

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

ANNOTATED BIBLIOGRAPHY OF RECENT PAPERS ON
ENVIRONMENTAL AND HUMAN HEALTH IMPACTS OF COAL AND
COAL USE

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

Introduction

The U.S. Geological Survey¹ (USGS) and its Geologic Division² have identified human health impacts of geologic materials as an important societal issue that the USGS can help address. Perhaps no geologic material is as significant as coal in impacting human health. Although coal constitutes less than 1/10,000 of the earth's crust, its presence and use has adversely affected the health of hundreds of millions of people worldwide³.

This report summarizes recent papers dealing with environmental and human health problems caused by coal and coal use. The purpose is not to emphasize the problems associated with coal but rather to identify health issues that geoscientists could help address.

Search Methods

The main source of papers dealing with coal and human health was the MEDLINE database. This was accessed through the National Library of Medicine's free Internet search vehicle, PubMed (<http://www.ncbi.nlm.nih.gov/PubMed/>). The first step was to search for coal and health, followed by searching various pairings of words: coal & India, coal & China, coal & mercury, coal & arsenic, coal & specific health problems such as CWP (Coal Workers' Pneumoconiosis).

¹ U.S. Geological Survey, 1996, Strategic plan for the U.S. Geological Survey 1996 to 2005, 52 pp.

² Bohlen and others, 1998, Geology for a changing world. U.S. Geological Survey Circular 1172, 59 pp.

³ World Resources Institute, 1998, World Resources 1998-99, 369 pp.

A search using only the key word of “coal” brought up over 5,000 entries. We focused on the most recent abstracts (i.e. since 1990) and then randomly selected older abstracts throughout the list. MEDLINE is updated periodically and the last search of the database was made on October 1, 1998.

Next, GeoRef was searched for articles and abstracts under the heading of coal & health. We also searched the International Energy Agency (IEA) Coal Highlights journal under Health & Safety and Environmental issues. Appropriate abstracts and articles were summarized and placed in one of four categories (Ecologic Impacts, Industrial Exposure, Regional Impacts, and Domestic Use).

This compilation is far from comprehensive. It should be considered as a sampling of the human health issues caused by coal, coal mining, and coal use being addressed by biomedical and public health researchers.

ECOLOGIC IMPACTS

Toxicology of selenium in a freshwater reservoir: implications for environmental hazard evaluation and safety

Lemly, A.D.

Ecotoxicol Environ Saf, 1985 Dec, 10(3), 314-338

The authors conducted a study documenting accumulation of Se in a power plant cooling reservoir in North Carolina. Se entered the reservoir by way of effluent from the coal ash disposal basin. The contaminated reservoir had concentrations of waterborne Se that were 20-30 times background levels. The results show that Se can accumulate and be biologically magnified to toxic levels in a reservoir even though the waterborne concentrations are low.

Effects of coal-fired thermal power plant discharges on agricultural soil and plant crops

Ajmal, M., and Khan, M.A.

Environ Res, 1986 Apr, 39(2), 405-417

The authors studied the direct effect of wastewaters from a coal-fired power plant on fertile soil and its indirect effect on pea and wheat crops. The various waters studied included discharged cooling tower water, machine washings, and scrubber and bottom ash effluents. All the waters were found to be responsible for altering the chemical composition of the soil. When irrigated with these various types of water, the growth of the plants was reduced.

Mercury concentrations in pond fish in relation to a coal-fired power plant

Pinkney, A.E., Logan, D.T. and Wilson, H.T.

Arch Environ Contam Toxicol, 1997 Aug, 33(2), 222-229

While many studies have looked at atmospheric mercury as the cause of bioaccumulation of mercury in fish, none have looked at the effects of near-field mercury deposition. Mercury concentrations were surveyed in fish from 23 ponds in the vicinity of a coal-fired

power plant located in Dickerson, Maryland. The observed pattern of mercury bioaccumulation did not match the pattern predicted by a wet deposition model.

Increased circulating levels of testosterone and corticosterone in southern toads, *Bufo terrestris*, exposed to coal combustion waste

Hopkins, W.A., Mendonca, M.T., and Congdon, J.D.

Gen Comp Endocrinol, 1997 Nov, 108(2), 237-246

This study describes the interrenal stress response in adult toads after exposure to coal combustion waste, which is characterized by a variety of trace elements. Both toads found at a coal ash polluted site and normal toads brought into the site were found to have increased levels of corticosterone (B) and testosterone. The authors hypothesized that high concentrations of various trace elements in the polluted site are responsible for these hormonal changes.

Elevated trace element concentrations in southern toads, *Bufo terrestris*, exposed to coal combustion waste

Hopkins, W.A., Mendonca, M.T., Rowe, C.L., and Congdon, J.D.

Arch Environ Contam Toxicol, 1998 Aug, 35(2), 325-329

This study compared total body concentrations of 20 trace elements in adult southern toads, *Bufo terrestris*, inhabiting coal ash settling basins with toads that were not exposed to the combustion wastes. In addition, they documented the accumulation of trace elements in toads transplanted to field enclosures in an ash-settling basin. Arsenic, Se, and vanadium levels were significantly elevated in toads captured in the ash-contaminated sites when compared to the reference toads. All three of these elements were also significantly elevated in toads exposed to the contaminated area for only 7 weeks.

Concentrations of Co, Cd, Cr, Ni, and Zn in crop plants cultivated in the vicinity of coal-fired power plants

Mejstrik, V., and Svacha, J.

Sci Total Environ, 1988 Jun 15, 72, 57-67

The objective of this study was to determine the effects of airborne emissions of trace elements (Co, Cd, Cr, Ni, and Zn) from coal-fired power plants on the environment. Concentrations were determined in different species of plants in the local environment and compared to the corresponding concentrations in soil and fallout. It was concluded that particle fallout from local power plants is too small to significantly change the natural distribution pattern of trace elements in soils and plant tissues.

Selenium bioaccumulation and hazards in a fish community affected by coal fly ash effluent

Besser, J.M., Giesy, J.P., Brown, R.W., Buell, J.M., and Dawson, G.A.

Ecotoxicol Environ Saf, 1996 Oct, 35(1), 7-15

Pigeon River & Pigeon Lake, Missouri, receives inputs of Se from a coal fly ash disposal facility and was studied to assess potential hazards of Se to fish, wildlife, and humans. Se concentrations in the fish did not exceed lowest observable adverse effect concentrations (LOAECs) for Se tissue of fish species, but exceeded LOAECs for dietary Se exposure for sensitive species of birds and mammals. Human consumption of moderate quantities of fish from the areas studied should not result in excessive Se intake.

Effects of pollution with fluoride on bone dynamics of periosteum in iliac of domestic pigs

Zhang, X., Qui, M.C., and Liu, W.B.

Chung Hua Yu Fang I Hsueh Tsa Chih, 1994 Nov, 28(6), 360-362

Studies on bone dynamic parameters of iliac periosteum and endosteum in domestic pigs with fluorosis caused by coal-burning contamination suggest that fluorosis plays significantly inhibitory roles in bone formation on the periosteal membrane of pig iliac.

Distribution of trace elements in egg samples collected near coal power plants

de Moraes Flores, E.M., and Martins, A.F.

J Environ Qual, 1997, 26, 744-748

Egg samples were collected from nonconfined hens in the vicinity of two major power plants in Brazil. The study found significant environmental contamination with Pb and F in these regions. There was relative Cd and Pb enrichment in the yolk, whereas F preferentially concentrated in the shell.

Ecosystem recovery following selenium contamination in a freshwater reservoir

Lemly, A.D.

