# Economic and Health Consequences of Lime Dust Emission in Digana, Kandy District

S.M.T.K. Samarakoon and S.Thiruchelvam[1]

Postgraduate Institute of Agriculture
University of Peradeniya,
Peradeniya, Sri Lanka

***ABSTRACT.*** *Health reports have indicated increased respiratory diseases in Sri Lanka, particularly in the central province. Pollution caused by the lime industry in Digana, Kandy district is a matter of serious concern. In this paper, an effort has been made to assess the severity of lime air pollution on health and socio economic factors of households. In each 500, 1000, 1500, and beyond 2000 m distance from the limekiln area, 35 households were randomly selected and were interviewed by using a structured questionnaire. The cost of illness approach was used to calculate the health damage. About 41 and 12% of the total population living within 500 and 1000 m distance from the limekiln area, respectively were experiencing significantly high health costs due to the exposure to lime dust. The factors affecting health were incorporated in a logit regression model. Results revealed that people above 60 years and children below 15 years were more affected with respiratory diseases mainly with asthma, bronchitis and tuberculosis. The workers involved in the lime industry faced acute and chronic health problem due to prolonged exposure to lime dust. The average cost of illness that includes treatment cost, loss of productivity and loss of earnings due to respiratory diseases was about Rs. 850.00 per capita per month. The distance, severity of dust exposure, and age are significantly influencing the probability of falling sick. The income and education of the people have not shown any influence on health. It has been concluded that implementing strong environmental standards, making people aware about the industry pollutants and their hazardous impacts, and improving health facilities are the indispensable measures to be taken to help the poor who live close to the lime industry.*

## INTRODUCTION

Air pollution is a serious, and growing problem in both industrialized and developing countries, in both rural and urban areas. The industrial revolution in Europe in the 19$^{th}$ century has seen the beginning of air pollution, which has gradually become a global problem today. The primary cause of air pollution is human activity, such as the generation of electricity, vehicle use and industrial operation, mainly in urban areas. The effect of air pollution on human beings and ecosystems has long been recognized, but it is only recently that the relationships between air-pollutant emissions and exposure have been well understood. The health effects of certain air pollutants have been documented in a number of studies (Croppers *et al.,* 1997; Dockery and Pope 1993; Ostro, 1994; Pope *et al.,* 1995; Schwarz and Dockery, 1992). Those pollutants which are of great concern on their health

[1] Department of Agricultural Economics and Business Management. Faculty of Agriculture, University of Peradeniya., Sri Lanka.

impacts are Carbon Monoxide (CO) for cardiovascular disease, Hydrocarbons (HC) for cancer, Sulphur Dioxide ($SO_2$) for asthmatics, Nitrogen Oxides (NOx) and Particulate Matter (PM) for affecting lung function. Substantial evidence of strong correlations between exposure to ambient air pollution concentrations and health risks has been gathered in developed countries and for some developing countries (Cropper *et al*., 1997; Ostro, 1994). The World Bank (1997) estimates that reducing PM to safe levels could reduce premature deaths by 30,000 to 700,000 a year in developing countries. There are several studies attempting to correlate air pollution levels with various demographic groups (*e.g.* disadvantaged groups with low income or low education). But this type of study has not yet been conducted in Sri Lanka.

Air pollution in Sri Lanka has been a major issue due to inadequate law enforcement (Senerath, 2000). According to the reports, 69% of the domestic sector and 17% of the industrial sector cause air pollution. The transport sector is the biggest contributor of pollutants to the environment (Sunil, 2000). The development of the industrial sector in Sri Lanka, particularly the construction sector, has created a high demand for lime use in building construction. In Sri Lanka, lime production is basically a domestic industry that follows traditional methods in a small-scale and producers are hardly concerned about the pollution and pollution-corrective measures. According to the health report issued by the Ministry of Health, the area which is most affected by disease like asthma, bronchitis, and tuberculosis is the Central Province. If no adequate measures are taken to control the emission of lime dust, it will lead to serious health hazards. Accurate information pertaining to costs and benefits associated with the lime industry is an important factor that would contribute to an effective resolution process and to establish more efficient pollution policies. Lime industry in Digana has brought about a gradual deterioration of ambient air quality in the vicinity of it. The limekilns discharge dust particulate fume and gases during the various stages of lime and dolomite production. The emission of the industry damage the ecological balances particularly, the air water quality, vegetation and agriculture in the area. Also due to sedimentation of excessive dust particulate, there is general property damage in the area.

