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Effect of Cement-kiln Dust Pollution on The Vegetation in The Western Mediterranean Desert of Egypt

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Abstract—This study investigated the ecological effects of particulate pollution from a cement factory on the vegetation in the western Mediterranean coastal desert of Egypt. Variations in vegetation, soil chemical characters, and some responses of *Atriplex halimus,* as a dominant species in the study area, were investigated in some sites located in different directions from the cement factory between Burg El-Arab in the east and El-Hammam in the west. The results showed an obvious decrease in vegetation diversity, in response to cement-kiln dust pollution, that accompanied by a high dominance attributed to the high contribution of *Atriplex halimus*. Annual species were found to be more sensitive to cement dust pollution as they all failed to persist in highly disturbed sites. It is remarkable that cover and phytomass of *Atriplex halimus* were increased greatly in response to cement dust pollution, and this was accompanied by a reduction in the mature seeds and leaf-area of the plant. The few seeds of the affected individuals seemed to be more fertile and attained higher germination percentages and exhibited hardening against drought stress.

Keywords—*Atriplex halimus*, Alpha diversity, Cement dust pollution.

I. INTRODUCTION

In the recent years, the definition of air pollution has been broadened, and research activities are expanding to include analysis of plant responses to a wide range of atmospheric chemicals emitted from anthropogenic sources. Plants in desert ecosystems often receive chemical inputs mostly from atmospheric deposition. Cement dust emitted from cement factories is considered to be one of the main sources of air pollution that greatly affect plant growth, phytomass and productivity [1] - [3], species composition, cover and biodiversity [4]- [6].Beside its major effects on soil properties [7] - [9].Air pollution, occurring at varying temporal and spatial scales, plays an important functional role in many types of vegetation [10]. There are few studies, which monitor the impacts of cement dust accumulation on the vegetation and soil seed banks in Egypt [11], [6]. Cement dust is largely made up of cement-kiln dust that is a by-product and is usually stored as waste in open-pit, unlined landfills. According to [12], Portland cement-kiln dust was found to be composed of finely ground cement raw materials ($CaCO_3$ and Na_2SO_4). Many studies [7], [9] noted that the particles of cement deposits were quite alkaline making soils neighboring cement factories, especially down-wind areas, exhibit elevated pH levels which in turn affect vegetation growth, decreasing rates of photosynthesis, respiration, transpiration and growth rate [6], [13], [14]. Dust accumulation from limestone cutting seriously affects the vegetation composition of some plant communities on Abu-Sir ridge in the western desert of Egypt [15].The present study aims at investigating the ecological effect of cement-kiln dust pollution produced by a cement factory on the diversity of the surrounding natural vegetation in the Egyptian western Mediterranean region (between Burg El-Arab and El-Hammam), and assessing the responses of *Atriplex halimus*, as a dominant species in the study area, to such air pollutant.

II. MATERIALS AND METHODS

A. Study Area

The study area is located in the western north desert of Egypt between Burg El-Arab in the east and El-Hammam in the west (48 and 55 km west of Alexandria: Fig. 1). The study area belongs to the arid climate with mild winter and warm summer. Annual rainfall averages about 150 mm and falls mostly during winter.

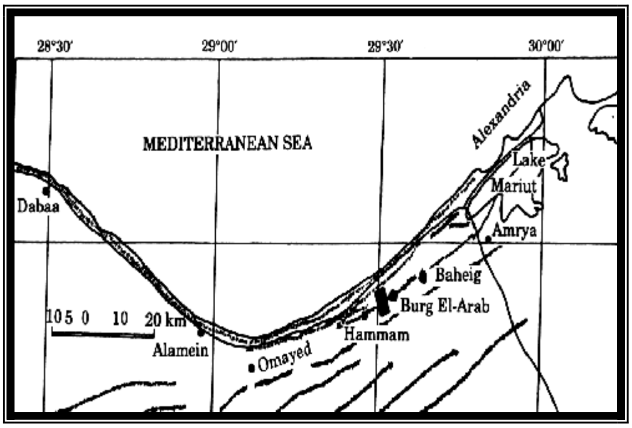

Fig. 1 Sketch-map indicating the location of the study site

B. Selection of Sites and Vegetation Records

Four sites were selected at different directions around the cement factory: south, south-east, east, and west. The north direction was excluded as the soil is flooded by water. A control site (fifth site) was selected at 9 km far from the cement factory where the dust load was negligible. The presence of perennial and annual species was recorded in five

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stands (50 m x 50 m) in each of the selected sites. Plant cover was estimated by the line intercept method (Causton 1988). Plants nomenclature was according to [17], [18].

