International Journal of Scientific Research and Modern Education (IJSRME)
Impact Factor: 6.225, ISSN (Online): 2455 – 5630
(www.rdmodernresearch.com) Volume 2, Issue 1, 2017

IDENTIFICATION OF HAZARDOUS MINERALS IN RESPIRABLE DUST SAMPLES IN AND AROUND ARIYALUR DISTRICT IN TAMILNADU

V. Raja*, G. Selvan*, A. Nataraj & R. Anbarasu***
* PG and Research Department of Physics, Thanthai Hans Roever College (Autonomous), Perambalur, Tamilnadu
** Department of Physics, SRM University, Ramapuram, Chennai, Tamilnadu

Cite This Article: V. Raja, G. Selvan, A. Nataraj & R. Anbarasu, "Identification of Hazardous Minerals in Respirable Dust Samples in and Around Ariyalur District in Tamilnadu", International Journal of Scientific Research and Modern Education, Volume 2, Issue 1, Page Number 11-16, 2017.

Abstract:
The infrared spectra of hazardous minerals in dust samples have been recorded in the region 4000–400 cm^{-1}. The range ensures that most of the useful vibrations are active in the infrared spectra. The relative distributions of hazardous minerals are explained through the determination of extinction co-efficient. The obtained results made through the IR analysis are briefly discussed with various diseases. The cement dust samples have been analyzed by powder XRD. The conclusive remarks are also given.
Key Words: Occupational Hazards, Cement Dust & Lung Function

Introduction:

Even in the twenty-first century, millions of people are working daily in a dusty environment. They are exposed to different types of health hazards i.e., fume, gases and dust, which are risk factors in developing occupational disease. Cement industry is involved in the development of structure of this advanced and modern world but generates dust during its production. Cement dust causes lung function impairment, chronic obstructive lung disease, restrictive lung disease, pneumoconiosis and carcinoma of the lungs, stomach and colon. Other studies have shown that cement dust may enter into the systemic circulation and thereby reach the essentially all the organs of body and affects the different tissues including heart, liver, spleen, bone, muscles and hairs and ultimately affecting their micro-structure and physiological performance. Most of the studies have been previously attempted to evaluate the effects of cement dust exposure on the basis of spirometry and / or radiology. However, collective effort describing the general effects of cement dust on different organ and systems in humans and / or animals has not been published. Therefore, the aim of this review is to gather the potential toxic effects of cement dust and to minimize the health risks in cement mill workers by providing them with information about the hazards of cement dust.

Background:

Before the invention of cement the earlier structures were composed of earth raised in the form of walls or domes by ramming successive layers of stone blocks, set one above another without the aid of any cementing material. The stability of walls was derived entirely from the regular placing of heavy masses of stones without any assistance from adhesion. With the passage of time, people began to construct their homes with a mixture of sand and a cementations material consisting of lime and / or gypsum. From twelfth century onward, the quality was improved and the lime being well burnt and well sifted. Joseph Aspdin, in October 1824, used a hard lime stone mixed with clay grinding to fine slurry with water and then broke the mixture into suitable lumps and calcines them in furnace, similar to a lime kiln till the carbonic acid was expelled. The mixture was so calcinied and ground beat or rolled to a fine powder. The name Portland cement was given to the product from a resemblance of the color of cement after setting to Portland stone. The Portland cement may be defined as a gray powder-like adhesive substance. It may also be defined as mineral dust which when mixed with a water form a plaster like adhesive mass.

Contents of Portland Cement: Cement is a mixture of Calcium oxide (CaO) (62% - 66%), Silicon oxide (SiO2) (19% - 22%), Aluminum tri-oxide (AL2O3) (4%-8%), Ferric oxide (Fe2O3) (2% - 5%), Magnesium oxide (MgO) (1% - 2%) and also Selenium, Thallium and other impurities.

