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Heavy Metals in Fruits and Vegetables Grown in Kuwait During the Oil Well Fires

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ABSTRACT. The exploding and burning of Kuwait's oil fields resulted in significant environmental pollution. To assess the impact of this pollution on locally grown food, samples of fruits and vegetables were collected from local fields and home gardens 6-7 months after the start of the oil well fires. These foods were analyzed for their inorganic pollutant content (Ni, V, Pb, Cd) either by an atomic absorption spectrophotometer with a graphite furnace or by the cold vapor technique (Hg). Results showed that toxic metals were detected in a number of samples, but contamination did not exceed the maximum permissible concentration of metals in fresh fruits and vegetables as recommended by the FAO/WHO except for higher Hg, Cd, and Pb levels in the tissues of a few fruit and vegetable samples.

Kuwait has experienced the worst man-made environmental catastrophe in history. The burning of Kuwait's oil wells by the retreating Iraqi army caused serious environmental pollution. The widespread atmospheric pollution has raised great public concern, particularly as regards inhalation of the polluted air and consumption of contaminated foods.

The objectives of this study were to investigate the levels of certain inorganic pollutants, *i.e.*, heavy and/or trace elements, in the tissues of various locally grown fruits and vegetables, commonly consumed in Kuwait. No published data on the levels of the same pollutants prior to the oil well fires were available for comparison.

Experimental

A) Materials: Locally-grown fruit and vegetable samples were collected from local farms (Wafra and Jahra) as well as from home gardens from different areas at different distances from Kuwait City, including the following: area I, 2 km (south east) from Kuwait City; area II, 4 km (south west); area III, 7.5 km (south); area IV 9 km (south east); area V, 13 km (south east); area VI, 32 km (north west); area VII, 39 km (south east); and area VIII 111 km (south). Sample collection was conducted during September and October 1991. The commodities sampled included dates (*Phoenix canariensis*), sweet basil (*Ocimum basilicum*), purslane (*Portulaca oleracea*), white radishes (*Raphanus sativas*), and garden rocket (*Eruca sativa*). These were usually eaten unpeeled and were commonly consumed by the population. The amounts of the samples varied for the different products: usually three pieces of each for dates, and three bundles of each for sweet basil, purslane, white radishes and garden rocket. The number of samples collected included 9 date samples, 3 sweet basil, 2 purslane, 3 white radish and 4 garden rocket.

B) Sample Handling: Samples collected were kept in plastic bags and frozen for further analyses.

C) Sample Preparation: Samples were prepared for the determination of heavy metals in the tissues in the following manner. Some 3-5g of the fruit or vegetable sample were placed in a 100 cm^3 round-bottomed flask connected to a reflux condenser. Then, 10 cm^3 of concentrated nitric acid was added to the sample and heated. Hydrogen peroxide (0.5-1.0 cm^3) was periodically added to the solution until the digestion of the sample was complete, *i.e.*, a clear solution was reached (2.0-2.5 cm^3 of hydrogen peroxide was usually sufficient). The solution was transferred into a 50 cm^3 volumetric flask and made up to 50 cm^3 with distilled water. The solution was analyzed for heavy metals.

i) Atomic Absorption Spectrophotometer Analysis

A Perkin Elmer Model 3030 atomic absorption spectrophotometer with a graphite furnace was used for the analysis of cadmium (Cd), lead (Pb), nickel (Ni) and vanadium (V) in the prepared samples. The levels of Cd, Pb, Ni and V were determined according to Clesceri *et al.* (1989).

ii) Cold Vapor Technique

Mercury (Hg) analysis was conducted using the cold vapor technique. The level of Hg was determined according to Clesceri *et al.* (1989).

iii) Quality Assurance/Quality Control

General quality control measures established in laboratories for measuring certain heavy and/or trace elements (Ni, V, Hg, Pb, Cd) were followed. The reliability of the results was justified by using the standard addition technique, *i.e.,* analyzing two different levels after spiking the fruit and vegetable tissues with the different pollutants; the fruit and vegetable samples having low concentrations of the different metals were used as the sample matrix. For each spiking level of heavy and/or trace element as well as for the unspiked sample, analysis was carried out in five aliquots. In the case of Hg, the coefficient of variation was 11.8% at the 0.5-1.0 μg/kg level, but it was between 1.7 and 3.0% in the concentration levels of 3.0 and 11.0 μg/kg respectively. Cd was determined with a coefficient of variation between 2.0 and 3.0% in each concentration in the range 2.5-15.0 μg/kg. In the case of Pb, the coefficient of variation was 9.4% at the 100 μg/kg level, but 1.5 to 4.4% when the concentration was between 200 and 700 μg/kg. The coefficient of variation was below 2.0% in the case of Ni above 100 μg/kg, and between 6.0 to 8.0% in the case of V in the range 50 to 300 μg/kg.