A sample of thirty leaves from *Atriplex halimus* was randomly collected from stands in each site and washed gently by distilled water; the washing water was collected in a clean pre-weighed beaker. Then water was evaporated to determine the weight of washed dust as mg cm^{-2} of leaf surface area [19]. Ten branches were clipped from mostly equal individual of *Atriplex halimus* shrubs at the selected sites for estimating the dry weight of branches per individual as g. $individual^{-1}$. One hundred fruits from each individual (2 individuals from each stand) were collected for the determination of the seeds maturity percentages.

C. Soil Sampling And Analysis

Two soil samples were collected in each of the selected stands, from the surface to a depth of 25 cm. These were air-dried and passed through a 2 mm sieve to eliminate gravel and debris. The soil pH, EC, $CaCO_3$, and SO_4^{--} estimated by glass electrode pH meter, electrical conductivity meter, calcimeter, and precipitation method using barium chloride, respectively [20].

D.Germination Experiment

The collected seeds from affected *Atriplex halimus* individuals with cement- kiln dust, and from unaffected individuals were surface sterilized using 3.0 % sodium hypochlorite. These seeds were washed with double distilled water, and germinated on filter papers wetted by water or mannitol solution (100 mM concentration) in petri-dishes. Wetting of filter paper in each petri-dish was done by adding 6 ml water or mannitol solution for each treatment. The final germination was assessed after sixteen days. There were four replicates (each of 10 seeds per dish) for each of the affected and unaffected treatments. The lengths of both shoot and root were measured and the seedling root/shoot ratio was calculated.

E. Application of Diversity Indices

Five of the alpha diversity indices (diversity within community samples) were applied on the studied sites [21], [22]: Species richness (S: straight forward count of the number of species), Simpson index of dominance ($D=\sum Pi^2$), and Shannon-Weiner index ($H'= \sum Pi \ln Pi$)., where Pi is the relative importance of the ith species (its relative cover). Hill's number N2: the reciprocal of Simpson's index was calculated as a measure of the number of very abundant species), and Evenness index or Shannon-evenness ($E1= H'/ \ln S$) as an attempt to quantify the evenness component of diversity. When all species in the sample are equally abundant, it seems intuitive that E1 should be maximum value and decreases towards zero as the relative abundance of species diverge away from evenness.

Statistical analysis (analysis of variance and LSD) was calculated for the results by using SAS soft ware [23]. The significant results were represented at two significant levels (highly significant at $P<0.01$and significant at $P<0.05$).

III. RESULTS

A. Floristic Composition and Vegetation Diversity

The recorded perennial species in the study area was only nine, seven of which are shrubby species: *Alhagi maurorum, Atriplex halimus, Arthrocnemum macrostachya, Halocnemum strobilaceum, Suaeda pruinosa, Deverra tortuosa and Thymelaea hirsuta*, and two are herbaceous species: *Juncus rigidus* and *Launaea nudicaulis*. These perennial species belong to six families: Chenopodiaceae, Apiaceae, Poaceae, Fabaceae, Asteraceae and Thymelaeaceae (Table I).

Fifteen annual species were recorded in the unaffected control site (Table I), while only eight species could persist the low level of cement dust pollution in the eastern direction (site 3). *Atriplex halimus* is the most dominant species in the study area (Table II). It exhibits a considerably higher cover percentages in the five selected sites than the other recorded perennial species. *Atriplex halimus* exhibits a high relative cover, ranging from 46.4 % to 79.6 % in the polluted sites, compared with 35.8 % in the control site. The absolute and relative cover of *Atriplex halimus* varied considerably with increasing the cement kiln dust pollution in the study area. Inspection of the data also indicates that only three species could resist the pollution level exerted by the cement factory: *Atriplex halimus, Halocnemum strobilaceum* and *Suaeda pruinosa*. It is also notable that the herbaceous species *Launaea nudicaulis* (absolute cover = 0.20 m 100 m^{-1}) is completely missed in the polluted sites. On the other hand, the shrubby species, *Halocnemum strobilaceum* is the only species adapted to all the disturbed sites (absolute cover ranging from .15-3.82 m 100 m^{-1}).