Ecotoxicol Environ Saf, 1997 Apr, 36(3), 275-281

Belews Lake, North Carolina, was contaminated by Se in wastewater released from a coal-fired electric power plant. Se bioaccumulated in aquatic food chains and caused severe reproductive failure and teratogenic deformities in fish. Eventually the dumping of wastewater into the lake was stopped. Toxic effects from the Se were still evident 10 years after Se inputs were stopped. The sediment-associated Se will likely continue to be a significant hazard to fish and aquatic birds for years to come.

Changes in concentrations of selenium and mercury in largemouth bass following elimination of fly ash discharge to a quarry

Southworth, G.R., Peterson, M.J., and Turner, R.R.

Chemosphere, 1994 Jul, 29(1), 71-79

Elimination of slurried fly ash discharges to a water-filled quarry was followed by a steady increase in concentrations of mercury in the axial muscle of resident largemouth bass. Previous studies have shown Se addition to be a viable means of ameliorating mercury contamination in fish in low alkalinity, low pH water. These results suggest that Se may also be effective at blocking the accumulation of methylmercury in harder, more alkaline waters.

Coal ash basin effects (particulates, metals, acidic pH) upon aquatic biota: An eight-year evaluation

Cherry, D.S., Guthrie, R.K., Davis, E.M. and Harvey, R.S.

Water Resources Bulletin, 1984 August, 20(4), 535-544

Coal ash effluent effects were studied as changes in water quality in a swamp drainage system over an eight-year period. Elemental concentrations of As, Cd, Cr, Cu, Se and Zn did not appear to limit aquatic flora and fauna on a short-term, acute basis. Long, chronic elemental exposures may have been instrumental in retarding the recovery of all forms of aquatic life in the receiving system.

Trace metal concentrations in a stream-swamp system receiving coal ash effluent

Evans, D.W. and Giesy, J.P. Jr.

in: Ecology and coal resource development, 1978, M.K. Wali (editor), Volume 2, 782-790
Water, suspended particulates, periphyton, and emergent plants were analyzed for trace metals in a stream-swamp system receiving effluents from a coal ash disposal basin and in a comparison stream on the Savannah River Plant, South Carolina. The effluent receiving system showed small elevations in metal concentrations in biotic and abiotic components relative to the comparison stream. Factors limiting the impact of the effluents on metal concentrations to such minor levels include metal concentrations in ash materials, particle retention in the basin, sorptive phenomena, dilution, and homeostatic regulation of essential elements by plants.

Trophic level accumulation of heavy metals in a coal ash basin drainage system

Guthrie, R.K. and Cherry, D.S.

Water Resources Bulletin, 1979 Feb, 15(1), 244-248

The uptake of ten chemical elements was measured in water, sediment, fly ash, and the major components of an ash basin drainage system. Sediment concentrations of all elements were highest in the ash drainage system with Al and Fe being consistently highest. *Hydrodictyon* sp. and *Lemna perpusilla* had the highest concentrations of Al and Fe while other macrophytes had the major accumulations of Mn and Ba. Invertebrates generally concentrated high amounts of Cu and Zn although Cd and Hg accumulated in crayfish. Bacteria, crayfish, and mosquitofish selectively concentrated the Se.

**Oral deformities in tadpoles (*Rana catesbeiana*) associated with coal ash deposition:
effects on grazing ability and growth**

Rowe, C.L., Kinney, O.M., Fiori, A.P., and Congdon, J.D.

Freshwater Biology, 1996, 26, 723-730

Tadpoles of the bullfrog *Rana catesbeiana* collected in a coal ash basin (contaminated with As, Cd, Cr, Cu, Se and other elements) had a reduced number of labial teeth and deformations of labial papillae compared to tadpoles from reference areas. The tadpoles with deformities were less able to graze periphyton than were normal tadpoles. It appears that the deformities associated with this coal ash-polluted environment can have ecological ramifications for the affected organisms by limiting both the type of food that can be consumed and the ability to grow when various types of food are not available.

Assessment of metal uptake and genetic damage in small mammals inhabiting a fly ash basin

Peles, J.D., and Barrett, G.W.

Bull Environ Contam Toxicol, 1997, 59, 279-284

This paper involved an in situ investigation to examine the effects of fly ash contaminants on species of small animals. The purpose was to examine uptake in cotton rats and rice rats collected from a fly-ash contaminated site and a reference site, and compare the extent of DNA damage in small mammals between the contaminated and the reference site as determined by flow cytometry. Small mammals are an important intermediate for the transfer of toxic metals to higher trophic levels. Thus, the results showing increased metal uptake among small mammals have important implications regarding potential bioaccumulation of metals in the food chain. Although no evidence of genetic damage was observed, effects of exposure to fly ash contaminants on organisms at higher trophic levels at this site warrant investigation.

Selenium in onions grown in media amended with coal fly ashes collected with differing efficiencies

Gutenmann, W.H., Doss, G.J., and Lisk, D.J.

Chemosphere, 1998 Aug, 37(3), 389-390

A study was conducted to learn if the extent of Se uptake by onions grown on coal fly ash-amended growth media would be influenced by the particle size distribution of the fly ash. Two fly ashes having differing percentages of finely sized particles were used as plant growth amendments in the media to yield equal concentrations of Se. Se concentrations in the harvested onion bulbs were found to be independent of fly ash particle size distribution.

Environmental causes for sinonasal cancers in pet dogs, and their usefulness as sentinels of indoor cancer risk

Bukowski J.A., Wartenberg, D., Goldschidt, M.

J Toxicol Environ Health, 1998 Aug 7, 54(7), 579-581

A case-control study was conducted to investigate the environmental causes of sinonasal cancers among pet dogs. Owners were asked to answer questions on canine factors, owner demographics, household exposures (including environmental tobacco smoke), and local pollution. Only household exposures were associated with increased cancer risk and the use of indoor coal and kerosene heaters represented the strongest risk factors.

Lung free cells following short-term inhalation of coal fly ash particles in golden hamsters

Negishi, T. and Nishimura, I.

Jikken Dobutsu, 1993 Jan, 42(2), 51-59

Male golden hamsters were exposed to coal fly ash (FA) at various concentrations and length of time and then maintained in clean air condition to investigate the effect on the induced changes in lung free cells. The ratio of particle-laden alveolar macrophages (AMs) tended to increase in a dose- and time-dependent manner in the exposed groups. Particle number ingested in AMs increased with exposure time. These results suggest that the pool size of AMs is mainly dependent on the inhaled dust concentrations and some of the particle-laden AMs remain in alveoli for a long time. The number of polymorphonuclear leukocytes (PMNs) also increased after inhalation of FA particles.

Scientists link coal fly ash disposal to amphibian abnormalities

Tyson, R.

Environmental Science & Technology News, 1997, 31(9), 408A

A correlation was found between coal fly ash deposits and abnormally heavy metals in amphibians at the Savannah River, South Carolina, site. These results could explain the biological and behavioral abnormalities among amphibians at the site.

INDUSTRIAL EXPOSURE

Exposure-response analysis of mortality among coal miners in the United States

Kuempel, E.D., Stayner, L.T., Attfield, M.D., and Buncher, C.R.

Am J Ind Med, 1995 Aug, 28(2), 167-184

The quantitative relationship between exposure to respirable coal mine dust and mortality from nonmalignant respiratory diseases was investigated in working male coal miners. No exposure related increases in lung cancer or stomach cancer were observed.

Pneumoconiosis mortality was found to vary significantly by the rank of coal dust to which miners were exposed. Miners exposed at or below the current U.S. coal dust standard over a working lifetime have an elevated risk of dying from pneumoconiosis or from chronic bronchitis or emphysema.

Incidence survey of aplastic anemia in China

Yang, C., and Zhang, X.

Chin Med Sci J, 1991 Dec, 6(4), 203-207

A nationwide survey in China of aplastic anemia (AA) showed that the incidence of AA in areas around coal mines was higher than that in other areas.

A prospective study on mortality among Japanese coal miners

Une, H., Esaki, H., Osajima, K., Ikui, H., Kodama, K., and Hatada, K.

