

AN ASSESSMENT OF THE EFFECTS OF FUGITIVE DUST AND ASH FROM THE ROAD AND INDUSTRIAL WASTES ON VEGETABLE CROPS PRODUCTION

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ABSTRACT

The aim of this study was to assess the possible effects of dust, ash and chemical pollutant emissions, from the industrial wastes, on vegetable crops production. Samples were collected in two successive seasons, namely winter and spring of 1990 and 1991 from the Agricultural Experimental Farm of Alexandria University (Abiss), and in the opposing direction across Alex.-Cairo high way. The possible physical effects of dust and ash emissions on vegetable crops production are summarized. The most important of these include (1) increased dust accumulation on leaves surfaces, (2) increased heavy metals (Cu, Mn, Zn, Ni, Cr, Pb and Hg) contents of leaves, (3) reduced leaves areas, (4) reduced tubers and roots size, (5) hindered pollination and (6) reduced fruits sizes and seeds number/fruits.

INTRODUCTION

Metals can impact soils and biota by deposition from polluted air. Many studies have been conducted on Stalk emissions of Zn, Cd, Cu, Pb, Ni...etc, (Lagerwerff and Specht, 1970; Adriano et al., 1971; Buchauer, 1973; Beavington, 1975; White, 1976 and Mengel and Kirkby, 1978). Plants may become heavily contaminated by surface particulates. Generally, most metals are deposited

within a few Kilometers of the Stack. Automobile Pb emissions are generally restricted to 30 meters (Polson and Adams, 1970). Metal smelters, foundries steel mills, coal-fired power plants and incinerators are demonstrated air emission sources for Cd,Pb,Zn and Cu.

The trace elements; Copper, Zinc, Manganese ...etc; are essential for plants, for growth and reproduction, at low concentrations in the growing medium. A plant must secure enough of each element for its requirements; but as concentrations in the growing medium approach toxic level, the plant must have a mechanism to avoid the uptake or translocation of toxic amounts to vegetative and reproductive parts of the plant, if it is to survive (Pratt, 1966; Wainwright and Woolhouse, 1975 and Satyanarayana et al., 1988).

Zinc toxicity results in a reductions in root growth and leaf expansion, which is followed by chlorosis (Zarrowska and Gworek, 1988). High levels of Zn in the nutrient medium depress the uptake of pand Fe (Ashton, 1972). The inhibition of root growth is one of the most rapid responses to toxic Cu level (Das, 1988).

Manganese toxicity symptoms are generally characterized by brown spots in older plant organs.

Plants suffering from severe Cr toxicity have small roots and narrow brownrish red leaves, covered with small necrotic spots (Bryce-Smith, 1975).

Lead is a major chemical pollutant of the environment and is highly toxic to people. It inhibits the activity of some important enzymes (Gingell et al., 1976). The major source of Pb pollution aries from Petrol combustion (Polson and Adams, 1970).

The objective of this study is to investigate the chemical distribution of Cu, Zn, Mn,

Ni, Cr, Hg and Pb in leaves of different nine food crops under both rural (Protected place) and urban (Unprotected place) environments.

MATERIALS AND METHODS

Experimental location: Two locations were chosen for this study in the seasons of 1990 and 1991. The first location was at the northern side of Alexandria-Cairo high way. This location is protected by Casuarina trees and it was 360 m far from the high way, at Alexandria Univ. Station Farm of Agriculture. The second location was at the southern side of the Alexandria-Cairo high way and very close to a station of paving mixture preparation. The later location, also, was not protected by any trees from the dust of the high way and the smokes of the paving mixture materials industry, and it was at 2050 m from the first location.

The two soils of these locations were analyzed according to the standard methods of Chapman and Pratt (1961), and the data are presented in Table (1).

Experimental plant materials: Three different groups of vegetable crops were used in this study; (1) Leaf vegetables: Roquette, Celery, Parsley and Cabbage. (2) Tuber vegetables: Radish, Turnip and Potato. (3) Fruit vegetables: Tomato and Peas. Dates of sowing or transplanting and dust recording times for various crops are illustrated in Table (2).

