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THE EFFECTS OF CEMENT DUST ON OLIVE TREES IN THE AREA SURROUNDING TARTOUS CEMENT FACTORY

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ABSTRACT

Concentration of total suspended particulate (TSP), particulate less than 10 microns (PM10) and particulate less than 3 microns (PM3), were measured in different sites in the surrounding area of Tartous cement factory.

The effects of cement dust emission on the growth of olive trees have been investigated. The results show that the, TSP, PM10 and PM3 concentrations in the air were higher than world health organization standards (WHO) at the factory site as well as in the surrounding area within a diameter of 3 – 4 km.

The study shows that branch length, branch weight, amount of chlorophyll and leaves number were decreased significantly. The average weight of the annual dust fall on leaves was 34.5, 26.4 and 10.9 g/m^2 at the sites around the cement plant, while in the reference site a value of 1.9 g/m^2 was measured.

Key Words: Cement dust emission, olive trees, TSP, PM10, Syria.

1. INTRODUCTION

Cement industry in most countries is considered one of the most air pollution sources, especially for a lack or insufficient filtration systems. For example an air pollution of cement about 200 ton/day in Halwan factories in Egypt was investigated (El-Awag, 1994). Lerman mentioned that the quantity of dust fall around cement factory in some part of Germany is in a range between 45-114 ton/km^2/month (Lerman and Darley, 1975).

Cement dust contains many elements such as, calcium, silicon, lead, and arsenic etc (Turbas, 1991). In addition cement industry forms an important source of vanadium (Abdel Shafi et al., 1990) and mercury pollution (Fukuzaki et al., 1986).

Studies (Yhdego, 1992), (WHO, 1987), (Yong et al., 1996) show that the pollution of cement dust increase lung sicknesses for people living near by the plants, especially bronchitis, emphysema, forced expiratory volume and forced expiratory flow.

Cement dust also cause sister chromated changes in lymphocytes (Fatima et al., 1995). Also all plants are affected on their growth, harvest. The quantity of chlorophyll decrease in leaves and increase the exposures of infestations to insects and fungus diseases because of forming a hard salt crust at the surfaces of leaves, especially with the presence of high percentage of humidity (Mudd and Kozlowski, 1975). This crust is not removable by wind or rain and is a reason for the changing of specific structure of plants societies (Hegazy, 1996; Brandt et al., 1973).

The particulate pollutants are divided into ‘respirable’ particulates with diameters below 10 µm (PM_{10}) and ‘non-respirable’ particles with diameters up to 100µm (TSP) [Ormstand et al., 1997]. The heavier particles deposit faster than the lighter ones. Therefore their effects can be observed mainly near emission sources. Small particles sometimes behave like gases and remain in the air for a long time (Vesilind, 1982).

The goal of this study was the proof of the influence of these pollutants on growth of olive trees existing around the factory. The total suspended particulate, distribution of particulate matters less than 10 microns according to aerodynamic diameter were measured in the investigation area.

2. METHODOLOGY

2.1. Particulate Measurements

Sampling of total suspended particulate TSP, Particulate less than 10 microns PM10 and distribution of PM10 according to particle size were executed in selected sites, inside and near the Tartous cement factory up to a distance of 4 km.

A high volume air Samplers (HVAS), 5 stages Anderssen cascade impactors with an average air flow rate of 50 m^3/h were used. TSP and total PM10 samples were collected with Whatman EPM2000 glass fibber filters. PM10 samples as a function of particle size were collected with filters type SAC230GF.

The impactor stages consist of aluminum plates with outside dimensions of (15x18) cm. The 2, 3, 4 , 5, 6 have 10 parallel slotted impaction jets. Stage 1 has 9 slots. This impactors has the ability to distribute the PM10 according to the aerodynamic diameter in six ranges (10-7.2; 7.2-3; 3-1.5; 1.5-0.95;0.95-0.49; less than 0.45 microns).

