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Ecological Effect of Mergheb Cement Emissions on the Vegetation in the Northwest Libya Here

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Abstract: The study area is located in the coastal region of northwestern libya, west of khoms city. This region is characterized by a temperate climate with an average annual precipitation of 17 mm. Cement emissions are proven to have damaging impacts on different plant species. This study focuses on the impact of stack emissions from mergheb cement factory on the abundance, frequency, density and number of species at each site surrounding the factory under the effect of wind direction. The surrounding areas are subdivided into sites to assess plant species variability and their growth. It is concluded that there is a gradual reduction in density and vegetation cover towards the cement factory. Field observations revealed that the biodiversity in the east of cement factory is greater than that in the southwards.

Keywords: vegetation, cement emissions, Khoms, Libya

1. Introduction:

Mergheb Cement factory which is located few kilometers west of Khoms city has left a pronounced environmental impact can easily be detected by the naked eye on the soil surface and leaves of all plant species across a large area of land. Biodiversity is one of the main characteristics of a living society as it begets stability and hence, studies of flora and fauna biodiversity over the last several decades have become an increasing interest in the scientific community. This interest is not a product of the rapid environmental changes and damages only but it is also a product of growing evidences link diversity levels to changes in ecosystems (Smith and Knapp, 2003; Nijs and Impens, 2000). The main pollutants of cement industry are dust, nitrogen oxides and sulphur dioxide (Ibrahim et al 2012) . According to Wilson & Anable (1986), Portland cement-kiln dust was found to be composed of finely ground cement raw materials ($CaCO_3$ and Na_2SO_4).

Cement dust is considered to be one of the main sources of air pollution that greatly affect plant growth, phytomass and productivity, species composition and biodiversity [Sai, (1987), Prasad and Inandar (1991), Misra, et al, (1993); Wahid, 2006; Rai and Agrawal, 2008]. The most obvious effect of cement particles deposition on plant leaves is reduction of light transmission to the plant, and decrease of photosynthesis (Murugesan, et al, 2004; Amal, 2011). Biodiversity is even more important for the species constitute the base of food pyramid and hence they are regarded as biological indicators for change in the ecosystems (Mikola, et al., 2002) and some of those species serve as indicators of pollution levels (Belnap and Harper,1990; Tripathi, and Gautam, 2007). Fuel combustion causes oxidation of atmospheric nitrogen to nitrogen oxide (NO) and nitrogen dioxide (NO_2). NO oxidizes photochemically and transforms to NO_2. Despite the presence of SO_2 in stack emissions, NO_2 injury threshold concentrations are much higher than that of SO_2, and vary according to type of species. Short and long term exposure to SO_2 can harm many

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plant species(Pfanz, et al, 1987). Numerous studies investigating the effects of SO_2 on vegetation including crop plants, trees, shrubs and herbaceous plants reveal that SO_2 can cause interveinal necrotic blotches in angiosperms and red brown banding in gymnosperms (Chauhan, and Joshi, 2010). Susceptible plants to SO_2 injury include red cedar (Juniperus virginiana), oaks, sumacs (Rhus spp.), raspberries (Rubus spp.), American elm (Ulmus americana), red maple (Acer rubrum), black willow (Salix nigra), bracken fern (Pteridium aquilinum), soybean (Glycine max), and corn (Zea mays). There are several studies propose the use of lichens as indicators of air pollution caused by SOx. It is reported that 40 µg/m^3 of SO_2 in the air can couse a noticeable effect on lichens and 70 µg/m^3 can make them disappear (Hawksworth and Rose,1970). Belnap and Harper (1990) concluded that lichens morbidity in the vicinity of a coal operated power station in Arizona depends on the distance from the emission source and wind direction, an effect increases during humid seasons.

This study investigates the effect of cement industry on the density and size of the vegetation cover in the coastal region west of Khoms city in Libya.

2 MATERIALS AND METHODS

2.1 Area of study

The study area is situated at 32^{o}:38^{-} E , 14^{o}:13^{-} N and enjoys a Mediterranean climate of average temperatures ranging between 13^{o}C during January and 27 ^{o}C during August, and an average precipitation of 17 mm/day during the months of September through March. The dominant winds during the months of October through April blow from northern and western directions where the dominant winds during the months of June through August blow from east and south. The region is semiarid, bisected by number of valleys and characterized ~~most~~ by Mediterranean herbaceous plants and olive trees.