In the context discussed above, the general objective of this study was to examine the severity of lime air pollution on health. The results of this study could be used in improving policies on air pollution, especially due to lime emission in the locality in Digana, in the Kandy district and other similarly affected areas. The specific objectives of the study included; (i) determining the public perception of the severity of lime air pollution, (ii) assessing the type of health problem faced by the people in the vicinity of limekiln area and estimate the cost of respiratory diseases of people, and (iii) assessing the probability of health risk relative to the socio economic characteristics, of people and drawing policy recommendations to minimize health damage in people affected by the lime dust pollution in Digana and other affected areas.

## MATERIALS AND METHODS

### Study area

Digana is a small town in the Central Province of Sri Lanka located 16 km away from the Kandy town. About 40 ha of large rock of lime is found in Digana. The estimated

population in the study area is 3,200. There are eight lime factories involved in the production of lime and dolomite using raw material in the locality. Explosives and heavy machineries are used for extraction of lime rock. During the process of mining, a large volume of limestone dust is emitted to the atmosphere in the form of fumes. The impact of lime dust is felt up to 2 km from the lime production area. Due to lime industry, transport and other infrastructure facilities have developed in this area. Gonawala North and South and Digana *Grama Niladhari* divisions, located in Kundasalae Divisional Secretariat were selected to investigate the problem. The selection of these areas was based on the information collected by a rapid appraisal, conducted prior to the field survey.

**Data collection**

The sampling was based on stratified-based-radius distance from the location of the lime production area classified as within 500, 1000, 1500 and beyond 2000 m. In each category, 35 households and thus a total of 140 households were interviewed. Information from 464 people from these 140 households was collected using a structured questionnaire during February to March 2006. After explaining the purpose of the survey, the respondents were asked to provide information on their health related to respiration and the socio economic characteristics of the household head and the family members. Patients were diagnosed with the help of midwives and the clinic card was also used to confirm the health status of the patients. Care has been taken to calculate the treatment cost with regard to respiratory diseases. It covered incidents and duration of illness, symptoms, actions taken, treatment cost and loss of income due to respiratory related illness. Secondary data was gathered from the hospital, medical practitioners, and the *Grama Niladhari* and through group discussions with people concerned about the environment and lime industry owners.

**Perception of lime pollution**

The perception of the people towards air pollution problem was measured in five different aspects using the Likert scaling method. The response to each aspect was recorded as; strongly agree (5), agree (4), neutral (3), disagree (2) and strongly disagree (1), for favorable statement and vice versa. To get an overall perception, total scores for the responses of all five perceptions were summed up.

**Cost of illness**

The health impacts of air pollution have been divided into sickness or morbidity, and premature deaths or mortality. Once the physical health impacts have been estimated, a monetary value needs to be placed on them, in order to give economic benefits of a reduction in air pollution. There are two main approaches that the economists use to value health outcomes. These approaches are the cost of illness for morbidity and mortality, and the human capital for mortality, based on either individual preference compensation or resource or opportunity cost. The latter one is more direct and the most commonly used to value the health damage.

Air pollutant emitted due to the lime industry could be divided into two types as gases and particulates. These gases could be further classified as Carbon Dioxide (CD) and CO. Similarly, suspended particulate also can be sub divided into coarse particulate and fine

particulate. The fine particulate can travel a great distances before settling down. The present study focuses only on local impacts of air pollution damage on human health.