TABLE I
THE RECORDED SPECIES AND THEIR LIFE FORMS IN THE 5 SELECTED SITES (1= SOUTH, 2= SOUTH EAST, 3= EAST, 4= WEST AND 5= CONTROL)

Family	Species	life form	Site
Aizoaceae	*Mesembrynthemum nodiflorum*	annual	3, 5
Caryophyllaceae	*Herniaria hirsuta*	annual	3, 5
	Spergularia marina	annual	5
Chenopodiaceae	*Arthrocnemum macrostachya*	perennial	1, 4, 5
	Atriplex halimus	perennial	1, 2, 3, 4, 5
	Bassia muricata	annual	3, 5
	Halocnemum strobilaceum	perennial	1, 2, 3, 4
	Suaeda pruinosa	perennial	1, 2, 3, 4, 5
Compositae **(Asteraceae)**	*Calendula arvensis*	annual	3, 5
	Launaea nudicaulis	perennial	5
Cruciferae **(Brassicaceae)**	*Enarthrocarpus lyratus*	annual	3, 5
	Matthiola longipetala	annual	3,5
Gramineae **(Poaceae)**	*Bromus rubens*	annual	5
	Cutandia dichotoma	annual	5
	Hordeum leporinum	annual	5
	Juncus rigidus	perennial	4
	Lophochloa cristata	annual	5
	Parapholis marginata	annual	5
Leguminosae **(Fabaceae)**	*Alhagi maurorum*	perennial	5
	Trigonella maritima	annual	3, 5
Malvaceae	*Malva parviflora*	annual	5
Plantaginaceae	*Plantago crypsoides*	annual	3, 5
Thymelaeaceae	*Thymelaea hirsuta*	perennial	2, 3, 5
Umbelliferae **(Apiaceae)**	*Deverra tortuosa*	perennial	3

TABLE II
ABSOLUTE (AC: M/100M) AND RELATIVE COVER (RC: %) OF THE PERENNIAL SPECIES RECORDED IN THE 5 SELECTED SITES

Species	**Site**									
	1		**2**		**3**		**4**		**5**	
	south		**south-eas**		**east**		**west**		**control**	
	AC	**RC**	**AC**	**RC**	**AC**	**RC**	**AC**	**RC**	**AC**	**RC**
A. maurorum									**0.42**	**8.99**
A. macrostachya	**0.12**	**1.61**					**0.17**	**2.10**	**1.50**	**32.12**
A. halimus	**6.10**	**79.60**	**5.78**	**73.21**	**2.16**	**53.72**	**3.71**	**46.39**	**1.67**	**35.76**
H. strobilaceum	**1.31**	**17.16**	**1.22**	**15.49**	**0.15**	**3.74**	**3.83**	**47.89**		
J. rigidus							**0.13**	**1.57**		
L.nudicaulis									**0.20**	**4.28**
S. pruinosa	**0.12**	**1.63**	**0.84**	**10.61**	**0.57**	**14.25**	**0.17**	**2.06**	**0.08**	**1.71**
T. hirsuta			**0.06**	**0.70**	**1.05**	**26.20**			**0.80**	**17.13**
Total absolute cover	**7.65**		**7.9**		**4.02**		**7.99**		**4.67**	
Total species	**4**		**4**		**5**		**5**		**6**	

TABLE III
SPECIES DIVERSITY IN THE SELECTED SITES. D: SIMPSON'S DOMINANCE INDEX, H': SHANNON-WEINER INDEX, N2: HILL'S NUMBER 2, E1: SHANNON-EVENNESS AND S: SPECIES RICHNESS