2.2 Methods

2.2.1 Sample collection sites

Samples are collected from 8 sites located between 500 meters and 1500 meters far from the source. The samples are collected from four locations south of the factory and other four locations east of the plant identified by GPS – GARMIN model 12. (Figure 1)

2.2.2 Vegetation study

In order to identify the most representative sites of the region regarding the characteristics of vegetation, the method of area quadrat is applied according to the area -species curve (Alsalman and Elmethnany, 2007). The optimum representation square is found to be 2 m^2 based on the standard characteristics of the vegetation such as frequency, density, abundance and number of species recorded in each site. Samples of each species are recorded in 25 squares at each site.

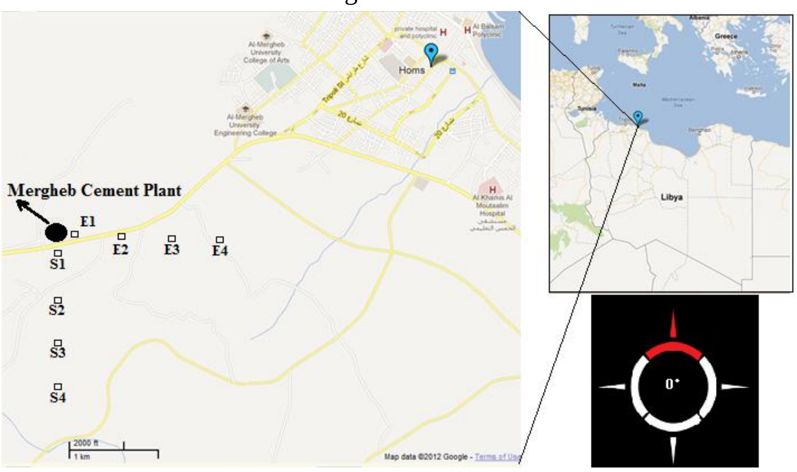

Figure 1. Google map of Khoms shows Mergheb Cement Plant and eight sample collection sites southwards and eastwards of the plant.

2.2.3 Soil study

The relationship between the vegetation characteristics and soil composition is investigated by collecting 3 soil samples from each site, conducting laboratory analysis following the procedures outlined in Aldomy (1998) and using methods and instruments listed in Table 1. Soil texture is identified by the mechanical hydrometer method.

Table 1. Soil solution (1:1) analysis measurements and instruments

Measurements	Instruments
pH	pH-meter, HANNA model HI8014
Electrical conductivity	EC meter, JENWAY model 4520
Na^+ & K^+ concentrations	Flame photometer, JENWAY model PFP7
Ca^{++} & Mg^{++} concentrations	Titration by EDTA solution
Sulfates (Turbidimetric method)	UV-Vis spectrophotometer model Unicam 8700
Cl^- concentration	Titration by Silver nitrate solution
Alkalinity	Titration by hydrochloric acid

2.2.4 Cement plant emissions

Gas and dust emission rates from Mergheb Cement factory (Table, 2) are computer simulation estimates (Ibrahim et al 2012). The composition of emitted pollutants are based on analyzing four samples collected from a rising plume by using X-ray fluorescence (Spectro X lab 2000).

Table 2. Stack emissions from the Mergheb Cement Plant

Emission type	Emission rate (kg/h)
NOx	930.3
SO_2	28
CO_2	37642.8
H_2O	10312.2
Dust	1306.4
Total	142357.2

1. RESULTS AND DISCUSSION

3.1 Cement plant emissions

A twenty meters stack height is not sufficient to achieve an efficient dilution and dispersion of emissions specially during stable meteorological conditions. Despite the presence of electrostatic precipitators in the plant to control dust, considerable cement dust accumulations the plant site and the surrounding areas as well as the observable dense particulate emission from the stack indicate that the performance of the precipitators is inadequate. The analyses of emitted dust samples show that alkali oxides such as calcium, magnesium oxides and some other oxides as well as silica ferrous and aluminum are the main constituents of the solid pollutants as illustrated in Table 3.

Table 3. Emitted cement dust chemical composition

Compound	*weight %	Standard Deviation
CaO	46.52	0.25
SiO_2	8.34	0.14
Al_2O_3	2.25	0.07
Fe_2O_3	2.07	0.07
MgO	0.964	0.048
K_2O	0.944	0.47
TiO_2	0.263	0.13
Loss in Combustion	38	--

*An average based on four samples.

