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Vegetation record around a cement factory and the impact of dust pollution on crop productivity

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Abstract

Effect of cement dust pollution on crop productivity in the environment of Himal Cement Factory, Kathmandu, Nepal has been studied. The productivity of the crops like wheat, maize and mustard were significantly low in the fields 1.5 km around the factory site in comparison to the fields at 3-4-km distance. Productivity of rice was least affected. Polluted area around the cement factory becomes unsuitable for vegetable production due to deposition of dust particles on the leaves. A list of plants growing around the factory has also been presented.

***Key words*:** Air pollution, vegetation, crop productivity, cement dust.

Introduction

Suspended particulate matter and gaseous chemicals are the main forms of air pollution that are potential health and ecological hazards. Cement dust is a localized air pollution problem in the vicinity of a cement factory. Dust particles from the limestone mines, coal yards and cement clinkers are emitted into the air, together with dust from various processes such as crushing and clinkerisation. Heavy encrustation of cement dust is formed on the plants growing in cement polluted area. This dust coverage reduces the growth of the plants (Oblisami *et al.*, 1978), and brings physiological disorder to vegetation, which is responsible for the reduction of chlorophyll content and photosynthetic activities (Pandey & Kumar, 1996; Pandey & Simba, 1990 a; b) ultimately resulting in commensurate yield reduction. The loss due to the reduced agricultural production in vicinity of a cement factory might be of considerable significance not only in the economy of the people inhabiting these areas but in the economy of the whole country as well. An estimation of this economic loss in terms of reduced production of cultivated crops in the area affected by the dust emission of the cement factory is highly desired.

Certain plants are more sensitive to air pollution and used as indicators of the pollution (Brandt & Heck, 1968; LeBlanc & Rao, 1975). Prolonged exposure of the plants to cement dust might cause certain sensitive plants to disappear from the locality and if such plants are rare and endangered it could be a great loss of biodiversity resources. Heitherto, no attempt has been made to keep a record of the vegetation around a cement factory. Present paper presents a list of the plants growing within 4 km distance around a cement factory in Nepal together with a comparison of the crop productivity between dust polluted and dusts free area.

Material and Methods

The study area is situated in the environment of the Himal Cement Factory, at Chobhar near Kirtipur, 5 km south-west of Kathmandu, Nepal. Commissioned in 1974, the company has expanded its production capacity from 60 to 400 tonnes of clinker per day. The company estimates an average emission of 2.85 tonnes of dust per 24 h from the stack and around 10 tonnes of dust from limestone handling from the query site (Bhattarai, 1993). Himal Cement Factory also contributes to air quality degradation in Kathmandu Valley (NCP/ IUCN, 1993).

Plant specimens were collected from the area 4 km around the factory site and identified by comparing with the specimens at National Herbarium and Plant Laboratory, Godawari, Kathmandu, Lalitpur, Nepal. The sampling procedure was adopted in the two different steps to obtain the baseline survey data. The first step was to select villages that are having true chance of exposures and are nearer (within 0-1.5 km) to the factory and considered as dust affected area. The second was to select the villages that could be considered as pollution free area (within 3-4 km periphery from the factory) as no trace of the dust could be seen deposited on the plant surfaces. A semi-structured questionnaire was prepared for farmers and local people to find out information on general effects of the pollution that they are facing, and area and yield under cultivation. The data for land area and production were pooled separately from the two sites (polluted and pollution free) and average productivity was calculated on that basis. Three villages of Kathmandu districts (Upalloguth, Talloguth, Lapsibot) and four of the Lalitpur districts (Thapagaun, Pakhagaun, Thanagaun, Tokhaphant) were taken from the polluted site whereas from the pollution free zone Bhajangal, Panga, Itagol, Taudaha (Kathmandu district), Chalnakhel and Saibupakhagaun (Lalitpur districts) were sampled. Foliar injuries were observed by visual inspection in the field.

Results

Vegetation

In the study area 118 different species of plants (Table 1) were recorded of which two are the plants which have been enlisted as rare and vulnerable plants by Shrestha (1996). On the basis of frequency of collection rest of the plants are recorded as very common (VC), common (C) and seldom available (Sa). Collection was also made of the plants planted inside the complex of the factory, from where 17 plants were recorded out of which eight were exotic trees (Table 2).

Table 1. Enumeration of plants growing within 1.5 km periphery of Himal Cement Factory. C = Common, VC = Very common, Sa = Seldom available, V = Vulnerable, R = Rare.