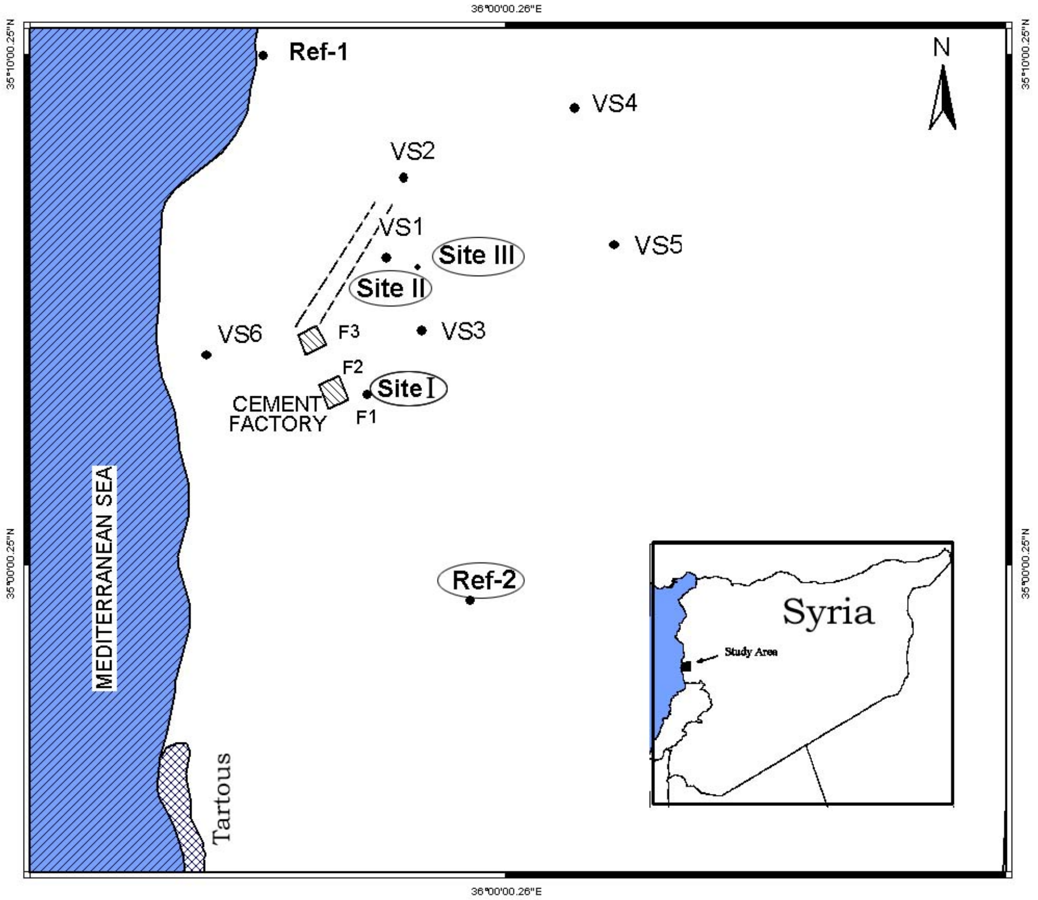

Figure 1: Map of the study sites.

2.2. Plant Measurements

Four sites of olive trees varying in distance from each other and from the cement factory were chosen. These sites are (Fig. 1):

1. Reference area, 7 km away from the factory, which is rarely exposed to the cement dust.
2. Site I, 500 m away from the factory and 30 m above sea level.
3. Site II, Husen Al- Bahr village, which is located 2 km north/east of the factory, altitude 50 m.
4. Site III, which is located 3 km from the factory, altitude 170 m.

Ten trees from each field were randomly chosen and the following parameters were measured:

- The length of annual growth of 10 branches from each tree, the number of leaves on each branch and the dry weight.
- The diameter of the 10 branches of the year before, from each, at the beginning (May 1999) and at the end of the growth season (September 1999).
- The number of growth rings of 10 main branches .
- The size of all leaves of the main branches; the measurements were carried out according to the procedures of (Klein and Klein, 1970).