3.2 Pollutants effect on number of species:

The results reveal that there are 116 species across the area of study dominated by species belonging to the Mediterranean region especially west Mediterranean sub region (Bashir, 2008). Those species include Iris planifolis; Rosmarinus officinalis, Epinus pinnata, Euphorbia peplus, Quercus cocciferas, Daphna jasminea, Ballots pseudodictaminus, Helianthemum cenanse, Arbutus bavarii and Cichorium spinosum . The presence of some species that belong to the western Saharan region such as Rbus tripartite and Stipa tenarcissicaisims can also be observed. Furthermore, species characterize the third stage of degradation such as Rhamnus alaternus and Zizyphus lotus are also found (Nahal, 1987).

An increasing occurrence of thorny plants towards the plant site is an indication of fourth stage degradation of the Mediterranean region plants. Continuation of that stage can lead a complete disappearance of the vegetation cover (Nahal, 1987). The spatial distribution of the collected species reveals that the count gradually increases as the distance away from the source increases (fig. 2). The number of species south of the cement plant increases from 19 near the source (S1) to 70 at a 1,500 m distance (S4). Similarly, in the eastern direction, the number increases from 26 near the plant (E1) to 107 at a 1,500 m distance (E4). This spatial variation in number of species density can only be attributed to the impact caused by the cement plant emissions that are more pronounced south of the plant as the dominant winds during the growth season of most species blow from the north. Reduced number of species towards the source can only be attributed to the higher concentrations of emitted pollutants such as dust and SO_2 near the source (Roberts, et al., 1971; Jensen and Kozlowski, 1974).

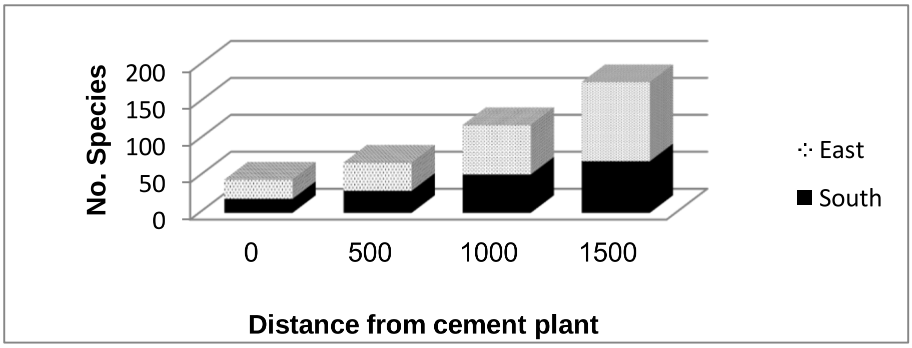

Figure 2. Number of species vs. distance from source

Previous studies in the neighboring areas provide further support to this finding. A study conducted at Misalata Natural Reservation twenty kilometers west of the study area show that there are more than 180 species in the reservation (Bashir, 2008), and a similar study conducted thirty kilometers east of the plant concludes the occurrence of 300 species (Alshif, 2005).

3.3 Effects on density of vegetation:

Plant counts south and east of the source range from 14.4 and 22.4 plants per m^2 near the source to 90 and 214.4 plants per m^2 at 1500 m from the factory (Figure 3) . This decline in species richness near the plant can be attributed to combined effects of SO_2, NOx and cement dust that can be observed by the naked eye on the leaves of the trees and plants (Figure 4).

The findings of this study are in agreement with findings of previous studies (Agrawal and Deepak, 2003; Agrawal et al., 2006) which indicate that the higher uptake of SO_2 turns toxic damaging plants and reducing growth and productivity by interfering with different physiological and metabolic processes.