Botanical name	Family	Common name	Abundance
Achyranthes aspera L.	Amaranthaceae	Apamarga	C
Adhatoda vasica Nees	Acanthaceae	Asuro	C
Agave americana L.	Amaryllidaceae	Ketuki	C
Ageratum conyzoides L.	Compositae	Ilame	C
Albizzia procera (Roxb.) Benth.	Mimosaceae	Siris	C
Alnus nepalensis D. Don	Betulaceae	Utis	C
Amaranthus viridis L.	Amaranthaceae	Latte	C
Amaranthus spinosus L.	Amarantheceae	Lunde	C
Artemisia vulgaris Linn.	Compositae	Titepati	VC
Berberis aristata DC.	Berberidaceae	Chutro	C
Bidens pilosa L.	Compositae		C
Boehmeria sp.	Urticaceae	Kamle	C

Boenninghausenia albiflorra (Hook.) Meisn.	Rutaceae		C
Bombax malabaricum DC.	Bambaceae	Simal	Sa
Buddleja asiatica Lour.	Loganiaceae		C
Cannabis sativa L.	Cannabinaceae	Bhanj	VC
Cassia tora L.	Caesalpinaceae		C
Celtis australis L.	Ulmaceae	Khari	VC
Centella asiatica (L) Urban	Umbelliferae	Ghodtapre	C
Centipedia minima (L)A.Br.et Aschers.	Compositae		C
Cestrum parqui L'Herit.	Solanaceae		C
Chenopodium album L.	Chenopodiaceae	Bethu	C
Choerospondias axillaris Burtt et Hill.	Anacardiaceae	Lapsi	C
Cinnamomum camphora (L) Sieb.	Lauraceae	Kapur	C
Cirsium sp	Compositae		C
Cissampelos pareira L.	Menispermaceae		Sa
Citrus grandis Linn.	Rutaceae	Bhogate	C
Colebrookea oppositifolia J.E. Smith	Labiatae	Dhursul	C
Conyza sp.	Compositae		C
Cuscuta reflexa roxb.	Cuscutaceae		C
Cyathocline purpurea O. Kuntz	Compositae	Chhichhine	C
Cynodon dactylon (L.) Pers.	Gramineae	Dubo	VC
Cynoglossum zeylanicum Thunb. ex Lehm.	Boraginaceae		C
Dendrocalamus sp.	Gramineae	Bans	C
Duranta repens L.	Verbenaceae	Nilkanda	VC
Eclipta prostrate L.	Compositae	Bhringiraj	C
Eupatorium adenophorum Spreng	Compositae	Banmara	VC
Equisetum diffusum D. Don	Equisetaceae		C
Eragrostis sp.	Gramineae		C
Erigeron bellidioides Benth ex C.B. Clarke	Compositae		C
Eucalyptus cameldulensis Dehn.	Myrtaceae		C
Euphorbia heterophylla L.	Euphorbiaceae		C
Ficus sp.	Moraceae		C
Fragaria indica Andr.	Rosaceae		C
Fraxinus floribunda Wall. in Roxb.	Oleaceae	Lankuri	C
Galinsuga ciliata (Rafin)Blake	Compositae		VC
Geranium nepalense Sweet	Geraniaceae		C
Gnaphalium purpureum L.	Compositae		C
Gonostegia hirta (Blume) Miq.	Urticaceae	Aternu	C
Grevillea robusta A. Cunn.	Proteaceae	Kangiyo	C
Hibiscus rosa-sinensis L.	Malvaceae	Ghantephul	C
Homalium nepaulense (DC.) Benth.	Flacourtiaceae		V
Imperata cylindrica (L.) Beauv.	Gramineae	Siru	C
Ipomoea purpurea (L.) Roth	Convolvulaceae		C
Jasminum humile L.	Oleaceae	Jai	C
Juglans regia L.	Juglandiaceae	Okhar	Sa
Lagerstroemia indica L.	Lythraceae	Asare	Sa
Lantana camera L.	Verbinaceae		C
Ligustrum confusum Decaisn	Olaceae		C
Maesa chisia Buch.-Ham. Ex D. Don	Myrsinaceae	Bilaune	Sa
Magnolia grandiflora L.	Magnoliaceae	Thalkamal	Sa
Melia azedarach L.	Meliaceae	Bakaino	C
Mussenda frondosa L.	Rubiaceae		C
Nasturtium officinal R.Br. ex Aiton	Cruciferae	Simsag	C
Oenothera erythrosepala Borbas	Onagraceae		C
Oxalis corniculata L.	Oxalidaceae		C
Plantago major Linn.	Plantaginaceae		VC