Ind Health, 1995, 33(2), 67-76

This study was done to clarify mortality patterns among Japanese coal miners. There were significantly high-risk ratios observed in all deaths and all malignant neoplasms. Risk ratios for all causes of death and all malignant neoplasms also rose with the length of experience in coal mining. Miners had high-risk ratios for stomach, liver, and lung cancers, although the ratios were not statistically significant. Analyzed according to length of experience, miners with 15 years or more experience had statistically significant risk ratios for lung cancer.

Toxicology of coal liquefaction products: an overview

Chu, L., Villeneuve, D.C., and Rousseaux, C.G.

J Applied Toxicol, 1994 Jul, 14(4), 241-256

Repeated exposure to coal liquefaction products produces a broad range of systemic effects. Teratological effects, as well as mutagenicity and carcinogenicity, of the coal liquefaction distillates seem to be linked to their PAH content. The potential effects of coal liquefaction products on human health can be severe, especially with long-term exposure.

Airborne arsenic and urinary excretion of arsenic metabolites during boiler cleaning operations in a Slovak coal-fired power plant

Yager, J.W., Hicks, J.B., and Fabianova, E.

Environ Health Perspect, 1997 Aug, 105(8), 836-842

This study was done at a coal-fired power plant in Slovakia to determine the relationship between exposure to inorganic Arsenic in coal fly ash and urinary excretion of Arsenic metabolites. As compound characteristics, matrix composition, and particle size distribution play roles in determining the actual uptake of airborne Arsenic.

Rate of malignant tumor mortality among coal burning power plant workers occupationally exposed to arsenic

Bencko, V., Symon, K., Stalnik, L., Batora, J., Vance, E., and Svandova, E.

J Hyg Epidemiol Microbiol Immunol, 1980, 24(3), 278-284

This study compared the mortality pattern among workers of a power plant combusting coal with high Arsenic levels and among workers of three other power plants where the Arsenic concentrations in coal are one magnitude lower. While the increase in tumor mortality rates from the first power plant is not statistically significant, it is significant that malignancy-caused deaths in the exposed group occurred in younger age categories and after a statistically shorter exposure time.

Immunological profiles in workers of a power plant burning coal rich in arsenic content

Bencko, V., Wagner, V., Wagnerova, M., and Batora, J.

J Hyg Epidemiol Microbiol Immunol, 1988, 32(2), 137-146

This study compares workers in a high As coal power plant versus a power plant where the As levels are more than ten times lower. There were statistically highly significant differences between the two groups in regard to levels of transferrin (TRF), orosomucoid (ORO), and ceruloplasmin (CPL). These findings, especially the CPL, are thought to be the cause of the rise in cancer mortality rates previously found in this group of power plant workers.

Health status of workers of a thermal power station exposed for prolonged periods to arsenic and other elements from fuel

Buchancova, J., Klimentova, G., Knizkova, M., Mesko, D., Galikova, E., Kubik, J., Fabianova, E., and Jakubis, M.

Cent Eur J Public Health, 1998 Feb, 6(1), 29-36

The Novaky Power Station in Slovakia has been using high As fuel coal. There have been 16 detailed cases of chronic As intoxication in the station workers. After 1989, there were no more As poisoning cases because of technical measures and safety and health protection of the workers.

Mortality of Dutch coal miners in relation to pneumoconiosis, chronic obstructive pulmonary disease, and lung function

Meijers, J.M., Swaen, G.M., and Slangen, J.J.

Occup Environ Med, 1997 Oct, 54(10), 708-713

The objective of this study was to analyze the mortality patterns of former Dutch coal miners. It was determined that infectious diseases, coal workers' pneumoconiosis (CWP), and chronic obstructive pulmonary diseases (COPD) are important causes of occupational mortality in miners having extensive exposure to coal mine dust.

Coal mine workers' pneumoconiosis (CWP): in vitro study of the release of organic compounds from coal mine dust in the presence of physiological fluids

Schulz, H.M.

Environ Res, 1997, 74(1), 74-83

Leaching of coal mine dust by dichloromethane yields extracts with comparable amounts of alkanes, aromatics, and phenolic compounds. Coal mine dust with varying coal content of different ranks is considered to reinforce the cytotoxic potential of coal mine dust.

Dust exposure, respiratory symptoms, and longitudinal decline of lung function in young coal miners

Carta, P., Aru, G., Barbieri, M.T., Avataneo, G., and Casula, D.

Occup Environ Med, 1996 May, 53(5), 312-319

This study was done to determine the role of dust exposure to incidence of respiratory symptoms and decline of lung function in young coal miners. The results show that even moderate exposures to mixed coal dust significantly affect lung function and incidence of symptoms in underground miners.

Respiratory symptoms and spirometry in experienced coal miners: effects of both distant and recent coal mine dust exposures

Henneberger, P.K., and Attfield, M.D.

Am J Ind Med, 1997 Sep, 32(3), 268-274

The goal of this study was to determine whether respiratory symptoms were associated with the lower concentrations of respirable coal mine dust required by the U.S. Coal Mine Health and Safety Act of 1969. Even after the change in concentrations, miners were still exhibiting respiratory symptoms and higher levels of exposure that increased the symptoms both before and after the change in the concentration.

Coal mine dust exposure and spirometry in experienced miners

Henneberger, P.K., Attfield, M.D.

Am J Respir Crit Care Med, 1996 May, 153(5), 1560-1566

A previous study of coal dust exposure associated with spirometry values showed that new miners would initially have a decrease in their spirometry followed by a partial recovery. This new study shows the effect for experienced miners, where the spirometry values decreased over time and recovery did not rise.

Respiratory impairments due to dust exposure: a comparative study among workers exposed to silica, asbestos, and coalmine dust

Wang, X., Yano, E., Nonaka, K., Wang, M., and Wang, Z.

Am J Ind Med, 1997 May, 31(5), 495-502

The study compared pulmonary dysfunction among workers who were exposed to silica, asbestos or coalmine dust. It was concluded that all three dusts caused functional abnormalities that preceded changes in pneumoconiosis.

A study of physicochemical characteristics of respirable dust in an Indian coal mine

Rawat, N.S.

Sci Total Environ, 1982 Apr, 23, 47-54

The respirable coal dust samples were collected from Indian mines and trace element concentrations were determined. This study explains the nature and mode of trace elements in Indian coal as well as the causes of respiratory disease affecting workers in the mine.

Contrasting geographical distribution of mortality from pneumoconiosis and chronic bronchitis and emphysema in British coal miners

Coggon, D., Inskip, H., Winter, P., and Pannett, B.

Occup Environ Med, 1995 Aug, 52(8), 554-55

The objective of this study was to explore whether the characteristics of coal mine dust that predispose to chronic airways obstruction are the same as those associated with pneumoconiosis. Mortality rates from the two diseases were compared in coal miners in various counties of England and Wales. The findings indicate that the pathogenic mechanisms by which coal dust causes chronic bronchitis and emphysema depend on

different features of the dust from those producing pneumoconiosis. Therefore, there are differences among the counties.

Laryngeal and hypopharyngeal cancer and occupation: results of a case control-study

Goldberg, P., Leclaire, A., Luce, D., Morcet, J.F., and Brugere, J.

Occup Environ Med, 1997 Jul, 54(7), 477-482

This study was done to ascertain whether certain occupations were associated with laryngeal or hypopharyngeal cancer. Analysis by industrial branch showed an excess risk for coal mining.

Occupational risk factors for prostate cancer: results from a case-control study in Montreal, Quebec, Canada

Aronson, K.J., Siemiatycki, J., Dewar, R., and Gerin, M.

Am J Epidemiol, 1996 Feb, 143(4), 363-373

A population-based case-control study of prostate cancer and occupation was carried out in Montreal, Canada. Polycyclic aromatic hydrocarbons from coal were found to exhibit moderately strong associations with prostate cancer.