Types and Production of Cement: There are two main types of cement, natural and artificial. The natural cement is obtained from natural material having a cement-like structure and requires only calcining and grinding to yield cement powder. Artificial cement is also called Portland cement, there are different types of Portland cement such as Ordinary or Rapid hardening, Sulphate resisting, White, Colored, Low heat, Masonry, Hydrophobic, Water replant, Expanding and non Shrinking, High Aluminum, Blast furnace and Oil well cement. Portland cement is produced in cement factories under consideration of different substances especially the limestone and clay, which are heated to approximately 1250° C for a period of 90 minutes. The chemical reactions which take place during heating process produces four major phases which are known as Tri-calcium silicate, Di-calcium silicate, Ferrite phase and Tri-calcium aluminates phases. The final product is obtained by

grinding its contents with addition to 5% gypsum. When cement gets in contact with water, it hydrates quickly at different rates for the different phases.

Exposure to Cement Dust: Cement mill workers are exposed to dust at various manufacturing and production processes, such as quarrying and handling of raw materials, during grinding the clinker, blending, packing and shipping of the finished products.

Pathogenesis: The aerodynamic diameter of cement particles range from 0.05 to 5.0 micrometer in diameter. These particles are respirable in size hence cement is important as a potential cause of occupational lung disease. This particle size distribution would make the tracheobronchial respiratory zone, the primary target of cement deposition. The main route of entry of cement dust particles in the body is the respiratory tract and / or the gastrointestinal tract by inhalation or swallowing respectively. Both routes, especially the respiratory tract are exposed to numerous potentially harmful substances in the cement mill environment. The physical properties that are of importance include particle size and density, shape and penetrability, surface area, electrostatic charge, and hygroscopicity. Among the more important chemical properties influencing the respiratory tract's response is the acidity or alkalinity of the inhaled agent. The deposition of inhaled material is primarily dependent on particle size and is best described in forms of an aerodynamic diameter. All particles with an aerodynamic diameter in excess of 10mm are deposited on the mucous membrane in the nose and pharynx and particles between 3 and 10mm in diameter can be deposited throughout the tracheobronchial tree. Particles between 0.1 and 3mm in diameter are mostly deposited within the alveoli and particles smaller then 0.1mm remain in the air stream and are exhaled. The pathogenesis is most probably due to its irritating, sensitizing and pneumoconiotic properties.

Health Effects:

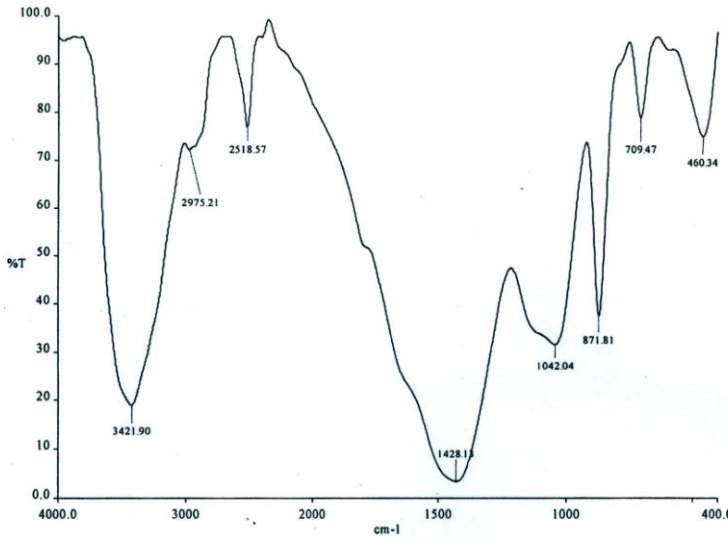
General Clinical Manifestations: High concentration and / or prolonged inhalation of cement dust in cement industry workers can provoke clinical symptoms and inflammatory response that may result in functional and structural abnormalities. The most frequently reported clinical features in cement mill workers are chronic cough and phlegm production, impairment of lung function, chest tightness, obstructive and restrictive lung disease, skin irritation, conjunctivitis, stomach ache, headache, fatigue and carcinoma of lung, stomach and colon.

Materials and Methods:

The sampling of Dust particles of Ariyalur District in Tamil Nadu has been performed in summer of the year 2016. The method of sampling the Dust Particles deposited in various places in the cement factories. Among eight factories, I have chosen three factories for the minor research project. Eight points of sampling have been chosen from the three factories based on the dominant directions of the wind: NW, SW, SE and E. The sampling has not been achieved in the west direction because of the presence of the relief. All samples were collected 3 km far from the factories. The stations of sampling were accurately located using global positioning system device.