Site	**Diversity index**				
	D	**H'**	**N2**	**E1**	**S**
South	0.67	0.62	1.51	0.45	4.00
South-east	0.57	0.79	1.76	0.57	4.00
East	0.37	1.17	2.68	0.72	5.00
West	0.44	0.94	2.27	0.58	5.00
Control	0.26	1.46	3.8	0.81	6.00

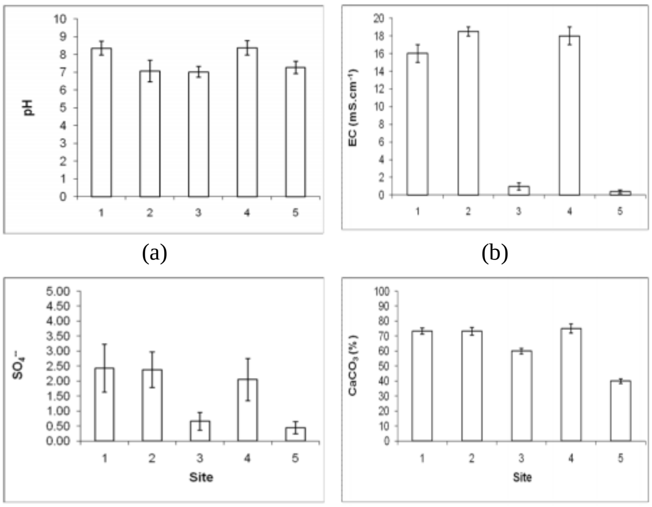
TABLE IV
RESPONSES OF *ATRIPLEX HALIMUS* TO CEMENT DUST POLLUTION IN THE SELECTED SITES. THE VALUES AFTER ± THE STANDARD DEVIATIONS OF THE MEANS. F VALUES ARE THE RESULTS OF ONE-WAY ANALYSIS OF VARIANCE (**= HIGH SIGNIFICANT AND *= SIGNIFICANT)

Site	**Leaf-area (cm^2)**	**Mature seeds (%)**	**Phytomass/ individual (g)**	**Cement dust υg/cm^2**
South	3.61±1.43	0	776.25±2.14	1.42±0.47
South-east	2.51±1.07	0	757.94±2.08	1.19±0.17
East	2.67±0.79	20	724.20±1.36	0.69±0.16
West	2.03±0.86	0	1324.47±1.70	2.31±1.69
Control	8.35±1.22	100	264.65±1.20	0.21±0.09
F	298.0**		43.07**	123.63**
LSD	0.55		208.2	0.26

It is obvious that *Halocnemum strobilaceum* and *Suaeda pruinosa* were recorded in all the polluted sites with cement kiln-dust, and both *Thymelaea hirsuta* and *Arthrocnemum macrostachya* were recorded in 50% from these polluted sites. *Thymelaea hirsuta* exhibited its highest absolute cover (1.05 m 100 m^{-1}) in site 3, while the highest cover of *Arthrocnemum macrostachya* is 0.17 m 100 m^{-1} in the western direction (site 4). *Deverra tortuosa* and *Juncus rigidus* were recorded only at site 3. Both species exhibit very low absolute cover of about 0.08 and 0.13 m 100 m^{-1}, respectively. Generally, the eastern direction (site 3) from the cement factory exhibited the lowest total absolute vegetation cover (4.02 m 100 m^{-1}), while the other three sites exhibited higher values with a narrow range of variation.Variations in the results of species diversity indices (Table III) showed a little relation between site direction from the cement factory and vegetation diversity. The data also indicating that species diversity shows a slight decrease in the eastern site as compared to the control site. While a considerable decrease in both diversity and evenness of species abundance is noticed in the other three polluted studied sites, accompanied by a considerable increase in dominance as confirmed by Simpson’s index. Shannon’s index estimated the vegetation diversity in the control and eastern sites as H' = 1.46 and 1.17, while Simpson's index was (D= 0.26 and 0.37). Hill’s number N2 (the number of the frequent species) were estimated to equal about four species in the control site and three in the eastern site. This illustrates considerable high evenness of species relative abundances in the control (E1= 0.81) and eastern (E1 = 0.72) sites.The western site exhibited lower vegetation diversity than that of the eastern (H' = 0.94), but both sites are similar in species richness (five perennial species in each of them). Lower vegetation diversity and higher dominance were observed in sites 1 (H' = 0.62, D= 0.66) and 2 (H' = 0.79, D= 0.57), which were located in the southern and southeastern directions from the cement factory, respectively. This high dominance is due to the increase in cover of *Atriplex halimus*. Species richness is reduced to four perennial species in each of the two sites.