Excess of cancer in Swedish chimney sweeps

Gustavsson, P., Gustavsson, A., and Hogstedt, C.

Br J Ind Med, 1988 Nov, 45(11), 777-781

An analysis of the mortality of Swedish chimney sweeps showed an increased number of deaths from coronary heart disease, respiratory diseases and lung, oesophageal, and liver cancer. Chimney sweeps are exposed to polycyclic aromatic hydrocarbons generated by the combustion of organic material (coal, wood, coke and oil). They are also exposed to cancerogenic metals (Arsenic, nickel and chromium).

Lung cancer risk and workplace exposures in black men and women

Muscat, J. E., Stellman, S.D., Richie, J.P., and Wynder, E. L.

Environ Res, 1998 Feb, 76(2), 78-84

This is a case-control study of lung cancer risk and workplace exposure in blacks. In men, there were significant associations with reported exposure to coal dust.

Risk of gastric cancer in pneumoconiotic coal miners and the effect of respiratory impairment

Swaen, G.M., Meijers, J.M., and Slangen, J.J.

Occup Environ Med, 1995 Sep, 52(9), 606-610

This study showed there is a reported risk of gastric cancer in coal miners. It also confirmed the hypothesis that this risk of gastric cancer is limited to workers with a mild degree of pneumoconiosis or none. In workers with severe cases of pneumoconiosis, the pulmonary clearance system is impaired in such a way that the inhaled coal dust does not reach the digestive tract.

An investigation into the relationship between coal workers' pneumoconiosis and dust exposure in U.S. coal miners

Attfield, M.D., and Moring, K.

Am Ind Hyg Assoc J, 1992 Aug, 53(8), 486-492

Prevalence of coal worker's pneumoconiosis (CWP) was related to indexes of dust exposure. Clear relationships between prevalences of simple CWP and progressive massive fibrosis (PMF) and estimated dust exposure were found. Additional effects independently associated with coal rank and age were also seen.

Respiratory disease in Utah coal miners

Rom, W.N., Kanner, R.E., Renzetti, A.D. Jr., Shigeoka, J.W., Barkman, H.W., Nichols, M., Turner, W.A., Coleman, M., and Wright, W.E.

Am Rev Respir Dis, 1981 April, 123(4 Pt 1), 372-377

Utah underground coal miners participated in a respiratory disease study. Significant impairment of pulmonary function was found among those with a history of cigarette smoking. There was significant association among nonsmokers between increasing

exposure to coal dust and coal workers' pneumoconiosis. Coal mine dust had a significant influence on causing chronic cough and sputum production and coal workers' pneumoconiosis.

Buffering capacity of coal and its acid-soluble Fe²⁺ content: Possible role in coal workers' pneumoconiosis

Huang, X., Fournier, J., Koenig, K., and Chen, L.C.

Chem Res Toxicol, 1998 Jul 20, 11(7), 722-729

Epidemiological studies have shown that the prevalence of coal workers' pneumoconiosis (CWP) differed between different coal mine regions despite comparable exposures to respirable dust. In the US, CWP was found to be most common in Pennsylvania coal miners and least common in miners from Utah. In the present study, they found that coals from Pennsylvania showed a much lower buffering capacity and released larger amounts of Fe²⁺ than the coals from Utah. This supports the hypothesis that the prevalence of CWP may be higher in coal workers exposed to coal with high acid-soluble Fe²⁺ and low buffering capacity than in workers exposed to coal with low acid-soluble Fe²⁺ and high buffering capacity.

Clinical aspects of coal workers' pneumoconiosis and silicosis

Balaan, M.R., Weber, S.L., and Banks, D.E.

Occup Med, 1993 Jan, 8(1), 19-34

Coal workers' pneumoconiosis and silicosis are important respiratory disorders that result from the inhalation of respirable particles in mining. This paper focused on the clinical aspects of these disorders, including their pathogenesis and pathology, and approaches to their evaluation and management.

Respiratory health effects of opencast coalmining: a cross sectional study of current workers

Love, R.G., Miller, B.G., Groat, S.K., Hagen, S., Cowie, H.A., Johnston, P.P., Soutar, C.A.

Occup Environ Med, 1997 Jun, 54(6), 416-423

The objective of this study was to identify whether there is evidence of pneumoconiosis and other respiratory effects associated with exposure to respirable mixed dust and quartz in United Kingdom opencast coal mines. Frequency of mostly mild chest radiographic abnormalities associated with working in the dustier, preproduction jobs in the industry. Although some of these mild abnormalities may be non-occupational (due to aging or smoking), the association with exposure indicated a small risk of pneumoconiosis in these men, and the need to monitor and control exposures, particularly in the high-risk occupations.

REGIONAL IMPACTS

Endemic selenium intoxication of humans in China

Yang, G.Q., Wang, S.Z., Zhou, R.H., and Sun, S.Z.

Am J Clin Nutr, 1983 May, 37(5), 872-881

During the early sixties, Se intoxication was discovered in parts of the population of Enshi County, Hubei Province, China. The ultimate environmental source of Se was a stony coal of very high Se content (avg. 300 mg/g). Se entered the soil after weathering of the coal and was available for uptake by crops because of the traditional use of lime fertilizer in that region.

Immunological aspects of exposure to emissions from burning coal of high beryllium content

Bencko, V., Vasilieva, E.V., and Symon, K.

Environmental Research, 1980, 22, 439-449

A study was conducted on groups of people exposed to the combustion products of coal containing a comparatively high concentration of beryllium compared to a group of people with no contact with beryllium. The exposed groups had elevated levels of IgG and IgA and increased concentration of antibodies. The demonstrated changes could be used as signs of beryllium exposure.

Effect of trace elements found in coal fly ash, on lymphocyte blastogenesis

Shifrine, M., Fisher, G.L., and Taylor, N.J.

J Environ Pathol Toxicol Oncol, 1984 Jul, 5(4-5), 15-24

To evaluate the potential health effects of coal fly ash on the immune system, the authors studied the effects of trace elements found in fly ash on lymphocyte blastogenesis. The data suggests that whole blood lectin-induced lymphocyte blastogenesis is a sensitive and reproducible test for in vitro screening of trace elements affecting the immune system.

Health aspects of burning coal with a high arsenic content: the central Slovakia experience

Bencko, V.

in: Abernathy, C.O., Calderon, R.L., and Chappell, W.R (eds.), *Arsenic: Exposure and Health Effects*, Chapman & Hall, 84-92

The author has studied the environmental and occupational health aspects of environmental pollution by Arsenic in the vicinity of and within a power plant in central Slovakia. A substantial portion of the emissions was in the form of Arsenic trioxide contained in the fines of the solid phase. It was mostly condensed at the surface of the fly ash particles.

Health aspects of burning coal with a high arsenic content. I. Arsenic in hair, urine, and blood in children residing in a polluted area

Bencko, V., and Symon, K.

Environ Res, 1977 Jun, 13(3), 378-385

Arsenic determination was carried out on hair, urine and blood samples taken from groups of boys residing in a region polluted by arsenic from a power plant burning high arsenic coal. The most useful material for estimation of nonoccupational exposure to arsenic seems to be hair.

Health aspects of burning coal with high arsenic content. II. Hearing changes in exposed children

Bencko, V., Symon, K., Chladek, V., and Pihrt, J.

Environ Res, 1977 Jun, 13(3), 386-395

Hearing changes were analyzed for 10-year-old children residing near a power plant burning high arsenic coal and compared to a second group of children living outside the polluted area. For the exposed children, significant degrees of hearing loss were found in bone conduction as well as in corresponding ranges of frequencies. The possibility of central damage to the ear could not be excluded.

Excess leukemia and multiple myeloma in a mining county in Northeast Texas

Strom, S.S., Spitz, M.R., Cech, I.M., Annegers, J.F., and Downs, T.D.