Result and Discussion:

FTIR Study:

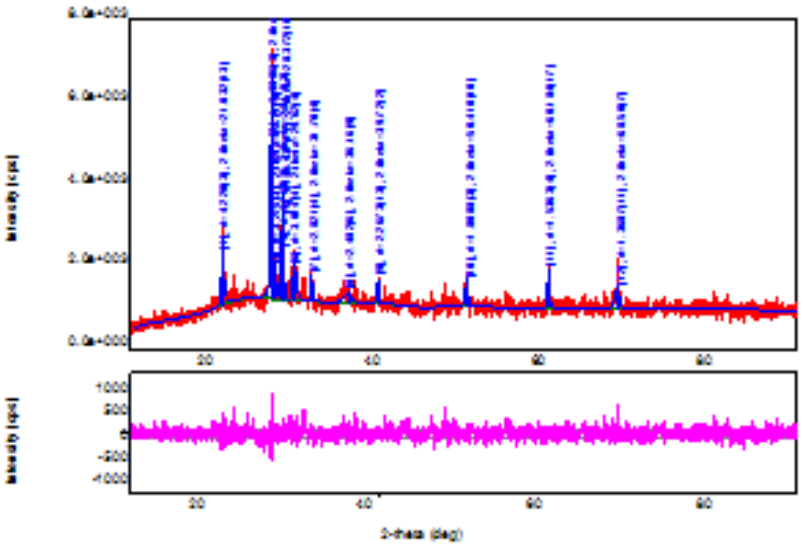


In the present work, the observed peak at around 800 cm^{-1} is present in various spectra which may be assigned to Si–O bending vibrations. In almost all the samples, a peak at around 780 cm^{-1} is present which may be assigned to Si–O–Si symmetrical stretching vibrations. The peak in the region 692–694 cm^{-1} is a characteristic peak of quartz due to Si–O bending vibration. This peak is present all the samples. The sharp intense band at

around 465 cm^{-1} is due to Si–O asymmetrical bending of quartz which is present in all the samples. According to Russell [1], the characteristic absorption bands of quartz are 1096, 800 - 879, 760 - 780, 695 - 710, 514, 462 cm^{-1}. But in the present study, only three peaks in the range 708 cm^{-1}, 766 cm^{-1} and 874 cm^{-1} are present. The reason for the absence of other characteristic peaks may be due to the interference of other minerals. The inhalation of quartz mineral in dust may produce diseases such as chronic silicosis, acute silicosis, accelerated silicosis and silica tuberculosis. The asbestoses exhibit intense absorptions in the regions 1200– 900 cm^{-1} and 600–300 cm^{-1} of the infrared spectra. The presence of band at around 600 cm^{-1} along with 1032 cm^{-1} is due to chrysotile. The observed band at around 613 cm^{-1} and 1032 cm^{-1} are almost present in all the site samples. On the lines of Coates [2] the presence of a band at around 613 cm^{-1} is due to chrysotile and a band at around 1032 cm^{-1} is due to amphibole. These two minerals are the types of asbestos. The presence of the "asbestos" in all the dust samples will create health hazards. The greatest hazard from asbestos is the inhalation of the fine dust fibrous and their retention in lung and bronchial passages. This will create a thickening and scarring of lung tissue especially the inhalation of amphiboles will cause lung and bronchial cancers and mesothelioma. The observed absorption frequencies in the regions 524–538 cm^{-1}, 571–583 cm^{-1}, 754–756 cm^{-1}, 1621–1624 cm^{-1} and at 3695 cm^{-1} are the characteristic peaks of clay mineral kaolinite associated with dust samples. The intensity of the bands varies from sample to sample at different places. This means the amount of the kaolinite varies from sample to sample. The peak at around 3695 cm^{-1} is due to OH–stretching of hydroxyl group, 1572 cm^{-1} is due to Al–OH vibrations, 756 cm^{-1} is due to Si–O bending vibrations 583 cm^{-1} is due to symmetrical bending vibrations and 538 cm^{-1} is due to symmetrical bending vibrations. There is an appearance of the peak at 443 cm^{-1} due to Si–O bending vibrations, 631–637 cm^{-1} due to coordination vibrations and 1020–1022 cm^{-1} due to Si–O stretching vibrations which are the characterics peaks of talc. The obtained results are very well matched with Russell [1]. Thus, all the dust samples collected from different areas of Ariyalur district of Tamilnadu, show quartz, calcite, montmorillonite, coal, kaolinite and asbestos in major quantity. The presence of talc and microcline may be considered as minor minerals and the other mineral such are nacrite, anothite, palygorskite and illite are associate minerals found as traces. With reference to the literature, the presence of quartz, asbestos, kaolinite, calcite, coal and montmorillonite are hazardous minerals in dust.