This study uses the cost of illness approach. This approach includes direct and indirect costs. The direct cost includes medical cost (*e.g.* drugs, tests and other investigations) and non-medical cost (*e.g.* cost of stay, consultations and nursing care), while indirect cost includes loss of earnings during the stay in hospitals, visits to hospitals, due to convalescence and minimum wage.

### Health risk model

A logit model was used to relate econometrically a set of medical risk indicators to a set of characteristics of people, and to estimate the probabilities of health risk due to lime dust pollution exposure. The logistic distribution has been used in many applications because of its mathematical convenience. The general mathematical expression for two variables $X_1$ lime dust pollution exposure and $X_2$ socio economic characteristic is presented as;

$$\ln (p_i/1-p_i) = \alpha + \beta_1 X_{1i} + \beta_2 X_{2i} . \quad (1)$$

Where, $p_i$ is the probability of having health impairment and $1-p_i$ is the probability of not having health impairment. The probability of a person in the surveyed area suffering from specific respiratory health impairment can be estimated by;

$$p_i = Exp.(\alpha + \beta_1 X_{1i} + \beta_2 X_{2i})/1 + Exp.(\alpha + \beta_1 X_{1i} + \beta_2 X_{2i}) \quad (2)$$

It was hypothesized that a set of factors such as the total monthly house hold income ($X_1$), the education levels of the household head and house wife ($X_4$) and the distance from the limekiln area ($X_7$) are negatively related to health risk due to the exposure to lime dust emission, while the age of the respondent ($X_2$), the family size ($X_3$), the number of years respondent has been a resident of Digana ($X_5$), the gender ($X_6$: male = 1 or female = 0), the employment ($X_8$: employed in limekiln = 1 or = 0) and the visibility of lime dust pollution ($X_9$: Dummy variable law = 1 to high = 4) are assumed to be positively related to health risk due to lime dust emission exposure. Thus, a linear logistic model of the following form was fit to estimate the likelihood of health damage.

$$Logit (p) = f ( X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9) \quad (3)$$

## RESULTS AND DISCUSSION

### Characteristics of households

The average age of the household head was 48 years. The average family size for the sample (4.6) is greater than that of Sri Lanka's average family size (4.3). According to the survey findings, 12% of the head of households had not received any level of education. Majority of them are laborers. About 37 and 55% have had an education lower than secondary education and above, respectively. About 36% of the sample was involved in paddy and vegetable cultivation, 18% were involved in private business, 8% were government employees and the majority (37%) was engaged as laborers in the lime industry

(Table 1). Laborers' education levels were relatively lower than that of the other employment categories.

**Table 1. Descriptive statistics of household and data used for Logit model.**

| Variable (units) | Mean | SD | Min. | Max. |
|---|---|---|---|---|
| Income ($X_1$: Rs./month) | 5,888.00 | 3,360.00 | 1,000.00 | 20,000.00 |
| Age ($X_2$: years) | 30.00 | 18.00 | 1.00 | 84.00 |
| Family size ($X_3$: number) | 4.64 | 0.69 | 2.00 | 6.00 |
| Education ($X_4$: years) | 10.00 | 3.00 | 0.00 | 12.00 |
| Years of residence ($X_5$: years) | 23.00 | 20.00 | 1.00 | 50.00 |
| Gender ($X_6$:1=male; 0=female) | 0.48 | 0.09 | | |
| Distance ($X_7$: m) | 982.00 | 776.00 | 10.00 | 2,000.00 |
| Employment ($X_8$: limekiln=1 if not 0) | 0.33 | 0.03 | | |
| Experience: ($X_9$: 1=Yes; 0=No) | 0.70 | 0.10 | | |
| Visibility: ($X_{10}$: dummy variable 1-4) | 2.60 | 0.52 | 1.00 | 4.00 |
| Medical expenditure Rs./month | 200.00 | 50.00 | 100.00 | 300.00 |
| Working days loss | 3.50 | 0.50 | 1.00 | 7.00 |
| Total health damage (Rs./person/month) | 865.00 | 210.00 | 540.00 | 1,700.00 |