Tex Med, 1994 Feb, 90(2), 55-59

In Titus County, Texas, there is significant excess of leukemia and multiple myeloma. The excess of cancers in this mining community may be relevant to the disposal of combustion wastes from mining and fossil fuel.

High incidence of gastric carcinoma in a coal mining region

Matolo, N.M., Klauber, M.R., Gorishee, W.M., and Dixon, J.A.

Cancer, March 1972, 29, 733-737

Carbon and Emery Counties contain the only coal mining regions in Utah. The rate of gastric cancer in these two counties is 4 times that of the state of Utah. The gastric cancer incidence of coal miners was at least 3 times that of non-coal miners living in the counties with coal mining and at least 8 times that of males in counties with no coal mining. All homes of patients afflicted with gastric cancer in both counties were heated with coal, and coal was used for cooking in some of the cases. It is concluded that coal mining in this area and the use of soft coals might be factors in the cancer cases.

Estimate of the annual per capita surplus dose due to the elevated indoor exposure to ^{222}Rn progeny caused by the use of slag and spoil of uranium rich coal for building purposes in Ajka Town, Hungary

Papp, Z.

Health Phys, 1998 Mar, 74(3), 393-397

Ajka Town, Hungary has been mining uranium-rich brown coal and using the slag and spoil for building purposes. Elevated indoor air ^{222}Rn levels were found in homes that used the coal byproducts as building materials or foundations.

The impact of natural radioactivity from a coal-fired power plant

Bauman, A., and Horvat, D.

Sci Total Environ, 1981 Jan, 17(1), 75-81

In a coal-fired power station burning coal that contained between 14-100 ppm U, 210Pb was detected in the urine of an exposed group of individuals. Chromosome aberrations were also noticed.

**Natural radiation environment of the Nasik and Neyveli thermal power stations,
India**

Lalit, B. Y., Ramachandran, T. V., and Mishra, U. C.

Sci Total Environ, 1986 Jul, 52(3), 221-232

The trace quantities of naturally occurring radionuclides present in the coal fuel of thermal power stations resulted in redistribution of these radionuclides in the vicinity of the power stations through the deposition and the disposal of ash. This study looked at the environmental radioactivity and radiation doses in the vicinity of two large size power stations. A minor increase was observed in radiation levels in the ash-pond areas. A few food samples grown in the surrounding areas showed marginal increases in their natural radioactivity content.

**Recent developments in molecular epidemiology: A study of the effects of
environmental polycyclic aromatic hydrocarbons on birth outcomes in Poland**

Perera, F. P., Whyatt, R. M., Jedrychowski, W., Rauh, V., Manchester, D., Santella, R. M., and Ottman, R.

Am J Epidemiol, 1998 Feb 1, 147(3), 309-314

The authors presented data from a study in Poland on the developmental effects of fetal exposure to polycyclic aromatic hydrocarbons (PAH) via pollution from coal burning. PAH-DNA adducts were measured in umbilical cord blood from newborns in Krakow and Limanowa. Newborns whose level of PAH-DNA adducts were above the median had significantly decreased birth length, weight, and head circumference.

Endemic goiter in western Columbia

Gaitan, E.

Ecol Dis, 1983, 2(4), 295-308

Goiter is prevalent in some areas of western Colombia. Significant relationships were found between goiter prevalence and both the geological composition of watersheds and bacterial contamination of water supplies. The presence of sedimentary rocks rich in organic matter (coals, shales, etc.) was the best indicator of disease. Epidemiological evidence indicates a cause-effect relationship between sources of drinking water and the persistence and development of goiter in this part of the world.

In vitro detection of antithyroid activity in rocks and small water samples from supplies of endemic goiter areas

Gaitan, E., Cooksey, R.C., Matthews, D., and Presson, R.

in: Trace Substances in Environmental Health-XV Proceedings of the University of Missouri's 15th annual conference on trace substances in environmental health, 1991, 247-257

An in vitro assay has been used to investigate antithyroid activity (AA) in rocks and water samples from an endemic goiter area in western Columbia. It was determined that the area which contained exclusively igneous rocks had low endemicity and no AA. These results back up the hypothesis that organic antithyroid compounds from sedimentary rocks (shale, coal, lignite, etc.) contaminate water supplies in areas where goiter persists despite adequate iodine supplementation.

Antithyroid effects of coal-derived pollutants

Lindsay, R.H., Hill, J.B., Gaitan, E., Cooksey, R.C., and Jolley, R.L.

J Toxicol Environ Health, 1992 Dec, 37(4), 467-481

Endemic goiter in iodide-sufficient areas of the United States and Colombia has been linked to watersheds rich in coal and shale, which several reports have suggested as the source of water-borne goitrogens. Antithyroid effects may be greatly amplified by exposure to multiple coal-derived goitrogens. The results demonstrate that potent water-borne goitrogens are derived from coal and shale and that their contamination of water supplies could pose a serious threat of thyroid disorders.

Epidemiology of pollution-induced airway disease: urban/rural differences in East and West Germany

Nicolai, T.

Allergy, 1997, 52(38 Suppl), 26-29

The prevalence of asthma and allergic disorders was assessed in children in Leipzig and Halle in East Germany and Munich, West Germany. The East German cities are heavily polluted due to private burning of coal and industrial emissions, while Munich has low smoke emissions but heavy road traffic. Bronchitis, cough, and autumn/winter nasal symptoms were most prevalent in East Germany, while hay fever and asthma were prevalent in West Germany.

Visual contrast sensitivity deficits in Bohemian children

Hudnell, H.K., Skalik, I., Otto, D., House, D., Subrt, P., and Sram, R.

Neurotoxicology, 1996, 17(3-4), 615-628

This paper presents visual contrast sensitivity (VCS) measurements on children in the Czech Republic. The study compared children in Teplice, an area in which soft-brown coal combustion has produced high levels of pollutants, with children in areas of low air pollution. It was hypothesized that in utero exposure to the combustion products disrupted neurological development. The authors also collected hair samples to test for As and Hg. It was determined that current Hg body-burdens are poor predictors of VCS. They also concluded that if the VCS deficits seen in the study are related to prenatal exposure, there also seems to be a developmental delay.

The effects of air pollution on children

Bates, D.V.

Environ Health Perspect, 1995 Sep, 103 Suppl 6, 49-53

Air pollutants have been documented as associated with a wide variety of adverse health impacts in children. These impacts are especially severe when high levels of outdoor pollution, usually from coal burning, are combined with high levels of indoor pollution. In

developed countries, increased traffic levels and elevated NO₂ levels appear to be the problem, as indoor pollution levels are usually lower.

Air pollution and daily mortality in Erfurt, East Germany, 1980-1989

Spix, C., Heainrich, J., Dockery, D., Schwartz, J., Volksch, G., Schwinkowski, K., Collen, C., and Wichmann, H.E.

Environ Health Perspect, 1993 Nov, 101(6), 518-526

In Erfurt, Germany, emissions from coal burning have led to very high pollution. Total daily mortality was obtained to assess possible health effects from exposure to this pollution. It was determined that the effect for particulates was stronger than for SO₂. Also, the effects of air pollution were smaller than the effects of influenza epidemics and similar in size to meteorological effects.

Assessment of health risks due to hazardous air pollutant emissions from electric utilities

French, C., Peters, W., Maxwell, B, Rice, G., Colli, A., Bullock, R., Cole, J., Heath, E., Turner, J., Hetes, B., Brown, D.C., Goldin, D., Behling, H., Loomis, D., and Nelson, C.