XRD Analysis for Dust Samples:

Factory1:



Peak	2θ (°)	θ (°)	d (Å)
1	21.032(13)	10.516	4.2238
2	26.992(3)	13.496	3.3035
3	27.21(3)	13.605	3.2779
4	28.14(3)	14.07	3.17112
5	28.372(10)	14.186	3.1465
6	29.62(4)	14.81	3.0160
7	31.70(4)	15.85	2.8226
8	36.16(9)	18.08	2.4843
9	39.72(2)	19.86	2.2693
10	50.410(10)	25.2	1.81089
11	60.184(17)	30.092	1.5375
12	68.50(7)	34.25	1.3697

Calcite (CaCo3) Mineral Data:

Axial Ratios	: a: c, 1:3.41992
Cell Dimentions	: a=7.4680, c=25.5399
Crystal System	: Trigonal – Hexagonal Scalenohedral
Colour	: Colorless, White, Pink, Yellow, Brown.
Density	: 2.8226(Cal), 2.71 (Mean)

Conclusion:

The infrared analysis of the various dust samples collected from the specified factories of Ariyalur district, Tamilnadu, indicates the presence of quartz, calcite, montmorillonite, palygorskite, coal, kaolinite, hematite and asbestos. With reference to the appearance of number of peaks, quartz, calcite, montmorillonite, coal, kaolinite and asbestos are considered to be main (or) major constituent of the dust samples and the polygorkite are considered to be minor minerals. The mineral anorthite is considered to be associate mineral which may be treated as traces. Factory1: The observation made through the extinction co-efficient suggest that the site number 2 (Factory Bus Stop) and 4 (Keelapalur Bus Stant) are having maximum hazardous minerals and the site number 1 (Factory outside) and 3 (By pass) are having minimum hazardous minerals. Thus, it is concluded that the peoples in and around Keelapalur area may be affected by lung diseases due to the inhalation of these hazardous minerals in dust through human respiratory system. X-ray Powder diffraction data reveals that the Cacite Minerals belong to trigonal system. Factory2: The observation made through the extinction co-efficient suggest that the site number 2 (Alathiyur cement factory Bus Stop) and 3 (Alathiyur village) are having maximum hazardous minerals and the site number 4 (Factory compound) and 5 (Alathiyur to Thalavai road) are having minimum hazardous minerals. Thus, it is concluded that the peoples in and around Alathiyur area may be affected by lung diseases due to the inhalation of these hazardous minerals in dust through human respiratory system. X-ray Powder diffraction data reveals that the Quarts Minerals belongs to trigonal system. Factory3: The observation made through the extinction co-efficient suggest that the site number 2 (Alathiyur cement factory) and 3 (Alathiyur Bus Stand) are having maximum hazardous minerals and the site number 1 (Pennadam – Alathiyur Road) and 3 (Alathiyur Village) are having minimum hazardous minerals. Thus, it is concluded that the peoples in and around Alathiyur area may be affected by lung diseases due to the inhalation of these hazardous minerals in dust through human respiratory system. X-ray Powder diffraction data reveals that the Kalonite Minerals belongs to triclinic system.

Protect the Lungs From Dusts:

The following are the seven main points to protect the lungs from dusts.

- ✓ Use of face masks
- ✓ Removal of dust by suction
- ✓ Enclosure of dust producing processes under negative air pressure.
- ✓ Exhausting air containing dust through a collection system before emission to the atmosphere.
- ✓ Use of vacuums instead of brooms.
- ✓ Good housekeeping.
- ✓ Efficient storage and transport and controlled disposal of dangerous waste.

