Chronic Health Effects of Inhalation of Dust or Sludge

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Abstract

During the 2011 Great East Japan Earthquake, different kinds of rubble, waste, ocean floor sludge, and other materials containing chemical substances were piled up by the tsunami in addition to the collapse of buildings. It is anticipated that large quantities of dust will be generated from these collapsed buildings and rubble during post-disaster reconstruction.

It has long been known that dust from work environments and air pollution can be carcinogenic and affect the respiratory system. There is a high possibility of inhalation of organic dust, bacteria, dust containing chemical substances, asbestos dust, and other materials during the post-disaster reconstruction. Inhalation of dust containing mold or Legionella bacteria causes hypersensitivity pneumonitis and Legionnaires disease. Inhalation of asbestos dust can cause lung cancer and mesothelioma ten-odd years later. To prevent inhalation of these kinds of dusts, it is important to control dust generation such as by sprinkling water, to rigidly enforce the wearing of dust masks, and for the elderly and children especially to avoid very dusty places.

Key words Dust, Asbestos, Mesothelioma, Sludge

Introduction

A year has already passed since the Great East Japan Earthquake of March 11, 2011. However, since this disaster involved a nuclear power plant accident on top of the damage caused by the earthquake and tsunami, a clear course toward recovery is still not visible.

In the Great East Japan Earthquake, in addition to the collapse of buildings and other structures as a result of the earthquake, the tsunami that struck after the quake caused rubble and waste mixed with metals, wood, plastic, and other materials, all of which was mixed with a large amount of ocean floor sludge, to pile up on land. The disposal of all this waste will continue over a long period toward recovery, and it is thought that the demolition and removal of buildings will shift into full swing from here on.

This paper examines the possibility of chronic health effects of inhalation of dust specific to disaster recovery and dust from sludge that could contain pollutants such as chemical substances and heavy metals. It also discusses preventive measures.

Respiratory Disorders Caused by Inhalation of Dust in the Environment

Dust in the work environment

It has long been known that inhalation of dust causes respiratory disorders. The following are the main chronic respiratory disorders that result from the inhalation dust in the work environment and their causes:

(1) Pneumoconiosis and pulmonary fibrosis (silica and asbestos, etc.)
(2) Hypersensitivity pneumonitis and farmer's lung (hay, mold, spores, etc.)
(3) Occupational asthma (toluen diisocyanate,

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phthalic anhydride, sawdust, etc.)
(4) Occupational lung cancer (asbestos, hexavalent chromium, etc.)

The Pneumoconiosis Act[1] was established in 1960, strengthening control of the work environment. However, in 2009 the rate of positive findings in pneumoconiosis examinations was 2.1%,[2] indicating that this is a problem that has yet to be solved.

Dust in the ambient air

Smoke and soot problems caused by coal burning occurred in areas throughout Japan from the Meiji period (1868–1912) forward. Not long after World War II, there was a high incidence of asthma among U.S. military personnel and their families stationed in Yokohama City, Kanagawa Prefecture close to the Keihin industrial area (what was called "Yokohama asthma"). These cases were recorded as asthma caused by air pollution.[3] In the late 1950s and early 1960s, the situation was severe in the center of Osaka, which is located in the Hanshin industrial area; visibility in wintertime was sometimes 0 meters, and there was a high incidence of chronic bronchitis and bronchial asthma.

It is well known that later there was a high incidence of health problems including asthma (Yokkaichi asthma) caused by sulfur dioxide (SO_2) at petrochemical complexes in Yokkaichi City, Mie Prefecture.

Dust in the ambient air was initially regulated as the total amount of dust. However, since it is mainly particles with a diameter under 10 μm that are inhaled into and affect the respiratory system and suspend in the air for a long time, ambient air quality standard was established for these particles as suspended particulate matter (SPM) in 1972. SPM concentrations have declined gradually since then.

There are two large peaks in SPM size. Fine particles, which have a diameter in the vicinity of 1 μm, are mainly produced by combustion. Diesel particulate and tobacco smoke are included in this category. Particles larger than that, called coarse particulate matter, include things like soil particles and sea salt particles. Moreover, the inhalation of dust into the respiratory system or the deposition rate in the respiratory system differs depending on particulate size, and evidence has suggested that fine particles have a stronger effect. In 1993, a paper was published that found a correlation between fine particulates with a diameter under 2.5 μm ($PM_{2.5}$) and an increase in mortality from lung cancer or cardiopulmonary disease.[4]

Thereafter, similar study results were published in many countries, and in 2009 a new air quality standard for $PM_{2.5}$ was established (yearly average of no more than 15 $\mu g/m^3$ and a daily average of no more than 35 $\mu g/m^3$) in Japan.[5,6]

Generation of Dust During Reconstruction After a Major Disaster

Dust is generated in the rubble and waste gathered in temporary collection sites and holding yards, and during the deconstruction of remaining buildings and removal and transport of those waste. That dust could contain asbestos fibers scattered in the air from sprayed asbestos and asbestos board used in the past. Additionally, the decay of food and household garbage generates organic dust including pathogens and mold.