**Note:** SD - Standard deviation; Min. - minimum; Max. - maximum.

The investigation shows that there was a significant difference in living standards among people living closer and the people living far from the lime industry. The average family income of the population was Rs. 5,888.00/month. The investigation revealed that the contribution to the income from the lime industry was higher among laborers living near the lime industry (66.5%) than those who were living away (43.6%) from the lime industry. This indicates that laborers are more dependent on lime industry for their livelihood. People tend to settle down closer to those areas owing to the availability of employment, both direct and indirect and also of the opportunities for investments. Even though some of these employments are risky and hazardous, people have no option other than seek for short-term benefits for survival**.** In addition, the increasing pressure of population, unemployment and poverty enhances this process.

**Perception of lime dust pollution**

It was evident that air pollution is a major concern for the residents, with moderate or extreme concerns reported by 90% for lime dust pollution, 85% for air pollution (all types), 81% for traffic exhaust, 78% for water and 76% for soil. Concerns on air pollution were significantly related to educational level. Respondents who had completed secondary education and above were more likely to report concerns about lime air pollution in their neighborhood. About 74% of them have complained of frequent headaches. This is followed by respiratory health (19%) and psychological effects (7%). Most respondents mentioned lifestyle disruption as the effect of lime dust pollution on their daily lives where

they have to stay indoors for a large part of the day in closed houses and more than 50% of the respondents also considered lime dust pollution to be a health related problem. From these data, it appears that the residents of Digana perceive links between lifestyle issues and health effects.

In terms of action taken by the respondents, 11% have written or spoken to politicians, the government or owners of lime industry about air pollution reduction, over the last two years. However, a somewhat higher percentage (28%), considered moving out of the neighborhood because of lime dust pollution. Of those who had expressed concerns about lime dust pollution, 64% believed it was the lime producer who should be responsible for reducing the lime dust pollution, while another 36% felt that the government should be responsible. It can be seen that due to lime dust pollution, the areas closer to lime industries are becoming not suitable for residential purposes. Air pollution affects the community by lowering the quality of life and its ability to attract new business and employment to Digana.

**Health damage due to lime dust pollution**

Data on the relationship between distance to the lime industry and the observation of respiratory disease in the study area is presented in Table 2. According to the results, respiratory diseases significantly affected 41 and 12% of the population living within 500 and 1000 m distance from the lime industry, respectively. Cases of respiratory diseases within 500 m distance were four times higher than within 1000 m distance.

**Table 2. Health damage in relation to distance to lime industry.**

| Distance (m) | Total No. | Affected No.* | Number affected by the type of respiratory diseases* | | | | |
|---|---|---|---|---|---|---|---|
| | | | Asthma | Bronchitis | Tubercu -losis | Pneum- onia | Pleurisy |
| 0-5000 | 116 | 47 (41.0) | 18 (16.0) | 12 (10.0) | 1 (0.9) | 01 (1.0) | 15 (13.0) |
| 501-1000 | 115 | 14 (12.0) | 04 (3.0) | 05 (04.0) | 1 (0.9) | 01 (1.0) | 03 (03.0) |
| 1001-1500 | 117 | 03 (03.0) | 01 (0.9) | 01 (01.0) | 0 (0.0) | 00 (6.0) | 01 (00.9) |
| 1501-2000 | 116 | 08 (07.0) | 02 (1.7) | 02 (01.7) | 0 (0.0) | 00 (0.0) | 04 (03.4) |
| Total | 464 | 72 (15.5) | 25 (5.4) | 20 (04.0) | 2 (0.4) | 02 (0.4) | 23 (05.0) |

**Note:** * Percentages are given in parenthesis.

The relationship between age group and respiratory disease in the study area (Table 3) indicates that people over 60 years (30%) and children below 15 years (27%) were more affected with respiratory diseases.