- The amount of dust accumulated at the surface of leaves, by sampling of 10 samples from each field. Each sample contains 100 leaves. The leaves were washed with water and the residues dried for calculating of the weight of dust.
- The leave content of chlorophyll was measured using an instrument of Minolta, SPAD-502 chlorophyll meter.
- For the statistic purposes an Anova, LSD, Statview4 program was used.
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3. RESULTS AND DISCUSSION

3.1. Suspended Particulates

Table 1 shows that TSP concentration was too high in the factory and in all other sites compared to the given standards of 120 µg/m^3. The range of concentration differs between 985 and 1844 µg/m^3 and exceeded the national standards (Syrian Ambient Air Quality Standards, 2004) and the world heath organization standard (WHO, 1987;) by 8-15 times.

Differences between the values were extreme, for example in "*Husen Al-Bahr*" values varied from 94 µg/m3 to 703 µg/m^3 and in worker's settlement beside the factory between 110 and 1499 µg/m^3.

In the selected villages near by the factory, TSP was also higher than the reference area value (80µg/m^3), whereas TSP reached to 290 µg/m^3 in "*Husen Al-Bahr*", and to 686µg/m^3 in worker's village. TSP concentrations differs according to the climatic situation (wind, rain etc.).

Table 1. Average concentration of suspended particulate (µg/m^3±SD).

Region	Site's name	TSP	PM10	PM3
Factory area	Main entrance	985±387	-	-
	Administration	1419±849	1067.0	341.0
	laboratory	1844	664.0	256
Reference Area	*Shekh saad*	80±20	14.0-36.0	5.8
	Shalehat	110±28	24.0-38.0	23.4
Villages surrounded the factory	*Husen Al-Bahr*	290±161	70.0-213.0	20.3-77.0
	Matn Al-shahel	164±50	49.0-67.0	49.0
	Dwer Taha	73±31	28.0-39.0	13.5
	Zamreen	91±29	-	-
	Worker's village	684±474	-	-

Data are means ± SD (Standard Deviation).

PM10 concentration was also high in factory area. The values ranged between 664-1067µg/m^3, and also they exceeded WHO standard of 70 µg/m^3 (WHO, 1987) by 9.5-15 times. In quarters surrounding the factory, the PM10 was diverse from one day to another, according to wind speed and direction. In "*Husen Al-Bahr*" it ranged between 70-210 µg/m3.

PM3 was also very high in factory site and reached up to 314 µg/m^3. Ditto these values exceeded the standard suggested by Environmental protection agency in the USA (EPA) of 15 µg/m^3 (Moghhissi, 1997) by 23 times.
In the villages surrounding the factory, PM3 was mainly within the standards, in some sites higher than the standards of the EPA, also depending on the climatic situation.

3.2. Effects Of Cement Dust On Olive Trees

Large amount of cement dust emitted during all manufacturing steps of cement has affected obviously olive trees surface by depositing a salt coat "crust" (Mudd and Kozlowski, 1975) on the leaves.

Table 2. effects of cement dust on growth of olive trees.

	Ref. Site	**Site I**	**Site II**	**Site III**	**LSD 95%**
Average dust weight precipitated g/m2 surface leaves	1.980	34.550	26.400	10.900	3.460
Average leaf area/cm2	5.030	2.700	3.360	3.940	0.440
Average leaf weight /g	0.113	0.072	0.084	0.093	0.020
Average length of branch in the year before /Cm	11.220	3.440	4.300	9.230	1.760
Average number of leaves/branch	19.300	7.750	8.200	13.00	2.070
Average weight of dry branch on the year before/g	1.810	0.510	0.780	1.380	0.250
Average increasing of main branch's diameter/Cm	0.180	0.027	0.036	0.086	0.046
Average increasing of 2 years old branch diameter/Cm	0.101	0.014	0.013	0.041	0.023
Average increasing of 1 year old branch diameter/Cm	0.086	0.019	0.017	0.030	0.024
Average diameter of growth ring	0.410	0.220	0.250	0.330	0.032

Data are means ten replicates.
LSD 95%: Lowest Significantly Different at 95% level of confidence.