Experimental design: In both experimental locations and in each season, vegetable crops were grown as usual in commercial production. Roquette, Celery and Parsely seeds were sowing in squared area 4 m², using 3 replications. Cabbage seedlings was transplanted in 10 ridges (5 m long and 1 m width), with spacing about 50 cm and using 3 replications. For the second group (Tuber vegetables): Radish and Turnip seeds were

Table 1: The physiochemical properties of soils of the two locations.

Location	Texture	Exchangeable cations (mg/100g)							
		pH	CaCO ₃ %	E.C.M /cm	O.N %	Ca ⁺⁺	g ⁺⁺	K ⁺	Na ⁺
1 st rural (Unpolluted)	Clay-loam	8.22	4.90	2.02	1.40	9.10	14.2	2.50	7.4
2 nd urban (Polluted)	Clay-loam	7.90	5.20	2.40	0.98	10.8	12.1	2.02	9.3

Table 2: Dates of sowing (Plantation) and dust recording times in the different vegetable crops.

Vegetable crops	Sowing (Plantation) time	Dust measurements
Roquette Celery Parsley	Last week of December 1989 and 1990	The 2 nd week of February 1990 and 1991
Cabbage	Transplanting on 2 nd week of October 1989 and 1990	The 3 rd week of February 1990 and 1991
Radish Turnip	Last week of December 1989 and last week of November 1990	Last and first week of February 1990 and 1991, respectively
Potato	The 2 nd week of January 1990 and 1991	The last week of April 1990 and 1991
Tomato	Transplanting on 2 nd week of October 1989 and 1990	The first week of March 1990 and 1991
Peas	The second week of December 1990	February, 20 th of 1991

sowing in 10 ridges (5 m long, 0.7 m width), with 5 cm spacing between plants, using 3 replications. Potatoes tubers-seeds were sown in 8 ridges (5 m long, 0.7 m width) using 4 replications, and its plants were spacing about 20 cm within ridges. For fruiting-vegetables group; Tomato seedlings were transplanted in 5 ridges (5 m long, 1 m width) in 5 replications, with spacing of about 20 cm within rows. Peas seeds were sown in ridges (5 m long, 0.7 m width) with 15 cm spacing, using 3 replications.

The data of dust accumulation, mineral elements concentrations and quality characteristics were recorded and statistically analyzed, using the standard methods of Steel and Torrie (1970).

Dust collection and estimation: Twenty leaves from each treatment were collected, washed with a constant volume of distilled water and the water carrying dust was then collected in glass containers and dried. The weight of dust was calculated to mg/100 cm² leaf area.

Leaf analysis: Leaf samples were oven dried to constant weight at 60-70°C and dried materials were ground to 20 mesh size. Each sample was analyzed for, Copper, Manganese, Zinc, Nickel, Cadmium, Lead and Mercury, using Perkin-Elmer Atomic Absorption Spectrophotometer, Model 305-B. The procedures described by Oien and Gjerdigen (1977) and in paper of Baghdady and Sippola (1984), were followed.

RESULTS AND DISCUSSION

Morphological and physiological differences between the vegetable crops, associated with the differences in the mineral elements contents under rural and urban conditions were measured

This preliminary study showed that urban and rural environments differed significantly in dust accumulation : mg/100 cm² of leaf area. The

dust fell on the leaves was significantly very high for the plants growing near the factory (Table 5). The highest accumulation of dust was on Radish "Balady" (515), then on Potato "Grata" (405) and Tomato (309), respectively; and the lowest accumulation was on Roquette (372 mg/100 cm² LA).

At rural environment, the leaves of all plants of the studied species tended to contain lower concentrations of total heavy metals (Mn, Zn, Cu, Ni, Cr, Pb and Hg) than did those grown under urban environments (Tables 3, 4 and Fig. 1). This result agreed with Czarrowska and Gworek (1988). The total concentrations of heavy metal of leaves were very high in Parsley "Balady" (697.94), and very low in Radish "Balady" (157.92). None of the studied crops accumulated excessive Hg in plant leaves.

Common vegetable species tended to contain high concentration of Pb and Cr under polluted conditions than under normal conditions. The differences were found significant at the 5% level. High Pb, Cr, Mn and Ni levels were detected in Roquette leaves. Furthermore, the Pb and Cr concentrations in the leaves were found to be above the permitted levels. The lowest Pb content was detected in Potato leaves which agreed with the report of Sillanpaa et al. (1988).