Drug Chem Toxicol, 1997 Nov, 20(4), 375-386

Hazardous air pollutant (HAP) emissions from electric utilities were evaluated in regard to inhalation exposure. Results suggest that As, Cr, and Ni are the HAPs as presenting the highest cancer risks due to inhalation exposure. For non-cancerous effects, hydrogen chloride appears to be the biggest concern. Mercury is of potential concern for multipathway exposures because it persists in the environment and bioaccumulates in the aquatic food web.

Comparative health risk assessment of nuclear power and coal power in China

Ren, T., Li, Y., Fang, D., and Li, H.

J Radiol Prot, 1998 Mar, 18(1), 29-36

In China, the public health risk of ionizing radiation released from the coal-fired energy chain is about 18 times that of the nuclear energy chain. The main factors contributing to the fatality risk for the former are public dose caused by the use of coal fly ash and the occupational exposure caused by radon and its daughter products in coal mines. The health risk of coal-fired energy chain could be significantly reduced if technique and management were improved. Even then the risk of the coal-fired energy chain is about 4.4 times that of the nuclear energy chain.

Relationship between ambient air pollution and DNA damage in Polish mothers and newborns

Whyatt, R.M., Santella, R.M., Jedrychowski, W., Garte, S.J., Bell, D.A., Ottman, R., Gladek-Yarborough, A., Cosma, G., Young, T.L., Cooper, T.B., Randall, M.C., Manchester, D.K., and Perera, F.P.

Environ Health Perspect, 1998 Jun, 106(Suppl 3), 821-826

Industrialized regions in Poland are characterized by high ambient pollution, including polycyclic aromatic hydrocarbons (PAHs) from coal burning for industry and home heating. This study measured the amount of PAHs bound to DNA (PAH-DNA adducts) in maternal and umbilical white blood cells. Results indicate that PAH-induced DNA damage in mothers and newborns was increased by ambient air pollution.

Concentrations of radionuclides of size fractionated fly-ash emissions from a thermal power plant using Taiwan coal

Weng, Y.H., and Chu, T.C.

J Radiat Res (Tokyo), 1992 Jun, 33(2), 141-150

Coal, fly ash and bottom ash samples were taken from a coal-fired power plant with a daily coal consumption of 2,400 tons. Determinations of the concentrations of radionuclides were carried out by either gamma or alpha spectrometry. For elements volatilized during combustion, the radionuclide concentrations decrease with increasing particle size. Of all radionuclides studied, ^{210}Po and ^{210}Pb are the most volatile

elements; therefore, an increase in the natural radiation level should first be indicated by an increase in these two nuclides.

The etiology of Balkan Endemic Nephropathy: Still more questions than answers

Tatu, C.A., Orem, W.H., Finkelman, R.B., and Feder, G.L.

Environmental Health Perspectives, 1998 November, 106(11)

Balkan endemic nephropathy (BEN) is a kidney disease found in the Balkans and is a possible environmental disease. Two competing theories to explain the cause of this disease is 1) BEN is produced by ochratoxin A ingested intermittently in small amounts by the individuals in the endemic regions, and 2) the disease is caused by long-term exposure to polycyclic aromatic hydrocarbons leaching into the water supply from low rank coals. This paper outlines the developments and prospects in the study of BEN and differentiate possible factors and cofactors in disease etiology.

DOMESTIC USE

There are numerous publications dealing with the issue of health impacts from coal in Xuan Wei, China. A small sampling is listed below.

Risk factors for lung cancer in non-smokers in Xuanwei County of China

Lan, Q., Chen, W., Chen, H., and He, X.Z.

Biomed Environ Sci, 1993 Jun, 6(2), 112-118

In Xuanwei County, Yunnan Province, China, lung cancer deaths were among the highest for China. There is marked district variation in cancer mortality within Xuanwei County. In the three lung cancer high mortality districts, the residents mainly burned the “smoky” coal from the Laibin smoky-coal mine. The fuel was burned in a shallow, unventilated fire pit in the floor of the dwelling, which has resulted in high indoor air pollution levels.

Lung cancer and indoor air pollution in Xuan Wei, China

Mumford, J.L., He, X.Z., Chapman, R.S., Cao, S.R., Harris, D.B., Li, X.M., Xian, Y.L.,
Jiang, W.Z., Xu, C.W., Chuang, J.C., et al

Science, 1987 Jan 9, 235(4785), 217-220

In Xuan Wei County, China, lung cancer mortality is more closely associated with indoor burning of “smoky” coal than with tobacco smoking. Smoky coal emission has high concentrations of submicrometer particles containing mutagenic organic compounds.

DNA adducts as biomarkers for assessing exposure to polycyclic aromatic hydrocarbons in tissues from Xuan Wei women with high exposure to coal combustion emissions and high lung cancer mortality

Mumford, J.L., Lee, X., Lewtas, J., Young, T.L., and Santella, R.M.

Environ Health Perspect, 1993 Mar, 99, 83-87

The high lung cancer rate in Xuan Wei, China, is associated with smoky coal use in unvented homes, but not with wood or smokeless coal. Smoky coal combustion emits higher polycyclic aromatic hydrocarbon (PAH) concentrations than wood combustion.

This study used DNA adducts as biomarkers for human exposure to PAH from combustion emissions. The results suggest that DNA adducts can be used as a qualitative biomarker to assess human exposure to combustion emissions.

A study on the relationship between in-door air pollution and chronic obstructive pulmonary disease in Xuanwei County

Zhou, X., Jin, Y., and He, X.

Chung Hua Yu Fang I Hsueh Tsa Chih, 1995 Jan, 29(1), 38-40

[Article in Chinese]

A study was done to explore the relationship between indoor air pollution caused by different fuels for domestic use and chronic obstructive pulmonary disease (COPD) in Xuanwei County, China. The results showed indoor air pollution caused by coal burning was the major risk factor for COPD. The risk of residents using soft coal and anthracite to suffer from COPD was 4.36 and 1.55 times higher, respectively, than in using firewood.

Human exposure and dosimetry of polycyclic aromatic hydrocarbons in urine from Xuan Wei, China with high lung cancer mortality associated with exposure to unvented coal smoke

Mumford, J.L., Li, X, Fuding, H., Lu, X.B., and Chuang, J.C.

Carcinogenesis, 1995 Dec, 16(12), 3031-3036

The lung cancer mortality rate in Xuan Wei county, China, is five-fold the national average of China and it is the highest rate for woman in China. This study investigated indoor air exposure of polycyclic aromatic hydrocarbons (PAHs) by residents using smoky coal for cooking or heating their homes. The conclusion showed that alkylated PAHs are the major mutagens in the indoor air and may be etiologically important in Xuan Wei lung cancer.

DNA adduct profiles and levels in placenta, blood and lung in relation to cigarette smoking and smoky coal emissions

Gallagher, J., Mumford, J., Li, X., Shank, T., Manchester, D., and Lewtas, J.

IARC Sci Publ, 1993, 124, 283-292

Tobacco smoking and indoor smoky coal combustion emissions lead to exposures to mixtures that have been associated with increased lung cancer mortality rates in the USA and Xuan Wei County, China, respectively. Human exposure to benzo[a]pyrene (BaP) present in smoky coal emissions are 20-200 times greater than exposure to BaP from smoking 1-2 packs of cigarettes per day. DNA adduct levels were approximately four-fold higher in bronchoalveolar lavage cells from individuals exposed to coal smoke compared to unexposed individuals.

Analysis and estimates of attributable risk factors for lung cancer in Nanjing, China

Shen, X.B., Wang, G.X., Huang, Y.Z., Xiang, L.S., and Wang, X.H.

Lung Cancer, 1996 Mar, 14 Suppl 1, S107-S112

A case control study was performed on cases of primary pulmonary squamous cell carcinoma and of primary pulmonary adenocarcinoma in Nanjing, China. The five risk factors for pulmonary squamous carcinoma were: smoking, indoor air pollution due to cooking fumes, family tumor history, type of fuel used in the home, and use of coal stoves for heating in winter. The four risk factors for pulmonary adenocarcinoma were smoking, cooking fumes, chronic bronchitis and family tumor history.