**Table 3. Health damage in relation to the age.**

| Age group (years)* | 0 – 15 | 16 - 30 | 31 - 45 | 46 - 60 | > 60. | Total |
|---|---|---|---|---|---|---|
| Affected by respiratory diseases* | 17 (27) | 5 (6) | 12 (16) | 16 (22) | 21 (30) | 72 (100) |

**Note:** * Percentages are given in parenthesis

**Table 4. Health damage in relation to the gender.**

| Gender | Total No. | Affected No.* | No. affected by the types of respiratory diseases* | | | | |
|---|---|---|---|---|---|---|---|
| | | | Asthma | Bronchitis | Tuberculosis | Pneumonia | Pleurisy |
| Male | 224 | 27 (12) | 09 (4.0) | 09 (4.0) | 01 (0.4) | 01 (0.4) | 07 (3.1) |
| Female | 240 | 45 (19) | 16 (6.7) | 11 (5.0) | 01 (0.4) | 01 (0.4) | 16 (6.7) |

**Note:** * Percentages are given in parenthesis.

Table 4 shows the types of respiratory diseases by gender. About 5.4% of the people reported that they or someone in their household currently have asthma as diagnosed by a doctor. Of these, 75% reported regular use of a puffer or inhaler. About 4.0 and 0.4% of the people have chronic bronchitis and pneumonia or a persistent cough, respectively as diagnosed by a doctor. More females (19%) are affected than males (12%) by these respiratory diseases (Table 4). Asthma was found to be more common among the female. This may be due to the reason that more female were working in the limestone quarry site and most of the housewives stay in the project area compared to their husbands who are employed outside. This inference was supported by information collected at the Menikhinna base hospital and from the private medical practitioner who serves in this area. It has also been indicated that diseases such as asthma, bronchitis, pleurisy, tuberculoses are found to have been increased in the past years.

The records maintained at Kundasale Government Hospital indicated that the reported asthma rates were 4.5% in the past two years. On average, about 15.3% of the population reported an illness episode and 52% sought treatment. This is due to the fact that the poor income group relies disproportionately on health treatment where as the average income group rely on hospitals and distance facilities.

**Cost of illness**

The estimated hospital cost per household and emergency treatment cost on account of air pollution were found to be in the range of Rs. 100.00 and Rs. 170.00 per month. This is about 1.7 to 2.9% of the average monthly income (Rs. 5,880.00) of people living in this study area. The total health damage cost including loss of earning during the hospital stay and hospital visits, loss of earning due to convalescence and minimum wage of labor category, works out to be in the range of Rs. 810.00 to 920.00/month. Thus, the total damage to health is about 4 times higher than the direct health cost. However, the actual health damage is much higher than these estimates.

**The empirical results of health impairment from lime dust pollution**

Tables 1 and 5 show the descriptive statistics of data used and the estimation results of logit model, respectively. The results of logit model (Table 5) indicated that the probability of people falling sick due to lime dust pollution is significantly affected by distance from the limekiln area, visibility of dust, income, age, years of resident and gender.

The estimated coefficient for distance from limekiln showed the negative sign as expected and significant at 1% level. This means that people living closer to the limekiln were more affected by the lime dust pollution. The household income has a negative sign and it was significant only at 10% level. This indicates that the health damage was high with low-income people. Age and probability of falling sick show a significant positive sign at 5% level as hypothesized. This indicates that the higher age tends to be associated with an increasing probability of falling sick.