Paspalum sp.	Gramineae		C
Phragmites karka Trin ex Steud.	Gramineae	Narkat	C
Pinus roxburghii Sargent	Pinaceae	Sallo	C
Plumbago zeylanica L.	Plumbaginaceae		C
Pogonatherum crinitum (Thunb.)Kunth	Gramineae		VC
Polygonum perfoliatum L.	Polygonaceae		C
Polygonum sp.	Polygonaceae		C
Populus sp.	Salicaceae	Lahrepipal	C
Princepia utilis Royle	Rosaceae		C
Prunus persica Sieb. et Zucc.	Rosaceae	Painyu	C
Pteris longifolia Aucct.	Pteridaceae		C
Punica granatum L.	Punicaceae	Anar	C
Pyracantha crenulata (D.Don) Roem	Rosaceae	Ghangaru	C
Pyrus communis L.	Rosaceae	Naspati	C
Pyrus malus L.	Rosaceae		C
Ranunculus sceleratus L.	Ranunculaceae		VC
Rhus javanica L.	Anacardiaceae	Bhakimlo	Sa
Rhus parviflora Roxb.	Anacardiaceae	Satibayar	Sa
Rosa microphylla Lindle	Rosaceae		C
Rubia cordifolia L.	Rubiaceae	Majito	Sa
Rubus ellipticus J.E. Smith	Rosaceae	Ainselu	C
Rubus paniculatus J.E. Smith	Rosaceae		C
Rumex nepalensis Spreng.	Polygonaceae	Halhale	VC
Saccharum spontaneum L.	Gramineae	Kansh	C
Salyx babylonica L.	Salicaceae	Bains	C
Sambucus hookeri Rehder in Sarg.	Caprifoliaceae	Jaliphul	C
Sapium insigne Benth ex Hook.f.	Euphorbiaceae	Khirra	C
Scutellaria discolor Celebr.	Labiatae		C
Setaria sp.	Gramineae		VC
Solanum nigrum L.	Solanaceae		C
Solanum sp	Solanaceae	Datura	C
Solanum xanthocarpum Schrad et Wendl.	Solanaceae	Kantakari	C
Soncus arvensis L.	Compositae	Dhude	C
Stellaria media L.	Caryophyllaceae		C
Stephania glandulifera Miers	Menispermaceae		Sa
Thelptyeris ciliata (Wall. ex Benth.) Ching	Thelypteridaceae		C
Toona ciliate M. Roem	Meliaceae	Tuni	R
Trifolium repens L.	Papilionaceae		VC
Urtica dioica Linn.	Urticaceae	Sisnu	C
Vitex negundo L.	Verbinaceae	Simali	C
Zanthoxylum armatum DC.	Rutaceae	Timur	Sa
Zizyphus incurva Roxb.	Rhamnaceae	Hadebayar	VC
Zizyphus jujube Lam.	Rhamnaceae	Bayar	Sa

Table 2. Plants growing inside the complex of the cement factory. * = Exotic

Botanical name	Family
Alnus nepalensis D. Don	Betulaceae
**Alnus nitida* (Spach.) Endl	Betulaceae
Callistemon citrinus (Curtis) Skeels	Myrtaceae
Celtis australis L.	Ulmaceae
**Cinnamomum camphora* (L.) Sieb.	Lauraceae
Duranta repens L.	Verbinaceae
**Eucalyptus cameldulensis* Dehn.	Myrtaceae
Fraxinus floribunda Wall. in Roxb.	Oleaceae

**Grevillea robusta* A.Cunn. ex R.Br.	Proteaceae
**Jacaranda mimosaefolia* D. Don.	Leguminosae
Juniperus sp.	Pinaceae
Pinus roxburghii Sargent	Pinaceae
**Populus deltoids* Marsh	Salicaceae
**Salix babylonica* L.	Salicaceae
Sapium insigne (Royle) Benth. ex Hook. f.	Euphorbiaceae
Sambucus hookeri Rehder in Sarg.	Caprifoliaceae
Zizyphus incurva Roxb.	Rhamnaceae

Problems associated with dust as perceived by the local community

Mechanical turbulence and poor sunlight during winter are most prominent problems, which create a direct problem to the farmers in their usual practice of sun drying their crops like rice, wheat etc. There is more serious effect on winter crops (Nov.- Feb.) as rainfall is poor to wash the dust and thus dust remain deposited for longer time over the foliage of plants.

The problem is serious 1 km from the factory site. People around the factory report that there is more roadside accident near to the factory. Due to heavy deposition of dust, no vegetable cultivation could be carried out in the severely affected area and the straw of rice, wheat and barley is not palatable to livestocks. Livestocks suffer from diseases if they are fed on the straws for a long time. In Tokhaphant there is a problem of threshing rice as no workers are available to thresh rice because of cement dust.

Foliar enjury

Following observations were made during site survey

a) The ventral part of the leaves is not exposed to rain water, so a layer of dust deposition is seen even after continuous rain.
b) From visual inspection it was observed that most affected plants were *Pinus roxburghii* and the color of the leaves of *P. roxburghii* look different from that of a normal tree.
c) Abrasions caused by cement dust were found on broad-leaved trees and leafy vegetables. But no serious diseases could be observed in the field.

Productivity

The average productivities of different crops from the polluted and pollution free zones are compared in Table 3.