The etiology of lung cancer in nonsmoking females in Harbin, China

Dai, X.D., Lin, C.Y., Sun, X.W., Shi, Y.B., and Lin, Y.J.

Lung Cancer, 1996 Mar, 14 Suppl 1, S85-S91

A case-control study of female lung adenocarcinoma in Harbin, China showed that high coal use, indoor air pollution, exposure to coal dust, frequently frying food, and a history of lung cancer in the family were statistically significant risk factors.

Indoor burning coal air pollution and lung cancer – a case-control study in Fuzhou, China

Luo, R.X., Wu, B., Yi, Y.N., Huang, Z.W., and Lin, R.T.

Lung Cancer, 1996 Mar, 14 Suppl 1, S113-S119

A case-control study on risk factors for lung cancer was carried out in Fuzhou, China. The major risk factors for lung adenocarcinoma were: indoor air pollution from burning coal, chronic bronchitis, and high economic income. The risk factors for lung squamous cell carcinoma were: amount of cigarettes smoked per day, "deep inhalation," a history of exposure to environmental tobacco smoke (ETS) before 20 years of age, burning coal indoors, and high economic income. The risks for lung cancer were burning coal indoors, smoking, exposure to ETS before 20 years of age, chronic bronchitis, and high economic income. Their research supports the hypothesis that smoking and indoor air pollution are the major risk factors for lung cancer in Fuzhou.

Risk of male lung cancer attributed to coal combustion indoors in Shanghai

Tao, X.G., Hong, C.J., Yu, S.Z., and Zhu, H.G.

Public Health Rev, 1991, 19(1-4), 127-134

Lung cancer is the leading cause of death among all male cancers in Shanghai. The purpose of the study is to determine the risk of lung cancer death in male residents who live in coal-using families. The result shows that male lung cancer mortality in the coal-using group is higher than that in the coal-gas-using group.

Possible role of indoor environment and coal combustion emission in lung carcinogenesis in Fuyuan County, China

Nakanishi, Y., Chen, S., Inutsuka, S., Ma, Y., Jiang, X., Hara, N., Sera, N., and Tokiwa, H.

Neoplasma, 1997, 44(1), 69-72

Fuyuan County, Yunnan Province, China has extremely high lung cancer mortality both in males and non-smoking females. Indoor soot and combustion emissions derived from smoky coal exhibited high mutagenic activities. These results suggest that mutagenic chemicals contained in coal may have a great influence on lung carcinogenesis.

Indoor air pollution by emissions of fossil fuel single stoves: possibly a hitherto underrated risk factor in the development of carcinomas in the head and neck

Dietz, A., Senneweld, E., and Maier, H.

Otolaryngol Head Neck Surg, 1995 Feb, 112(2), 308-315

This study looked at the relative risk of head and neck cancer in association with indoor air pollution. Significant results with laryngeal and pharyngeal cancer related to daily exposure to fossil fuels due to stove heating with oil, coal, gas, and wood for longer than 40 years.

Environmental determinants of lung cancer in Shenyang, China

Xu, Z.Y., Blot, W.J., Li, G., Fraumeni, J.F. Jr, Zhao, D.Z., Stone, B.J., Yin, Q., Wu, A., Henderson, B.E., and Guan, B.P.

IARC Sci Publ, 1991, 105, 460-465

It was determined that air pollution from coal-burning heating and cooking devices was significantly linked to lung cancer in Shenyang, China, with risks rising in proportion to duration of exposure to indoor pollutants.

Lifestyle, environmental pollution and lung cancer in cities of Liaoning in northeastern China

Xu, Z.Y., Brown, L., Pan, G.W., et. al,

Lung Cancer, 1996 Mar, 14 Suppl 1, S149-S160

Studies were conducted in cities in Liaoning Province, one of the areas of China with heavy concentrations of industry. Cigarette smoking was found to be the principal cause of lung cancer in this area. There was also increased risk associated with the index of indoor air pollution due to coal-burning emissions. Results also suggest that there were increased risk for all occupations in which there was exposure to dusts.

The investigation of the total amount of fluoride intake with correlative dental fluorosis polluted by burn coal in the epidemic fluorosis districts

Wu, D.L., and Li, Y.L.

Chung Hua Yu Fang I Hsueh Tsa Chih, 1990 Jan, 24(1), 1-5

[Article in Chinese]

In China, it was determined that the main sources of fluorosis are from pollution by coal smoke, and the content and amount of fluoride intake from the maize and capsicum by drying over the coal.

Air pollution-type fluorosis in the region of Pingxiang, Jiangxi, Peoples' Republic of China

Chen, Y., Lin, M., He, Z., Xie, X., Liu, Y., Xiao, Y., Zhou, J., Xiao, X., and Xu, F.

Arch Environ Health, 1993 Jul, 48(4), 246-249

There is high incidence of endemic fluorosis in the Pingxiang region in China. This type of endemic fluorosis is related to air pollution, the major source of which comes from the coal burned by residents in their homes. During the process of burning coal, a large amount of nonsoluble fluorine is converted into water-soluble fluoride, which can have major human health effects.

Health effects of indoor fluoride pollution from coal burning in China

Ando, M., Tadano, M., Asanuma, S., Tamura, K., Matsushima, S., Watanabe, T., Kondo, T., Sakurai, S., Ji, R., Liang, C., and Cao, S.

Environ Health Perspect, 1998 May, 106(5), 239-244

The combustion of high fluoride coal for heating, cooking, and food drying is a major emission source for suspended particulate matter and fluoride. Because indoor fluoride from combustion of coal is easily absorbed in stored food and because food consumption is a main source of fluoride exposure, it is necessary to reduce airborne fluoride and food contamination to prevent serious fluorosis in China.

An investigation of fluoride pollution caused by burning coal containing fluoride in Xiushan and Baojing

Yan, L.

Chung Hua Liu Hsing Ping Hsueh Tsa Chih, 1991 Apr, 12(2), 102-105

[Article in Chinese]

This article reports on the measurement of soluble fluoride in the air and foods in Xiushan and Baojing. After measuring concentrations of soluble fluoride in drinking water, soil, coal, air, fly ash, maize, chilies, and other vegetables, the authors determined that the pathway for fluoride migration from coal to humans is through the pollution of air and maize by fly ash and then by human consumption of the polluted maize. There is significant correlation between the concentration of fluoride in maize and fly ash.

The physical and chemical characteristics of particles in indoor air where high fluoride coal burning takes place

Gu, S.L., Ji, R.D., and Cao, S.R.

Biomed Environ Sci, 1990 Dec, 3(4), 384-390

In China, more than 10 million people suffer from fluorosis caused by the burning of high fluoride coal. It has been determined that the level of F^- in air was considered to be inadequate to cause the observed severity of fluorosis. It is speculated that additional intake of F^- from contaminated foods might also be a major factor contributing to fluorosis.

Human fluorosis and environmental geochemistry in southwest China

Zheng, B.S., and Huang, R.G.

in: Chinese Academy of Sciences, Development of Geoscience, Contribution to 28th International Geological Congress, Washington D.C., July 1989, 171-176

Endemic fluorosis imposes serious harm on the health of the Chinese people. In most cases, high fluorine contents in drinking water have played a role in this disease.

However, in southwest China, fluorosis is caused by polluted air and food as a result of indoor coal burning.

Investigation of chronic arsenic poisoning caused by high arsenic coal pollution

Zhou, D.X.

Chuang Hua Yu Fang I Hsueh Tsa Chih, 1993 May, 27(3), 147-150

[Article in Chinese]

Exploitation of high arsenic coal caused drinking and irrigating water to be polluted by arsenic and the burning of this coal caused severe arsenic pollution in the air, food, soil and drinking water. The polluted air and food were mainly responsible for chronic arsenic poisoning in thousands of villagers, although drinking water and skin absorption played a part in the poisoning. The author suggests that when the arsenic level in coal is as high as 100mg/kg, the possibility of environmental arsenic pollution and chronic arsenic poisoning should be considered.