The highest amount of Cu was observed in Tomato leaves, whereas, the lowest was in Cabbage leaves. Tomato leaves accumulated on unacceptably high Cu levels in the two seasons.

The reflected effect of the contaminated dust accumulation, which contains polluted elements, on plants was clear reduction on leaf areas in all studied for vegetable crops (Table 5). The reduction percentage on leaf areas were 16.82% in Roquette, 31.82% in Radish, 10.81% in Potato and 21.88% in Tomato.

In vegetable - tuber root (Radish), the reduction in root size due to the air and soil

Table 3: Concentrations of Mineral elements in the leaves of some vegetable crops grown on rural ⁽¹⁾ (R) and urban ⁽²⁾ (U) environments (season 1990).

Crop	mg/Kg Dry matter							
	Cu	Mn	Zn	Ni	Cr	Pb	Hg	Total
Leaf-vegetables:								
Roquette (U)	33.3	245	122	19.6	33.1	35.9	0.04	488.9
(R)	11.7	115	52.1	5.8	9.7	3.9	0.02	198.02
Celery*Balady* (U)	30.9	112	172	9.8	15.7	15.1	0.07	355.87
(R)	12.3	90	64.0	5.1	7.5	2.6	0.02	181.52
Parsley*Bal. " (U)	37.3	448	75.2	50.9	51.3	35.2	0.04	697.94
(R)	9.2	125	40.1	6.3	17.2	5.7	0.03	203.53
Cabbage*Bal. " (U)	18.2	75	51.1	16.6	10.2	15.1	0.02	186.22
(R)	6.1	29	27.0	6.2	8.0	3.6	0.02	79.92
Tuber root Vegetab.:								
Radish*Bal. " (U)	18.4	42	39.3	16.7	15.7	25.4	0.12	157.92
(R)	7.2	25	26.2	8.2	7.1	2.9	0.03	76.63
Turnip*Bal. " (U)	24.3	90	85.3	19.2	16.6	12.0	0.05	247.45
(R)	15.1	26	25.2	5.2	3.9	2.4	0.02	77.82
Potato*Grata" (U)	22.4	105	35.4	17.6	13.2	2.6	0.02	196.22
(R)	10.2	27	25.0	5.3	4.1	0.9	--	72.5
Fruit vegetable:								
Tomato UC97-3" (U)	40.3	121	55.6	14.7	18.5	10.3	0.08	260.48
(R)	7.8	43	26.3	4.3	2.9	2.2	0.03	85.53
*Normal Range ppm								
Lower	6	25	25	0	0	2	0	58
Upper	15	250	150	8	0.5	14	0.15	437.65
**Phytotoxic								
Range	>20	>500	>400	>80	>100	>20	--	1120.0

*, ** According to Cottenie et al., 1976.
 (1) Unpolluted. (2) Polluted.

Table 4: Concentrations of Mineral elements in the leaves of some vegetable crops grown on rural (1) (R) and urban (2) (U) environments (season 1991).

Crop		mg/Kg dry matter							Total
		Cu	Mn	Zn	Ni	Cr	Pb	Hg	
<u>Leaf-Vegetables:</u>									
Roquette	(U)	28.6	301	130	20.1	30.6	32.2	0.04	542.74
	(R)	12.2	90	35.6	9.7	8.9	15	0.02	171.52
Celery*Balady*	(U)	32.6	280	161	11	12.8	17.6	0.06	514.86
	(R)	15.3	150	41	7.3	1.7	4.7	0.02	219.92
Parsley*Bal. "	(U)	40.1	310	151	60.2	50.6	38.4	0.07	850.27
	(R)	11.6	170	96	20.2	10.2	12.2	--	320.4
Cabbage*Bal. "	(U)	9.6	60	60.2	3.6	8.2	16.1	0.05	157.75
	(R)	2.7	28	12.2	4.6	10	10	0.02	68.02
<u>Tuber root Vegetab.:</u>									
Radish*Bal. "	(U)	16.2	49	18.7	5.3	16.1	22.2	0.08	127.58
	(R)	9.3	28	8.2	4.8	14	10.3	0.03	74.63
Turnip*Bal. "	(U)	15.6	101	90.2	11.3	18.6	17.2	0.06	253.96
	(R)	10.3	38	40.6	8.0	17.2	11.3	0.02	125.42
Potato*Grata"	(U)	18.3	120	32.1	8.2	16.3	13.8	0.02	334.14
	(R)	9.1	33	15.6	5.3	9.2	1.2	0.02	73.42
Potato "Alpha"	(U)	22.6	90	19.9	4.7	11.9	11.2	0.02	160.32
	(R)	14.2	45	8.9	5.9	9.2	4.2	--	87.4
<u>Fruit Vegetable:</u>									
Tomato*UC97-3"	(U)	29.7	120	30.9	15.2	17.2	5.9	0.03	218.93
	(R)	13.1	38	18.2	7.3	9.3	2.3	0.02	88.22
Peas "Little-Marvels"	(U)	28.6	110	32.4	14.2	11.2	5.8	0.05	202.25
	(R)	12.3	65	22.6	6.8	5.6	3.1	0.02	115.42
*Normal Range ppm									
	Lower	6	25	25	0	0	2	0	58
	Upper	15	250	150	8	0.5	14	0.15	437.65
**Phytotoxic									
	Range	>20	>500	>400	>80	>100	>20	--	1120.0