References

1. Russell, J.D., “Infrared methods – A hand book of determinative methods in clay mineralogy”, Ed. by Wilson, M.J., Blackie and Son Ltd., New York, 133–173 (1987).
2. Coates, J.P., “The IR Analysis of Quartz and Asbestos”, Neolith Offset Ltd., Chesham, England, (1977).
3. Adler, H.H and Kerr, P.E., “Infrared Study of Aragonite and Calcite,” American Mineralogist, 47, 700-717 (1962).
4. Aiyengar, N.K.N., “Minerals of Madras”, Department of Industrial and Commerce, Madras, (1964).
5. Anderson, P.L., J. Am. Indust. Hyg. Assoc., 31, 767-778 (1975).
6. Andrew Churg, “Asbestos lung burden and disease patterns in man”. In health effect of mineral dusts” Ed. By George D. Guthrie. Jr.and Brooke T. Mossman. Mineralogical Society of America, Washington, 409-426 (1993).
7. Ball, D.J., “Environmental implications of increasing particulate emissions resulting from diesel engine penetration of the European automotive market”. Sci. Total Environ, 33, 15-30 (1984).
8. Coates, J.P., “The IR Analysis of Quartz and Asbestos”, Neolith Offset Ltd., Chesham, England, (1977).
9. Dalal, N.S., Suryan, M.M., Vallyathan, V., Green, F.H.Y., Jafari, B. and Wheeler, R., “Detection of reactive free radicals in fresh coal mine dust and their implication for pulmonary injury”, Anal. Occup. Hyg., 33, 79-84 (1989).
10. Department of Health Committee on the Medical Effect of Air pollutants. Non-biological particles and health (1995). London, HMSO.