B. Soil

The soils were alkaline in both the southern and western sites with pH values of 8.35 and 8.36, respectively, while the eastern and southeastern sites showed lower pH values of 7.01 and 7.06, respectively (Figure 2). The soil salinity, as depicted by electrical conductivity, was considerably high and ranged from 0.95 to 18.5 mS cm^{-1}. It is also notable that the eastern site shows the lowest EC value (0.95 mS cm^{-1}), while the south eastern site shows the highest EC value (18.5 mS cm^{-1}). Calcium carbonate ranges from 40 to 75 %, while sulphate ranges from 0.66 to 2.43 %. Considerably lower values were again noticed in site 3 located in the eastern direction from the factory.



(a) (b)

(c) (d)

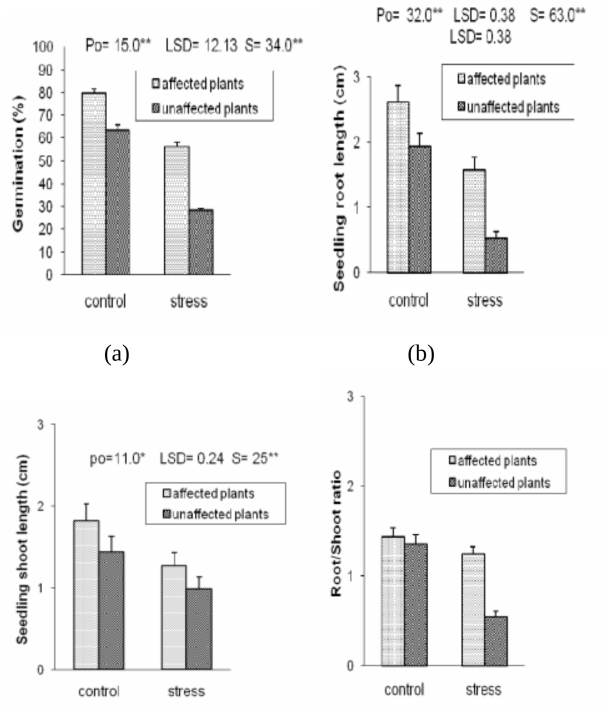
Fig. 2 Soil factors estimated in the 5 selected sites (1= south, 2= south-east, 3= east, 4= west and 5= control) around the cement factory. The vertical bars are the standard deviations of the means.

C. Responses of Atriplex halimus to Cement Dust Pollution

Atriplex halimus collected from the four selected sites received different amount of deposited cement-kiln dust ranging from 0.69 ± 0.16 µg cm^{-2} of leaf area in the eastern site to 2.31 ± 1.69 µg cm^{-2} of leaf area in the western site. These amounts are greater than that of the farthest site from the factory (control site) that receives 0.21± 0.09 µg cm^{-2} of leaf area of *A. halimus* (Table IV). Data shows also that there was no distinct link between location direction from the cement factory and the leaf area of *A. halimus.* The significant difference was only between the plants of the unaffected site and those of the four studied sites around the cement factory. Leaf area of *Atriplex halimus* plants decreased by about 75% in the polluted sites as compared with the unaffected one.

The variations in branches phytomass of *Atriplex halimus* (g dry wt $individual^{-1}$) were significant. Phytomass increased with the increase in the amount of deposited cement dust per leaf-area. The lowest branches phytomass was recorded in the unaffected site, while the highest was recorded in site 4 that receives the highest amount of cement dust.