*, ** According to Cottenie et al., 1976.

(1) Unpolluted. (2) Polluted.

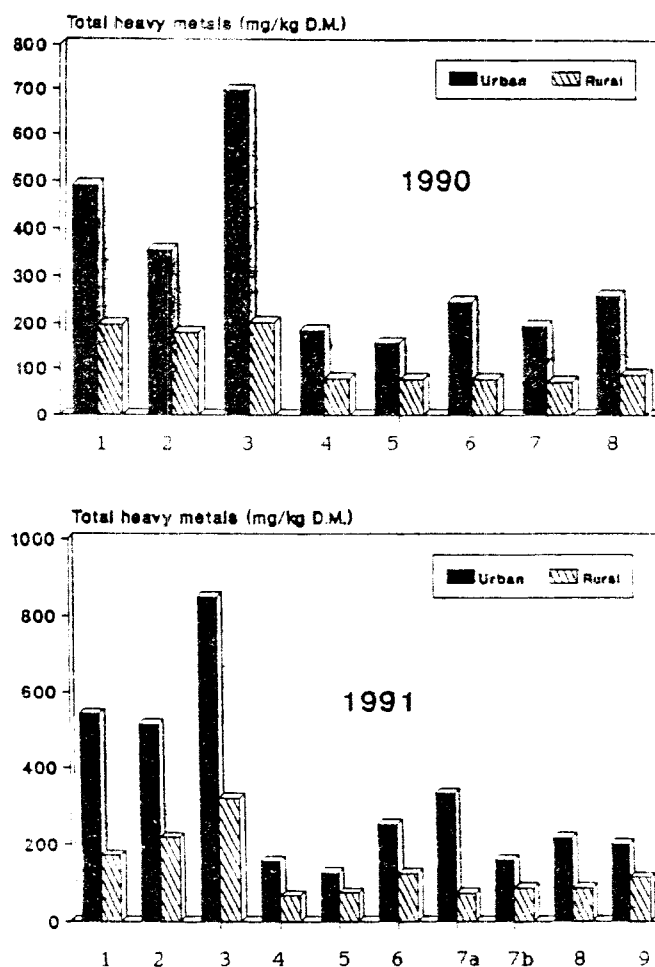
Table 5: The relationship between the production and the dust accumulation mg/100 cm² LA on leaves of some vegetable crops under rural(R) and urban(U) conditions during winter 1990 and 1991.

Crop treatments	Zucchini		Radish		Potato		Tomato	
	(U)	(R)	(U)	(R)	(U)	(R)	(U)	(R)
Dust accumulation mg/100 cm ² LA								
1990	372 ^a	56	515 ^a	125	405 ^a	93	396 ^a	98
1991	295 ^b	72	314 ^a	132	367 ^a	91	247 ^a	80
Leaf area cm ² /plant								
1990	460	553 ^b	420	616 ^a	2960	3016 ^a	2331	2984 ^a
1991	317	422 ^b	451	515 ^a	3180	3792 ^b	3470	4987 ^b
Average Root size(g)								
1990			32.1	56.12 ^a				
1991			40.2	62.11 ^a				
Average Tuber size(g)								
1990					52.4	80.7 ^b		
1991					48.9	72.5 ^a		
Average Fruit size(g)								
1990							39.6	59.35 ^a
1991							42.2	62.21 ^a
Number seeds/fruit(g)								
1990							28.2	58.4 ^a
1991							40.1	92.21 ^a

^a Significance at 0.05 level.