Rice was found to be relatively resistant to the cement dust pollution. Although the data shows less production of rice in polluted area the difference is not significant. Maize and wheat are most affected crop where 66.7 and 62.1% reduction is recorded, respectively in these crops. Mustard is also highly affected where a reduction up to 26.6% was observed.

Farmers reported that Millet was in cultivation in the polluted area up to 8-10 years ago. But, due to the dust problems no millet farming is seen in this area. No leafy vegetables were observed cultivated in the heavily polluted area.

Table 3. Comparison of the productivity of different crops in the polluted and pollution free areas. ±SD

Crops	Productivity (Kg/Ropani*)		Reduction
	Polluted area	**Non polluted area**	%
Rice	217 ± 19.8	231 ± 33	6.1

Wheat	99 ± 1.7	264 ± 40	62.1
Maize	33 ± 11.8	99 ± 1.7	66.7
Millet	-	66 ± 9	-
Barley	-	99 ± 1.7	-
Mustard	18.2 ± 1.7	24.8 ± 8.3	26.6
Potato	151.8 ± 19.8	165 ± 1.7	8.5

*1 Ropani = 5476 Sq ft.

Discussion

In order to improve economic and social well being, many developing countries give priority to rapid industrial development. Although it can lead to progress and improved quality of life, it can also produce serious environmental deterioration if not carefully controlled (Karmacharya & Shrestha, 1993). The economic costs related to air pollution are manifested in different ways. One of the significant effects is that it might affect the physiological life of the plants to such an extend that the sensitive plant may die and ultimately its population disappear from the polluted locality (Darley, 1966; LeBlanc & Rao, 1975). Air pollution from a cement factory could cause immeasurable loss if some endemic or threatened plants that are sensitive to pollution are growing in the area. As no previous record of the vegetation of the locality is available, present study is a first attempt to keep a record of the vegetation growing in the vicinity of a cement factory in Nepal.

The major air pollutants of the cement factory are particulate and gaseous wastes such as SO_2, CO and NO_2, which are emitted from chimneys or smoke stakes. Dust emitted generally contains carbonate, silicate, aluminate fluoride and alkalihalides (NCP/IUCN, 1993). The limestone required for the Himal Cement Factory comes from the limestone deposits of Chobhar hills. ISC (1987) reported that the flue gas emitted from the cement kiln before the factory's expansion (1989) contained various gaseous compounds including NO (200 ppm), NO_2 (30 ppm) and SO_2 (5 ppm). Carbondioxide form 16% of the flue gas and CO, 2-6%. Emission of NO_2 and SO_2 were within international standards but the dust emission was high even from the new kiln (Miyoshi, 1987). Dust is also emitted from the limestone crusher, saw mill, raw material storage yard and limestone excavation processes. These emissions have not been measured.

Meteorological parameters such as wind speed and direction, vertical temperature gradient and flux were not available and thus dispersal rates and area could not be calculated. Visual observation showed that a layer of dust remains deposited on the lower surface of the leaves even after heavy rainfall during the rainy season. Himal (1987) reported that depending on the wind conditions, Chobhar village near the factory and Saga village across the Bagmati river were enveloped in dust and the area looked whitish gray. The lack of adequate dust collectors was cited as the reason for high dust emission.

Effects of cement kiln dust on various aspects of plant life have been studied by various workers (Pierce, 1910; Oblisami *et al.*, 1978; Singh & Rao, 1978; Pandey & Simba, 1990 a; b; Pandey & Kumar, 1996). These works conform that dust pollution affects the growth and different physiological processes of the plants which is the ultimate cause of the yield reduction. Our survey and analysis of the collected data on productivity of various crops showed that productivity of the land around cement factory is considerably low as compared to the lands at a distance from the factory. Productivity of crop plants depends on various factors of which two significant factors are the quality of the land itself and the use of fertilizers. In the present survey all the possible attention was paid to ascertain that

the general quality of land in which the crops were grown falls in the same category. Although the judgement was based on local farmer's information, considering the fact that in villages the buying and selling of lands is generally based on the average productivity, it is expected that the average data on the productivity could be more or less uniform and reliable. The area considered as polluted is inhabited by poor farmers who use only the animal dung as fertilizers. A few farmers on pollution free villages use chemical fertilizers. However, these cultivation's were excluded from the present survey to keep uniformity on the results.

The health hazards due to the dust pollution of a cement factory are obvious and well known. Our observation shows that in addition to other problems, there is a general loss of crop productivity in the land around a cement factory. Wheat, maize and mustard crops are seriously affected and the area around the factory becomes totally unsuitable for vegetable production. Even the paddy hay and wheat straws become unpalatable to the livestocks. Thus it is desirable that while establishing a factory the economic loss due to its pollution be considered in totality and compare to the economic upliftment due to the industrial production.

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