The seeds collected from *Atriplex halimus* individuals grown in vicinity of the cement factory (affected plants) differed in maturation than those collected from individuals grown in the farthest site (unaffected plants). The germination experiment for affected and unaffected seeds showed a significant difference in the germination percentages especially under stress condition (100 mM mannitol). The germination percentages of the affected seeds were generally higher than those of the unaffected ones (Fig. 3). It is also remarkable that the germination percentages of the seeds affected by cement dust were reduced by one third when exposed to water stress (under mannitol treatment), while the germination percentages of the unaffected ones were reduced by half under stress using mannitol.



(a) (b)

(c) (d)

Fig. 3 Responses of affected and unaffected *Atriplex halimus* seeds to stress with mannitol. F values are results of 2-ways analysis of variance (** high significant and * significant) for the two different factors: pollution (po) and stress (s), in addition to LSD at $P < 0.05$

The root and shoot lengths (cm) of the seedlings from the seeds affected by cement dust were increased significantly by about 34.8 % and 26.8 %, respectively, as compared with the length of seedlings from the unaffected control treatment. The present study also reveals that treatment with mannitol (water stress) resulted in a considerable decrease in both root and shoot lengths of the emerged seedlings from both the affected and unaffected seeds. The root and shoot lengths of the affected seedlings, were found, to be reduced by 39.6 % and 29.9 %, respectively, when exposed to water stress by mannitol. The root and shoot lengths of the unaffected seedlings were also found to be reduced under mannitol treatment by about 72.4 % and 31.5 %, respectively. The seedlings from both affected and unaffected seeds showed a general trend of reducing root/shoot ratio when exposed to stress by mannitol treatment, while the reduction was lowest in case of the unaffected one.

IV. DISCUSSION

Vegetation analysis in the study area revealed that one third of the perennial species (3 species) could resist the disturbance exerted by the cement factory. These species are *Atriplex halimus, Suaeda pruinosa* and *Arthrocnemum macrostachya. Halocnemum strobilaceum* was found to adopt post disturbance condition as it was recorded only around the factory and not in the control site. The remaining perennial species: *Alhagi maurorum, Deverra tortuosa, Juncus rigidus, Launaea nudicaulis* and *Thymelaea hirsuta* were either completely disappeared from the disturbed sites or represented by very low species abundance. There was also a considerable effect of the cement factory on annual species limiting their presence in the eastern site that received the least amount of cement-kiln dust, and reducing their richness from fifteen to eight species.

In contrast with some similar studies [6], [24], the vegetation cover in the study area is greatly increased in sites received greater amounts of cement dust. This increase could be attributed to the increase of cover of some species in response to cement dust pollution, spatially *Atriplex halimus.* It exhibited a highest absolute cover up to 6.09 m 100 m^{-1} (RC= 79.6 %) in the site 1 as compared with 1.67 m 100 m^{-1} in the control site. *Atriplex halimus* cover was increased with increasing the cement dust pollution until its maximum value at medium pollution level it decreased again. At the highest pollution level the fugitive species *Halocnemum strobilaceum* attained a high cover value sharing the dominance with *Atriplex halimus*. This caused a notable increase in species diversity in the most polluted site (western site). *Atriplex halimus* is a perennial shrub found in semi-arid and arid environment and is characterized by high morphological and physiological variability. In Egypt, *Atriplex halimus* is widely distributed as a wild species. This halophyte is considered as a valuable source of forage. It is one of the most common indicator species in Matruh area in terms of abundance and palatability [25].

In addition, vegetation diversity is greatly reduced with increasing the cement pollution level, and consequently high dominance is estimated at polluted sites as compared with the control site. This could be also attributed to the increased abundance of *Atriplex halimus* in response to the increase in pollution level exerted by the cement factory in the study area. Reference [6] has described similar phenomenon in other vegetation types in the eastern desert of Egypt. The prevailing wind evidently distributes cement dust over a great distance, especially down-wind direction (e.g. south-western direction). The present study suggested also that the cover values of *Thymelaea hirsuta* might be affected greatly with cement dust. The plant persists in site 2 (EC= 18.5 mS cm^{-1}) but disappears from slightly lower saline site (site 4, EC= 18 mS cm^{-1}) that is the most polluted site. This may indicate that this species is more sensitive to cement dust than salinity. In the salinity adapted plant (*Halocnemum strobilaceum)* cover values increased in the most polluted site with about three times than in less polluted site 2. It is difficult to relate the detected variations amongst sites to factors other than cement-kiln dust accumulation.