Table 2 shows that the quantity of cement dust deposited on leaves surface is increasing proportionally with approaching to the factory. It was 1.98 g/m^2 from leaves surface in reference area and increased to 34.6, 26.4 and 10.9 g/m^2 from leaves surface in region I, II and III respectively. This means high cement dust deposition on the leaves surface in these regions compared to the reference area by 5.5 and 13 times.

It is worth to show that the cement dust deposition on leaves surface amounts to 0.8%, 13% , 10.6% and 4.6 % from the weight of dry leaves in reference area, region I, II and III respectively.

Deposition of cement dust on plant leaves has effected negatively the growth and proportional with approaching to the factory. Leaf size has decreased in comparison with the reference site by 34.5%, 33% and 21%. Leaf weight has also decreased by 36.5%, 26.3% and 18% in the sizes II, III and I respectively. More over dust fall has affected the growth of new shoots, so its average weight, length and number of leaves grown on these shoots decreased.

The average length of the new grown shoots at the end of growth season was about 11.2 cm in the reference area. In the sites I, II and III the average length decreased to 3.4, 4.3, 9.2 cm respectively. The number of leaves on each shoot decreased from 19 in reference area to 7.8, 8.2 and 13 leaves in the region I, II and III respectively. The dry weigh and amount of chlorophyll decreased in the same way and were less than reference area. In the sites I, II and III were lower by the following factors 25%, 15% and 9%.

Measurements of growth rings thickness in main shoots showed decreasing values with approaching of the factory. The annual average thickness of shoots in the reference area was 0.41 cm. This value decreased to 0.22, 0.25 and 0.33 cm in the sites I, II and III approaching to the factory respectively. Table 3 also shows that the diameter of the main, the 1 year and 2 years old shoots decreased registerable in comparison with the reference site. The average diameter of main shoots was 0.18 cm in the reference sites, and decreased to 0.027, 0.036 and 0.086 cm in the sites I, II and III respectively. The same was noticeable also for 1 and 2 years old shoots.

4. DISCUSSION

The results of this study show the TSP, PM10 and PM3 values were very high in the factory region. Especially those of PM3, which reached in some days 341 µg /m^3. This value exceeds the suggested values (15 µg/m^3) of EPA by 23 times (Moghhissi, 1997).

PM3 is considered to be the most dangerous particulate because of its effectiveness on health. PM3 penetrates the defenses of respiratory system and the lungs up to depth, which cause serious problems like asthma (Pope, 1991), emphysema (Shandaala and Zviniatskovski, 1988) and coughs (Ostro, 1991). Furthermore eyes diseases occur (Shandaala and Zviniatskovski, 1988).

High concentrations of PM3 were not limited to factory site, but were also registered in the villages near by, especially when the wind blew in the direction of these villages.

The Neutron Activation Analysis (NAA) of the cement dust showed a percentage of 27.5% of calcium (Meslmani and Al-Oudat, 2004). By presence of humidity calcium silicate occurs, which immediately dries and becomes a hard salt crust. Therefore in the regions near by the factory cement dust formed this kind of salt coat on the surface of the leaves.
This coat causes the decreasing of shoots growth, less number of leaves on it and lower leaves sizes and chlorophyll contents in the studied sites compared to the reference site.

Results of this study show like other studies carried out in the world that cement dust decreases the growth of trees by approximately 50% (Bohne et al., 1963), and cause death of leaves, and decrease chlorophyll content (Mandre et al., 1997).

5. CONCLUSIONS

TSP, PM10 and PM3 concentrations in the air of the factory site and neighborhood were higher than International and Syrian standards (Syrian Ambient Air Quality Standards, 2004). The cement dust in the factory neighborhood has a noticeable negative influence on the growth of trees, depending on the distance from the polluting source.

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