The status of arsenic poisoning in China

Niu, S., Cao, S., and Shen, E.

In: Abernathy, C.O., Calderon, R.L., and Chappell, W.R., (Eds.), *Arsenic: Exposure and Health Effects*, Chapman & Hall, 78-83

In the 1980's, the first cases of arsenic poisoning in mainland China were caused by arsenic contamination in drinking water wells. In the early 1990s, there were reports from Guizhou Province concerning chronic arsenic poisoning from burning coal with very high levels of arsenic. The third source of arsenic poisoning was found to be arsenic pollution from non-ferrous smelters located in Yunan Province.

Geochemistry of coals causing arsenism in southwest China

Belkin, H.E., Zheng, B.S., and Finkelman, R.B.

In: Wanty, R.B., Marsh, S.P., and Gough, L.P., (Eds.), *4th International Symposium on Environmental Geochemistry -- Program with Abstracts, 1997*, U.S. Geological Survey, OpenFile Report OF97-496, 10

The use of high arsenic (>1000 mg/kg) coals for heating and food preparation in the mountainous regions of Guizhou Province in China has led to over 3,000 cases of arsenic poisoning. The mineralogy and geochemistry of some of the coals are being studied to determine the source of the arsenic and to understand its behavior during combustion. The ingestion of various vegetables that are dried in homes with no chimneys is the primary pathway of human introduction.

Indoor air pollution in developing countries

Chen, B.H., Hong, C.J., Pandey, M.R., and Smith, K.R.

World Health Stat Q, 1990, 43(3), 127-138

This study involved research on combustion-generated pollutants from solid-fuel-fired (including coal) cooking and heating stoves in developing countries. The authors also described health problems from stoves in China, Nepal, and India.

Carbon monoxide poisoning related to the use of steam coal in poorly ventilated bucket stoves

Emri, S., Baris, B., Lheureux, P., Leduc, D., Yskenderany, A., Seber, O., and Baris, Y.I.

Eur J Emerg Med, 1995 Jun, 2(2), 92-95

In the late 1980's, there were an increasing number of people diagnosed with acute carbon monoxide (CO) poisoning in Ankara, Turkey. The source of CO poisoning was identified as improper combustion of recently marketed steam coal in inadequately ventilated bucket stoves.

Determinations of personal carbon monoxide exposure and blood carboxyhemoglobin levels in Korea

Chung, Y., Park, S.E., Lee, K., Yanagisawa, Y., Spengler, J.D.

Yonsei Med J, 1994 Dec, 35(4), 420-428

In Korea, CO poisoning has been a major public health problem due to coal briquette (Yeontan) combustion for space heating and cooking.

Ambient air pollution & respiratory symptoms complex in preschool children

Awasthi, S., Glick, H.A., Fletcher, R.H., and Ahmed, N.

Indian J Med Res, 1996 Oct, 104, 257-262

The authors studied the association between ambient air pollutants and respiratory symptoms complex (RSC) in preschool age children in Lucknow, India. Particulate matter

and SO₂ from cooking and heating fuels (including coal) and remaining indoors during cooking were associated with increased incidence of RSC, increased duration, or both.

Passive cigarette smoke, coal heating, and respiratory symptoms of nonsmoking women in China

Pope, C.A. 3d, and Xu, X.

Environ Health Perspect, 1993 Sep, 101(4), 314-316

This study evaluated data from never-smoking women who worked in textile mills in Anhui Province, China. Respiratory symptoms were associated with combined exposure to passive cigarette smoke and indoor coal heating.

Indoor air pollution of coal fumes as a risk factor of stroke, Shanghai

Zhang, Z.F., Yu, S.Z., and Zhou, G.D.

Am J Public Health, 1988 Aug, 78(8), 975-977

In this study, coal fumes were found to be an independent risk factor for stroke.

Carboxyhemoglobin levels in relation with home heating

Gonzalez Ruiz, J.M., Barrueco, M., Cordovilla, R., Gomez, F., Hernandez, M.A., and Rodriguez, M.C.

Arch Bronconeumol, 1997 Sep, 33(8), 378-383

[Article in Spanish]

The purpose of this study was to study carboxyhemoglobin (HbCO) levels associated with use of different types of home heating and to evaluate the usefulness of measuring hemoglobin oxygen saturation. High HbCO concentrations were related to chronic exposure to slack coal fumes.

Umbilical cord blood lead levels in Shanghai, China

Shen, X.M., Yan, C.H., Guo, D., Wu, S.M., Li, R.Q., Huang, H., Ao, L.M., Zhou, J.D., Hong, Z.Y., Xu, J.D., Jin, X.M., and Tang, J.M.

Biomed Environ Sci, 1997 Mar, 10(1), 38-46

This study was done to determine the cord blood lead (BPb) levels of babies born in one area of Shanghai and to determine factors that have an effect on these levels. A high percentage of newborns had high BPb levels. These babies are at risk for developing neuropsychological deficiencies caused by maternal lead exposure during pregnancy. Two factors in this exposure are household coal combustion and neighborhood coal combustion.

Air pollution-type fluorosis in the region of Pingxiang, Jiangxi, Peoples' Republic of China

Chen, Y., Lin, M., He, Z., Xie, X., Liu, Y., Xiao, Y., Zhou, J., Fan, Y., Xiao, X., and Xu, F.

Arch Environ Health, 1993 Jul, 48(4), 246-249

This paper addresses the epidemiology, environmental factors, geological features, and total amount of fluoride intake by residents of the Pingxiang region in the P.R. China where there is a high incidence of endemic fluorosis. This type of endemic fluorosis is related to air pollution; indoor coal burning is the major source. A second source is the mud used to make adobe for tiles. During the process of burning coal or baking tiles, a large amount of nonsoluble fluorine is converted into water-soluble fluoride, which can have major human health effects.

Indoor air pollution in four cities in China

Qin, Y.H., Zhang, X.M., Jin, H.Z., Liu, Y.Q., Fan, D.L., Yin, X.R., Li, Z., Fang, W., and Wang, G.F.

Biomed Environ Sci, 1991 Dec, 4(4), 366-372

The study reports the investigation of indoor air pollution carried out in four cities in China (Chengde, Shanghai, Shenyang and Wuhan). The concentrations of SO₂, CO and NO₂ were measured in kitchens and bedrooms, both in summer and winter. The results showed that indoor air pollution was heaviest when coal was used as domestic fuel. This was particularly severe in winter. The concentrations of pollutants in kitchens were higher than those in bedrooms.

Heating fuels and respiratory diseases in the risks of female lung cancer

Sun, X.W.

Chung Hua Chung Liu Tsa Chih, 1992 Nov, 13(6), 413-415

[Article in Chinese]

Lung cancer has become the number one cause of death for women of Harbin, P.R. China. The etiological factors for these cases still remain obscure. The purpose of this study was to determine the relevancy of heating fuels and respiratory diseases in the development of lung cancer in women. Soft coal and brazier were found to increase the risk of cancer. Also, both past history of pulmonary tuberculosis and pulmonary emphysema increased the risk of cancer.

Effect of cooking fuels on respiratory diseases in preschool children in Lucknow, India

Awasthi, S., Glick, H.A., and Fletcher, R.H.

Am J Trop Med Hyg, 1996 Jul, 55(1), 48-51

This paper studied the association between cooking fuels and the risk of respiratory disease in preschool children in Lucknow, India. The types of cooking fuel and the duration of exposure during the previous week were some of the potential predictors of respiratory disease. The cooking fuels used were wood, kerosene, coal, gas, and dung cakes.