The present study indicated an observed increase in the amount of cement dust either deposited on the leaf surfaces of *Atriplex halimus* or present in the air around the cement factory. The amount of cement-kiln dust in the study area, as measured by the High Institute of Health in Alexandria (personal communication) in stations built in different directions from the cement factory are: 128 μg m^{-3} in the eastern direction, 364 μg m^{-3} in the western direction and 133 μg m^{-3} in the southern direction.

The variations of soil chemical properties were greatly attributed to cement dust accumulation such as the increase in soil solution pH, salinity, calcium carbonate and sulphate contents. In the study area, at the vicinity of the cement factory especially in the southern and the western sites, a soil pH of 8.05 was recorded confirming a slightly alkaline soil. References [7], [8], [9] reported high pH values in soils which neighboring cement factories, spatially down-wind areas. The electrical conductivity is increased with increasing the cement dust accumulation reaching up to 18.5 mS cm^{-1}. Reference [26] also infers that cement dust pollution causes an increase in soil pH, electrical conductivity and total alkalinity beside the disturbance of soil texture.

The present study indicated that the cement dust accumulation affected maturity of *Atriplex halimus* seeds so as to produce a low mature seeds in the polluted sites. This observation was also reported for other plant species [6], [1]. Despite the fact that increasing intensity of disturbance (cement dust pollution) decreases the seed rain of *Atriplex halimus*, the germination percentage of seeds collected from individuals affected by cement dust pollution was greater by about 16 % than the germination percentage of seeds collected from unaffected individuals. The results of the present study showed also an increase in *Atriplex halimus* seedling root length associated with an increase in root/shoot ratio up to 1.44 in response to cement dust pollution and up to 1.24 under stress treatment using mannitol. In spite of cement-kiln dust was found to affect greatly on the seeds maturation, the mature seeds collected from the affected areas exhibited hardening against mannitol stress (water stress). Also the deposited cement dust on *Atriplex halimus* plant shoot reduces leaf-area by about 25%. Phytomass was significantly increased with increasing the pollution level. Reference [23] reported that cement dust pollution causes significant reduction in the number of leaves and leaf area of some xerophytic plant species.

Based on the results of the present study and previous similar studies, it could be concluded that cement factories in arid regions influence both vegetation diversity and the responses of individual species. The studied plant community exhibited an obvious decrease in vegetation diversity in response to cement pollution exerted by the cement factory at El-Hammam area. Annual species were found to be more sensitive to cement kiln dust pollution, and they failed to persist in sites subjected to high levels of disturbance. The lower diversity is always accompanied by high dominance that could be attributed to the high contribution of *Atriplex halimus* in the abundance distribution of perennial species in the study area. The remarkable increase in *Atriplex halimus* cover in response to cement-kiln dust pollution is accompanied by reduction in the plant seeds maturation, but the few provided seeds by the affected plant individuals exhibited hardening against water stress, and seemed to be more fertile and attain higher germination percentages than the unaffected ones. Root/shoot ratio of the affected seedlings was slightly increased due to the increase in root length. The present study also reveals that the leaf-area of *Atriplex halimus* is greatly reduced with increasing the cement dust accumulation, while the phytomass individual^{-} is increased. Further studies may be conducted in future to provide evidences of *Atriplex halimus* responses to cement-kiln dust pollution, and to insure natural recovery after degradation in order to maintain and preserve biological diversity.

REFERENCES

[1] M. S. V. Prasad,. and , J. A. Inandar (1991). Effect of cement kiln dust pollution on growth and yield of *Vigna spp*. Indian Journal of Ecology, 18: 91-94.

[2] J. Misra; V. Pandey; S. N. Singh; Singh, N.; M. Yunus,. and K. J. Ahmad (1993). Growth responses of *Lycopersicum esculentum* to cement dust treatment. Environmental Scientific Health, 28: 1771-1780.