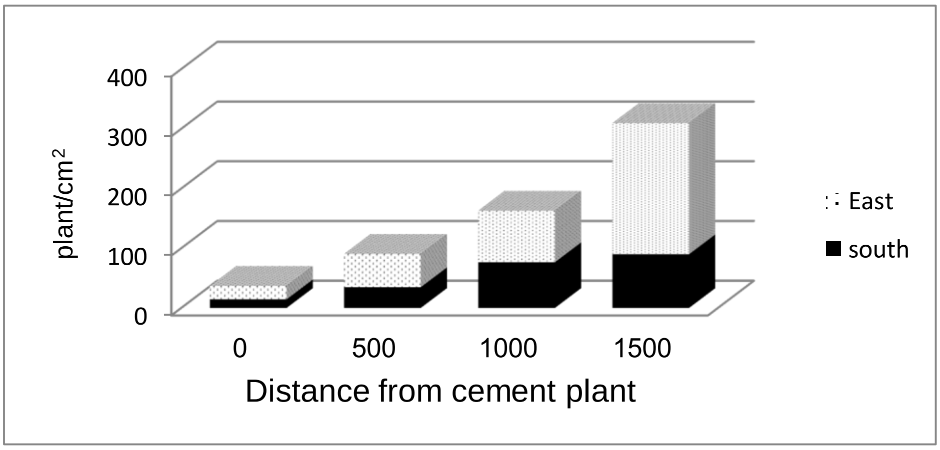

Figure 3: Vegetation density vs. distance from source.

Figure 4. Accumulation of cement dust on plant leafs near the Mergheb Cement Plant.

3.4 Lichens as air pollution indicators:

The nearest spotted species of lichens is found at 1000 m east of the site. A summary of observations is listed in table 4. These observations are in agreement with findings reported from USA by Taylor and Bell (1983).

Table 4. Lichens occurrence in the study area

Sample	Distance from source	NO. of species	Relative frequency %	Relative abundance %
S4	1500	2	12, 12	0.13
E3	1000	1	12	0.14
E5	1500	2	16, 20	0.07, 0.09

3.5 Vegetation characteristics vs. soil composition

The statistical analysis of the results obtained from the chemical analyses of soil samples using F-test. Table 5 reveal that the plants have no significant effect ($P > 0.05$) on the soil properties in both directions and at all sampling sites. The correlation coefficient indicate that there is no apparent relationship between soil composition and vegetation distribution characteristics. Therefore, gas pollutants such as SO_2 can be regarded as the main factor effecting the biodiversity of vegetation in the surrounding of the cement plant.

Table 5. Chemical analyses of 1:1 soil samples

Direction	East				South			
Distance from cement plant	1500	1000	500	0	1500	1000	500	0
(pH)	±6.80 0.1	±7.27 0.2	±7.20 0.1	±7.35 0.1	±7.25 0.1	±7.23 0.1	±7.33 0.1	0.2±7.11
E.C (ms/cm)	±1.71 0.12	±1.63 0.33	±2.12 0.10	±1.72 0.16	±1.61 0.24	±1.69 0.07	±1.62 0.04	±1.87 0.03
Cl^- (mg/l)	±840.2 98	±934.8 79	±1005.8 74	±923.0 78	±757.3 68	±627.2 74	±828.3 48	±982.2 89
Ca^{+2} (mg/l)	±100.0 9.2	±120.0 20.0	±160.0 20.0	±133.3 21.1	±133.3 23.9	±106.7 21.1	±146.7 13.3	±106.7 11.6
Mg^{+2} (mg/l)	±36.0 6.7	±22.8 1.2	±29.3 4.6	±36.0 3.3	±26.0 4.7	±22.0 3.4	±30.7 6.3	6.1±53.3
$CO3^{-2}$ (mg/l)	±650.7 70	±880.0 86	±942.7 77	±599.6 56	±732.0 68	±610.0 82	±569.3 58	±691.3 70
$SO4^{-2}$ (mg/l)	±92.4 7.1	±93.6 3.7	±108.5 6.1	±98.6 3.4	±67.6 3.6	±91.7 10.9	±77.7 13.6	5.8±95.5
Na^+ (mg/l)	±435.5 9.3	±417.1 5.3	±430.9 22.7	±403.3 10.6	±381.8 31.8	±391.0 7.9	±410.9 2.6	±378.7 33.9
K^+ (mg/l)	±64.4 3.7	±112.5 10.6	±193.7 11.8	±127.1 5.9	±149.1 15.8	±97.6 7.2	±92.4 8.8	±173.3 18.7

CONCLUSION

The study concludes that Mergheb Cement Plant has a pronounced impact on the density and diversity of the vegetation cover in the area of study that may impact other living species and drive the region towards progressive stages of desertification.

Stringent environmental measures in controlling and monitoring emissions from the plant and other emissions sources in the region ought to be applied. Further environmental impact assessment studies are recommended especially for any future industrial expansions.

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