Results and Discussion

The Contents of Hg, Cd, Pb, Ni and V in the tissues of different kinds of locally grown fruits and vegetables are presented in Table 1. These values should be compared with the maximum permissible concentration of 10, 30, 200 and 300 μg/kg for Hg, Cd and Pb, respectively as recommended by the Codex Alimentarius Commission (FAO/WHO 1984).

As shown in Table 1, the highest mean level of Hg is found in dates (30.08 μg/kg). The highest individual Hg level was detected in a date sample collected from area II (230 μg/kg). Eventually, these Hg levels exceeded the maximum permissible concentration of Hg in fresh fruits and vegetables, *i.e.,* 10 μg/kg (FAO/WHO 1984). For Cd, the maximum permissible concentration of 30 μg/kg (FAO/WHO 1984) in fresh fruits and vegetables was not exceeded in any of the fruits and vegetables investigated, except for dates (39 μg/kg, area V). Since Hg and Cd do not occur in significant levels in crude oil, it is probable that the higher levels of Hg and Cd observed were not caused by the pollutants emitted from the burning oil wells, but rather from other possible sources of contamination such as cadmium – containing phosphate fertilizers or from the practice of growing these fruits and vegetables on soil amended with sewage sludge. Other investigators (Ellen *et al.* 1989) reported relatively high values of Cd and Hg concentrations in red currants and avocados in the Netherlands (46 and 21 μg/kg respectively). Moreover, Treptow and Bielig (1978) also reported high Cd concentrations in chives, spinach and parsley of 82, 69 and 58 μg/kg respectively; this was attributed to the fact that certain vegetable species tend to accumulate higher Cd levels than those that existed in the soil as a result of environmental contamination.

Table 1. Contents of Hg, Cd, Pb, Ni and V in locally grown fruit and vegetable samples collected from different areas in Kuwait

		Date	**Sweet basil**	**Purslane**	**White radish**	**Garden rocket**
N		9	3	2	3	4
Mercury (μg/kg)	Mean	30.08	11.49	8.50	2.74	6.98
	Range	ND-230	5.21-25.50	4.90-12.10	0.92-5.71	5.44-8.24
Cadmium (μg/kg)	Mean	16.89	10.91	17.25	11.70	19.75
	Range	5.68-39.30	5.49-18.50	16.70-17.80	9-15.40	11.30-26.30
Lead (μg/kg)	Mean	104.27	198.50	125	176.70	140.63
	Range	22.50-330	45.50-417	112-138	26.10-391	49.50-310
Nickel (μg/kg)	Mean	100.26	328.33	188.40	235.33	352.50
	Range	24.50-202	282-401	83.80-293	125-352	139-470
Vanadium (μg/kg)	Mean	16.84	157.47	96.90	172.60	242
	Range	ND-31.60	20.40-255	42.80-151	29.80-343	131-422

N = Number of samples.
ND = Not detectable.
Mean = Mean of all data for each particular crop collected from all sites sampled.

The maximum permissible concentrations of 200 and 300 μg/kg of Pb in fresh fruits and vegetables as recommended by the Codex Alimentarius Commission (FAO/WHO 1984) were not exceeded in the samples analyzed, except for the following individual values recorded: area VI, sweet basil 417 μg/kg and dates 330 μg/kg; and area VIII, white radish 391 μg/kg and garden rocket 310 μg/kg. Since Pb is usually released after gasoline combustion from car exhaust into the environment and given that certain foods such as mint, parsley and kale, that have a high area-to-mass ratio, may accumulate elevated concentrations of Pb as a result of atmospheric deposition, then these elevated individual Pb concentrations recorded in area VI and VIII could be attributed to Pb deposition, especially as these two areas are located adjacent to major roads. Similar findings were also reported by Scanlon (1987), where the overall lead concentrations in vegetation grown near major highways in the US varied from 286 μg/g 6 m from highway 95 to < 10 μg/g in control samples that were collected from areas located at distances of more than 400 m from the same highway. Likewise, the heavy metal contamination of produce from market gardens in the vicinity of airfields and roads during three seasons were investigated by Schmid *et al.* (1976). Mn, Cu, Zn, Pb, Cd and Cr concentrations were determined in root, leaf, fruit and bulb (onion-type) vegetables at distances of 10-100 m from roads. Data showed that leafy vegetables were the main group affected. While air traffic increased the toxic metal content, a mean increase of 11.5% Pb was observed between 100 and 10 m from roads. Cd, Zn, Mn and Cu concentrations were not affected.