**Table 5. Regression results of Logit regression on health impairments of people.**

| Variables | Coefficient | Std. Er. | t-value | P-value |
|---|---|---|---|---|
| Constant | -1.265 | 0.097 | -1.344 | 0.191 |
| Income | -0.011 | 0.003 | -1.601 | 0.009 |
| Age | 0.019 | 0.008 | 2.315 | 0.005 |
| Family size | 0.002 | 0.191 | 0.122 | 0.903 |
| Education | 0.076 | 0.050 | 1.152 | 0.127 |
| Years | 0.031 | 0.013 | 2.311 | 0.006 |
| Employment | 0.342 | 0.012 | 2.842 | 0.001 |
| Gender | 0.019 | 0.014 | 1.191 | 0.102 |
| Visibility | 1.043 | 0.377 | 2.771 | 0.003 |
| Distance | -0.011 | 0.002 | -4.534 | 0.000 |
| Log likelihood | -624.206 | | | |
| Restricted Log likelihood | -656.762 | | | |
| No. of observations | 140 | | | |

The coefficients for the family size and education were not significant. Further, results suggested that health damage increased with increasing visibility of lime dust pollution. Gender variable showed a positive sign, but not significant. However, the opportunity cost for a female member falling ill is higher than that for a male member. People employed in the limekiln industry showed positive and 1% significant probability of the health risk. Further, workers without protective clothes exposed to such polluted air in various operations for prolonged periods are more affected by respiratory diseases and there is a high health risk for their lives.

## CONCLUSIONS

The lime cottage industry in Digana has brought about a gradual deterioration of the ambient quality in the vicinity of the limekiln. People who live close to the limekiln are much exposed to the dust particulate and fume, emitted from the kiln experience relatively high levels respiratory diseases such as asthma bronchitis and tuberculosis. This exposure led to a considerable increase in their expenses for medical treatment for respiratory diseases. Levels of concern for lime dust pollution were much higher than other types of

pollutions such as water and soil. Thus, the intervention of the government has become indispensable to implement strong environmental policy, make people aware about the industry pollutants and their hazardous impacts, and improving health facilities should help the poor those who live close to the lime industry.

There may be possibilities of improving emission-controlling systems and to use eco-friendly technologies in lime production. More importantly reductions of emission will result in increase in the cost of production at the first place and as a results improve the labor productivity and the improvement of standard of living of the people in general. Research in the area of environmental management is important to formulate policy measures related to environmental pollution at the national level.

## ACKNOWLEDGEMENTS

Authors would like to extend their gratitude to the Ministry of Economic Reform Science and Technology for granting the financial assistance to carry out this study. The authors also appreciate the anonymous referees 'valuable comments and constructive suggestions.

## REFERENCES

Cropper, M.LN.B., Simon, A., Alberni, A. and Sharma, P.K. (1997). The health effects of air pollution in Delhi, India. Policy research working paper No 1860. World Bank, Washington, DC.

Dockery, D. and . Pope, A. (1993). An association between air pollution and mortality in six U.S cities in the New England. J. Medic. 329(24): 1753-1759.

Ostro, B. (1994). The effects of air pollution on work loss and morbidity. J. Environt. Econ. and Mgt. 10: 371-382.

Pope, A., Thun, M., Namboordiri, N., Dockery, D., Evans, J., Speizer, F. and Heath, L. (1995). Particulate air pollution as predictor of mortality in a prospective study of U.S. adults. American J. Respiratory and Critical Care Medicine. 151(3): 669-674.

Schwartz, J. and. Dockery, D. (1992). Increased mortality in Philandelphia, associated with daily air pollution concentration: American Rev. of Respiratory Disease. 145: 600-604.

Senerath, C. (2000) Overview of Air Pollution and Respiratory Illness in Sri Lanka. http://www.cleanairnet.org/caiasia.

Sunil, S. (2000) Colombo choke son the car, the case for controlling automotive air. http://www.idrc.ca/en/ev-8268-201-1-DO-TOPIC.html.

World Bank. (1997). The economic toll of pollution's effects on health, Pollution Prevention and Abatement Handbook-Part II, World Bank, Washington, DC.