in all the months, the nitrate content in any vegetable sample did not cross

the ADI limit of 3.65 ppm body wt day^{-1} set by the scientific committee for food (SCF). No significant change was found in nitrate content in vegetable due to storage conditions however, boiling reduces nitrate content in vegetables significantly. The highest nitrate-N loss after boiling was found highest for spinach followed by beet root. The levels of nitrate found in vegetables in this study were unlikely to pose any health risk to the general population. Maintain a balanced diet including leafy vegetables, *brassica* vegetables, root and tuber vegetables, fruiting vegetables, legume vegetables. Vegetables are handle and cook properly (i.e. keep vegetables under refrigeration if they are not being cooked immediately; cook vegetables soon after chopping or mashing; wash, peel, vegetables; blanch high-nitrate vegetables in water and discard the cooking water before consumption). The result confirmed that vegetables under study content heavy metal content within safe limit preseribed by the FASSI and WHO. This is important result as human health is directly affected by ingestion of vegetables. The magnitude of heavy metals detected in different kinds of vegetables was arranged as Fe >Mn>Zn>Cu>Cr>Ni>Pb>Cd.

References

1. FAO/WHO (2001) Food additives and contaminants, Joint Codex Alimentarius Commission, FAO/WHO. Food Standards Program, ALINORM 01/12A.
2. Savci S (2012) An agricultural pollutant: Chemical fertilizer. Int J Environ Sci Develop 3 : 77—80.
3. Marshall (2004) Enhancing food chain integrity: Quality assurance mechanism for air pollution impacts on fruits and vegetables systems. Crop Post Harvest Program, Final Tech Rep (R7530).<http://www.sussex.ac.uk/spru/1-4-7-1-11-1.html>
4. Radwan MA, Salama AK (2006) Market basket survey for some heavy metals in Egyptian fruits and vegetables. Food and Chem Toxicol 44 : 1273—1278.
5. Khan S, Cao Q, Zheng YM, Huang YZ, Zhu YU (2008) Health risk of heavy metals in contaminated soils and food crops irrigated with waste water in Beijing, China. Environm Poll 152 : 686—692.
6. Elwell WT, Gridley JAF (1967) Atomic absorption spectrophotometery, Pergamon. Press Ltd, London, W-1.
7. Jana JC, Moktan P (2013) Nitrate concentration of leafy vegetables: A survey of nitrite concentrations in retail fresh leafy vegetables from daily markets of different locations. J Food and Agric Sci 3 : 1—5.
8. Santamaria P (2006) Nitrate in vegetables: Toxicity, content, intake and EC regulation. J Sci Food Agric 86 : 10—17.
9. WHO (World Health Organization) (1994) Quality directive of potable water, Geneva, Second edn, pp 197.
10. Zahir E, Naqvi II, Mohi Uddin Sh (2009) Market basket survey of selected metals in fruits from Karachi city (Pakistan). J Basic and Appl Sci 5 : 47—52.
11. Sharma RK, Agrawal M, Marshall FM (2006) Heavy metals contamination in vegetables grown in wastewater irrigated areas of Varanasi, India. Bull Environ Contam and Toxicol 77 : 311—318.
12. Kaur H, Goyal D (2011) Assessing potential risk of heavy metal exposure in green leafy vegetables. Int J Res in Environ Sci and Technol 1 : 43—46.
13. Jarup L (2013) Hazards of heavy metals contamination. Br Med Bull 68 : 167—182.
14. Zhuang P, Zou B, Li NY, Li ZA (2009) Heavy metal contamination in soils and food crops around Dabaoshan mine in Guangdong, China: Implication for human health. Environm Geochem and Hlth 6 : 707—715.