The maximum mean Ni and V concentrations were recorded for garden rocket samples collected from area VIII (352.50 μg/kg and 242 μg/kg respectively). The highest individual levels of Ni and V were recorded for garden rocket collected from area VIII (470 μg/kg and 422 μg/kg respectively). Since no maximum permissible concentrations for Ni and V in fresh fruits and vegetables have been established yet, it is expected that the maximum permissible concentration of Pb in fresh fruits and vegetables (FAO/WHO 1984) is probably lower than those for Ni and V. Consequently, the levels of Ni and V detected, although relatively higher than that of Pb, might not constitute a major public health risk. It is worth mentioning that area VIII is surrounded from the north by three oil fields with varying distances namely Wafra (northwest), 10 km; Burgan (northeast), 38 km; and Umqadeir (northwest), 43 km. During the oil well fires, large quantities of smoke originated from these oil fields and moved south to Dhahran and Bahrain with the onset of the northerly (shamal) winds (Sadiq and McCain 1993). Area VIII lay in the path of the smoke cloud, so the elevated levels observed in some vegetable samples collected from this area could have been caused by contaminants emitted from the burning oil wells. In other reports in the literature, Wolf (1990) reported Ni concentrations of 290 to 940 μg/kg in unpolluted lettuce and peppers, respectively, whereas Ershow and Wong-Chen (1990) reported concentrations of 240 to 860 μg/kg in Chinese cabbage.

Based on the results obtained, it can be concluded that the heavy and/or trace metal concentrations in the tissues of fruits and vegetables grown locally during the period 6-7 months after the exploding and burning of the oil wells did not exceed the maximum permissible concentrations of heavy/or trace metals in fresh fruits and vegetables as recommended by the Codex Alimentarius Commission (FAO/WHO 1984), except for higher Hg, Cd, and Pb levels detected in some of the samples investigated. Since mercury, lead and cadmium occur only in trace levels in crude oil, it is probable that such pollutants were not a result of the pollutants from the burning oil wells. Thus, further work is needed to identify the sources of contamination. However, it is of the utmost importance: 1. to further investigate the levels of these pollutants in the locally grown fruits and vegetables cultivated in soils which might have been contaminated by the burning oil well fire fallout; 2. to monitor any uptake of these heavy/trace elements by plants via the soil; 3. to assess if such uptake constitutes a public health concern.

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محتوى الفواكه والخضروات المزروعة في الكويت من المعادن الثقيلة خلال فترة احتراق آبار النفط

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أدى تفجير واحراق آبار النفط في الكويت على أيدي العدو العراقي إلى اصابة البيئة المحلية بدرجة عالية من التلوث . وفي اطار الجهود المبذولة لتقييم أثر هذا التلوث على المحاصيل الزراعية المحلية ، تم جمع عينات من الفواكه والخضروات من المزارع العامة وحدائق المنازل ، وذلك بعد مضي ٦-٧ شهور على احتراق آبار النفط ، حيث جرى بعدها اخضاع هذه العينات إلى سلسلة من التحاليل استهدفت تحديد محتواها من الملوثات اللاعضوية (Ni, V, Pb, Cd) ، وشملت هذه التحاليل التحليل الطيفي للامتصاص الذري بالفرن الغرافيتي وتقنية التحليل بالبخار البارد . وأظهرت النتائج وجود معادن سامة في عدد من العينات ، علما بأن تركيزات هذه المعادن لم تكن لتتجاوز الحدود المسموح بها للمعادن من قبل منظمة الأغذية والزراعة العالمية/ منظمة الصحة العالمية ، باستثناء وجود معادن الزئبق ، والكادميوم والرصاص ، التي وجدت بتركيزات عالية في أنسجة بعض عينات الفواكه والخضار .