[3] W. E. Winner (1994). Mechanistic analysis of plant responses to air pollution. Ecological Applied, 4: 651-661.

[4] L. Marlin. and E. Nilsa, on the distribution of epiphytic lichens. Proc. Eston. Acad. Sci. Ecol., 2: 181-185.

[5] M. Ayyad. and A. Fakhry (1996). Plant biodiversity in the western Mediterranean desert of Egypt. Verhandlungen der Gesellschaft fur Okologie, 25: 56-76.

[6] A. K. Hegazy (1996). Effects of cement-kiln dust pollution on the vegetation and seed-bank species diversity in the Eastern desert of Egypt. Environmental Conservation, 23: 249-258.

[7] E. Adamson; H. Adamson and R. Seppelt, (1994). Cement dust contamination of *Ceratodon purpureus* at Casey, East Antarctica. Journal of Biology, 18: 127-137.

[8] M. Mandre (1997). Changes in a forest landscape affected by alkaline industrial dust. Oil Shale, 14: 409-418.

[9] M. Mandre; K. Ots; J. Rauch and L. Tuulmets (1998). Impacts of air pollution emitted from the cement industry on forest bioproduction. Oil Shale, 15: 353-364.

[10] J. J. Mackenzie and M. T. El-Ashry (1989). Air Pollutions Toll on Forests and Crops. London: Yale University Press, 376 pp.

[11] M. M. Migahid,. and S. M. El-Darier,. (1995). Effect of cement dust on three halophytic species of the Mediterranean salt marshes in Egypt. Journal of Arid Environment, 30: 361-366.

[12] E. D.Wilson, and W. E. Anable (1986). Removal of alkalines from Portland cement kiln dust. U. S. Department of the Interior, Bureau of Mines. 10 pp.

[13] A. M. Farmer (1993). The effects of dust on vegetation-a review. Environmental Pollution, 79: 63-75.

[14] M. R.Sharifi; A. C. Gibson and P. W. Rundel (1997). Surface dust impacts on gas exchange in Mojave Desert shrubs. Journal of Applied Ecology, 34: 837-846.

[15] M. M. Migahid (2000). Effect of lime dust on major nutrient elements and photosynthetic pigments of the common plant species of North West Egypt. Proc. 1st Int. Conf. Biol. (ICBS) Fac. Sci., Tanta Univ. 7-8 May 2000. vol. 1: 199-212.

[16] Causton, D. R. (1988). Introduction to Vegetation Analysis. 1st. ed. Academic division of Unv. In Hyman Ltd. Pp. 341.

[17] V. Tackholm (1974). Students Flora of Egypt. (2nd Edn). Cairo University Press. Cairo, 888 pp.

[18] L. Boulos (1995). Flora of Egypt Checklist. Cairo, Al Hadara Publishing, 287 pp.

[19] R. E. Stickland (1969). A caliber for measuring plant diameter. Journal of Agricultural Engineering Research, 14: 290-291.

[20] S. Allen,; H. M. Grimshaw,; J. A. Parkinson, and C. Quarmby (1974). Chemical Analysis of Ecological Materials. Blackwell Scientific Publications Osney, Oxford, London 565pp.

[21] J. A. Ludwigand J. F. Reynolds (1988). Statistical Ecology. A primer on methods and computing. Wiley, New York, 337 pp.

[22] A. E. Magurran (1988). Ecological Diversity and Its Measurement. Princeton University Press. Princeton, New Jersey, 179 pp.

[23] SAS, (1985). SAS/STAT User`s Guide, SAS Institute Inc. Cary. NC.

[24] M. Z. Iqbal, and M. Shafig (1998). Toxicity of cement dust on the growth of some tree seedlings. Ekologia-Bratislava, 17: 434-439.

[25] S. Z. Heneidy, (2002). Role of indicator range species as browsing forage and effective nutritive source, in Matruh area, a Mediterranean Coastal Region, NW-Egypt. Online Journal of Biological Sciences. 2: 136-142.

[26] S. Sivakumar, and A. J. De Britto, (1995). Effect of cement pollution on soil fertility. Journal Ecotoxicolgy Environmental Monitor, 5: 147-149.

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