^b Significance at 0.01 level
after an analysis of variance.

Fig. 1: Concentration of total heavy metals in the leaves of vegetable crops grown in rural and urban environments during 1990 and 1991 seasons.



Vegetable crops

- | | | | | |
|-------------|--------------------|------------------|------------|-----------|
| 1- Roquette | 2- Celery | 3- Parsley | 4- Cabbage | 5- Radish |
| 6- Turnip | 7.7a- Potato Grata | 7b- Potato Alpha | | |
| 8- Tomato | 9- Peas | | | |

pollution reached 42.82% ; whereas, the reduction of tuber in Potato was 35.03%. The reduction in root size seemed to be mainly due to the toxic effect of Cu as illustrated by Galati et al. (1989).

In vegetable fruits (Tomato), the reduction in fruit size was around 33.28%. The maximum reduction was found on the number of seeds/fruit (51.71%), which reflected the toxic and greatest harmful effect of polluted dust on the hinder pollination (McCrea, 1986).

The major effect of dust and ash emissions pollution was the toxic effect, which led to burning and necrotic symptoms, and resulting in losses in the vitality of pollen - grain as measured by low number of seeds/fruit, (Table 5).

The reductions in the morphological and physiological characteristics of all plant parts grown under rural conditions, are apparently due to the effects of its contaminated dust particles, whereas at 5 mg/cm², the light transmission is reduced by 75% (Das, 1988 and Satyanarayana et al., 1988). The net assimilation and chlorophyll contents are also affected compared with those grown under urban conditions.

The results of this study clearly illustrate the harmful and toxic effects of dust and ash emission from factories on vegetable crops production.

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الهدف الرئيسى من هذه الدراسة هو تقدير التأثيرات القارن للآثارية والادخنة الملوثة بالمواد الكيماوية والمخلفات الصناعية المصنوعة من المصانع على انتاج القمح . وقد تمت هذه الدراسة بمزرعة كلية الزراعة - جامعة الاسكندرية والقريبة من الطريق الزراعى وبجانب مصنع لاعداد مواد الاسفلت ورصف الطرق وهى مواد بترولية . وقد تم جمع العينات فى موسمين زراعيين متتاليين ١٩٩٠ و ١٩٩١ من خمسة خسروات مختلفة لتقدير الضرر الواقع على انتاج هذه القمح وكذلك لمل لهذه الملوثة من قدرة على الحراخه داخل جسم الكائن الحي (انسان او حيوان) وعيوبه الخلفى منها ، ويمكنها ان تسبب تأثيرات ضارة مزمنة بعد فترات زمنية مختلفة .

وقد وجد عند اخذ العينات الورقية من المحاصيل المنزرعة بالقرب من مناطق التلوث ومناطق اخرى متعربة بمحطات الريساج وبعبدة عن مناطق التلوث ، ان هناك فرق معنوى بين هيمات الاثرية المتراكمة على الاوراق فى المناطق الملوثة وغير الملوثة . وكانت اكبر كمية لتراكم الاثرية على القمح البلدى وقدرت بـ ١٥٥ ملليجرام / ١٠٠ سم² مساحة ورقية .

وذلك وجد عند تحليل الاوراق ان القمح المنزرعة فى المناطق الملوثة قد تراكمت بها المعادن الثقيلة بنسبة عالية و فرق معنوى عنها فى المناطق النقية ، وكانت أعلى نسبة لمجموع المعادن الثقيلة فى التلوث . وقد وجد ان أعلى المعادن تراكمها على الاوراق هو النحاس تحت ظروف التلوث

وقد ظهرت انتاج أيضا انخفاض كل من جودة وحيوية الخسروات النامية تحت ظروف التلوث ممثلا ذلك فى حناقم المساحة الورقية وحجم جذور القمح ودرجات البطاطم وثمار الطماطم بالإضافة الى حناقم طيبير فى عدد البذور المستخرجة من ثمار الطماطم (قد يرجع ذلك الى انخفاض حيوية حبوب اللقاح وفشل عملية العقد)