11. Dodgson, J. and Whittaker, W., "The determination of quartz in respirable dust samples by infrared spectroscopy-1. The potassium bromide disc model". Ann. Occup. Hyg., 16, 373-387 (1973).
12. Douglas, A.N., Robertson, A., Chapman, J.S and Ruckley, V.A "Dust exposure, dust recovered from the lung, and associated pathology in a group of British coal miners". British J. Indust. Med., 43, 795-801 (1986).
13. Farmer, V.C., "The IR Spectra of Minerals", Mineralogical Society, London, 183 (1974).
14. Finkelman, R.B., "Trace and Minor Elements in Coal": Engel, M.H., Macko, S.A. (Eds.), organic geochemistry. Plenum, New York. 593-607 (1993).
15. Foster, R.D. and Walker, R.F., Analyst, 109, 1117-1127 (1984).
16. Gade, M. and Luft, K.F., Staub, 23, 353-357 (1963).
17. Ganguly, J and Banerjee, B.K., "Appraisal of Infra-red of isolated clay fractions from different soil profiles". Transac. Indian Ceramic Soc., 44(1), 17-19 (1985).
18. Ghosh S.N., "Infrared spectra of some selected minerals, rocks and products". J. Mat. Sci., 13, 1877-1886 (1978).
19. Ghosh, S.N. and Chatterjee, A.K. "Absorption and reflection infra-red of major cement minerals, clinkers and cements". J. Mat. Sci., 9, 1577-1584 (1974).
20. Goddu, S.R., Appel, E., Jordanova, D. and Wehland, R. "Magnetic properties of road dust from Visakapatnam (India) – relationship to industrial pollution and road traffic". Phys. Chem. Earth, 29(13-14), 985-995 (2004).
21. Gorell, J.M., Johnson, C.C., Rubicki, B.A., Peterson, E.L., Kortsha, G.X., Brown, G.G. and Richardson, R.J., "Occupational exposure to manganese, copper, lead, iron mercury and zinc and the risk of Parkinson's disease neurotoxicology", 20(2-3), 239-248 (1999).
22. Hlavay, J., Jonas, K., Elek, S. and Incredy J., "Characterisation of the particle size and the crystallinity of certain minerals by infrared spectrometry and other instrumental methods-I. Investigation on clay minerals". Clay and Clay Minerals, 25, 456 (1977).
23. Hlavay, J., Jonas, K., Eleks, S. and Incredy J., "Characterisation of the particle size and the crystallinity of certain minerals by infrared spectrometry and other instrumental methods-II. Investigation on quartz and feldspar". Clay and Clay Minerals, 26(2), 139-145 (1978).
24. Hunt, J.M., Wishered, M.P. and Bonhan, L.C. Infrared absorption spectra of minerals and other inorganic compounds. Anal. Chem., 22(2), 1478-1497 (1950).
25. IARC, "Monographs on the evaluation of carcinogalic risks to humans. Diesel and Gasoline Engine Exhausts and Some Nitroaerenses", 46 (1989).
26. Janko, M., McCrae, R.E., O'Donnell, J.F. and Austria, R.J., J. Am. Indust. Hyg. Assoc., 50, 460-465 (1989).
27. Joe L. White, "Interpretation of Infrared spectra of soil minerals". Soil Sci., 112(1), 22-31 (1971).
28. John Davis, M.G., "In vivo assays evaluate the pathogenic effects of minerals in rodents". In Health effect of mineral dusts, Ed. By George D. Guthrie, Jr. and Brooke T. Mossman, Mineralogical society of America, Washington, D.C., 28, 471-475 (1993).
29. Jun Ojima, "Determining of crystalline silica in respirable dust samples by infrared spectrophotometry in the presence of interferences". Journal of Occupational Health, 45, 94-103 (2003).
30. Krivacsy, Z. and Hlavay, J., "Determination of quartz in dust samples by diffuse reflection FTIR spectroscopy". J. Mole. Struct., 294, 251-254 (1993).
31. Lan, Q., Chapman, R.S., Schreinemachers, D.M., Tian, L. and He, X., "Household stove improvement and risk of lung cancer in Xuanwei, China". J. Nat. Cancer Inst., 94(11): 826-835 (2002).
32. Langer, A.M., Nolan, R.P. and Pooley, F.D., "Phyllosilicates: Associated fibrous minerals. In: Health related effects of phyllosilicates". Bigon. J., Ed. Springer-Verlag, New York, 59-74 (1990).
33. Lapp, N.L., Clinics in Chest Medicine, 2, 219-233 (1981).
34. Mackonzie, R.C. and A.A. Rahman, Thermo. Chem. Acta. 121, 15 (1987).
35. Malcolm Ross, Robert P. Nolon, Arthur M. Langer and Clark Cooper, W. "Health effect of mineral dust other than asbestos". In Health Effects of Minerals Dusts, Ed. By George D. Guthrie, Jr and Brooke T. Mossman, Mineralogical society of America, Washington, D.C., 28, 363-384 (1993).
36. Nagelschmidt, G., Rivers, D., King, K. J and Trevella, W., "Dust and collagen content of lungs of coal-workers with progressive massive fibrosis". British J. Indust. Med., 20, 181-191 (1963).
37. Nagvi Mahmood, S. and John, J.W. Roget. "Oxford monographs of geology and geophysical no.6" in Pre-Cambrian Geology of India, Oxford University Press, Oxford, (1987).
38. Oxman, A.D., Muir, D.C., Shannon, H.S., Stock, S.R.T., Hnizdo, E. and Lante, H.J., "Occupational dust exposure and chronic obstructive pulmonary disease". Am. Rev. Resp. Dis., 148, 38-48 (1993).
39. Parker, T.W. "A classification of kaolinite by infrared spectroscopy". Clay Minerals, 8, 141 (1969).
40. Quade, J., Chivas, A. and McCullock, M.T., "Paleogr Palaeoecol" Sleads Conf. In Rev., (1991).

41. Ramasamy, V., Dheenathayalu, M., Ponnusamy, V., Hemalatha, J. and Prasanna Lakshmi, P., Indian J. Phys., 13(4), 443-450 (2003).
42. Ramasamy, V., M. Dheenathalu, K. Anandalakshmi, V. Ponnusamy and R. Ravisankar, "Characterization of quartz using FTIR". Bulletin of Pure and Applied Sciences. 21F(2), 89-94 (2002).
43. Saravanan, S., "Geology of Tamilnadu", Tamin Pub., (1984).
44. Schilling, C.J., Tams, I.P., Schilling, R.S.F., Nevitt, A., Rositer, C.E. and Wilkinson, B., "A survey into the respiratory effects of prolonged exposure to pulverized fuel ash". British J. Indust. Med., 45, 810-817 (1988).
45. Tuddenham, W.M., and Lyon, R.J.P., "Infrared techniques in the identification and measurement of minerals". Anal. Chem., 32(12), 1630-1634 (1960).
46. Wadia, D.N., "Geology of India", Tata McGraw Hill Publications, Delhi, India, (1986).