Unlike soil particles, the sludge transported by the tsunami consists of fine clay particles that tend to create dust when dried. Furthermore, the tsunami could swallow up various chemical substances as it moved over the land. This sludge that was piled up by the tsunami could turn into dust that contains chemical substances and heavy metals.

Respiratory disorders caused by inhalation of organic dust such as mold and bacteria

Mold and bacteria tend to multiply in buildings that have flooded, collapsed, or been left vacant for a long time. Repeatedly inhaling the organic dust created from these organisms during the cleanup of rubble causes the development of hypersensitivity pneumonitis.

Farmer's lung, which is caused by the spores of thermophilic actinomycetes in hay, has long been known. In houses, certain types of mold, such as *Aspergillus fumigatus* and *Trichosporon asahii*, that propagate inside air conditioners and in humid areas also cause hypersensitivity pneumonitis.

The conditions that develop at the time of year when people start using air conditioners are called summer hypersensitivity pneumonitis and ventilator pneumonia (air conditioning lung, humidifier lung). Inhaling chemical substances and/or organic dusts that become antigens together with dust while picking up in disaster-affected houses and removing rubble during the daytime often results in the development of cough, phlegm, and febrile symptoms four to six hours later in the evening and night. This may result in pneumonia symptoms including shortness of breath and dyspnea. Symptoms persist for 8–12 hours and will naturally improve in a few to 10 days if the antigens are removed or the similar dusty place is avoided. Steroid administration is effective in the case of a strong allergic reaction.

Although not a chronic effect, care is also needed regarding Legionnaire' disease caused by bacteria belonging to the genus *Legionella*, typified by *Legionella pneumophila*, which usually lives in moist soil. Once *Legionella* bacteria enter amoebae or ciliates in water, they can live for a long time, even in a poor environment. Inhaling *Legionella* bacteria living in bathtub circulating systems, showers, or cooling tower water, etc., can cause mass infection. The incubation period for Legionella pneumonia is 2–10 days. While there are cases of the condition becoming serious and fatal in the elderly, there is no human-to-human transmission. Milder cases, called Pontiac fever, present with cold-like symptoms followed by recovery. While there have been no reports of mass infection during or after a disaster thus far, a clinical kit that easily detects antigens in urine is on the market, which has made diagnosis simple. Consequentially, reports of Legionnaire' disease could increase from here on. Under Japan's law concerning infectious diseases, this disease is classified as a class 4 requiring report immediately after diagnosis.

In any case, avoiding inhalation of these kinds of organic dusts is important as a countermeasure. The elderly and children should be made to avoid dusty areas and the raising of dust should be controlled by sprinkling water and the wearing of effective dust masks should be enforced when cleaning up houses and removing rubble.

Respiratory disorders caused by inhalation of asbestos dust

The problems of mesothelioma and lung cancer caused by inhalation of asbestos are what are important as chronic effects on the respiratory system.

The use of asbestos increased rapidly when sprayed asbestos was used extensively in steel-frame structures. In 1972, the World Health Organization (WHO) and International Labor Organization (ILO) announced that, "asbestos is a carcinogenic substance." Japan has prohibited the use of sprayed asbestos (exceeding 5%) since 1975 with the aim of protecting workers. However, asbestos continued to be used in large amounts as a building material and it was not until 2004 that its manufacture and use were completely banned. Consequently, it is highly likely that sprayed asbestos is remained in buildings constructed up to around 1980, when it is possible that even alternative sprays contaminated asbestos.

It was 1989 when the asbestos concentration in the general environment became regulated and a standard value at the boundary of factory grounds (10 fibers/liter) was established. The WHO's Environmental Health Criteria 53 of 1986, which was the basis for the standard value, indicated that the asbestos concentration in ambient air of cities around the world at that time was 1–10 fibers/liter, upon which it stated that, "In the general population [living in cities], the risks of mesothelioma and lung cancer attributable to asbestos cannot be quantified reliably and are probably undetectably low."[6]

Presuming that there is a green belt or roads where people do not live, normally about 10–20 meters wide between the boundary of factory grounds and general residential areas, the standard value at the boundary of factory grounds assumes that if the concentration at the boundary of factory grounds is 10 fibers/liter or less, it will diffuse and dilute to about 1 fiber/liter by the time it reaches general residential areas. Therefore, it is not true that an ambient air concentration or indoor air concentration of asbestos no more than 10 fibers/liter is safe.

The asbestos concentration in the environment of major Japanese cities gradually declined from 1 fiber/liter around 1985 and has remained at about 0.1–0.4 fibers/liter recently. However, following the 1995 Great Hanshin Earthquake, the asbestos concentration in the environment was observed to have increased compared to before the earthquake for over six months due to the deconstruction and removal of collapsed buildings and structures. For this reason, the Ministry of the Environment (MOE) of Japan revised the Air Pollution Control Law in 1996, making it mandatory working practice to remove sprayed asbestos before disassemble or renovation. Additionally, a Handling Manual for the Asbestos Splash Prevention in Times of Disaster[7] was established in 2007 based on experiences in two major disasters up to that point.

Since the second half of the 1990s, quantitative risk assessment has been conducted on carcinogens with no threshold (hazardous air pollutants) such as benzene, based on the use of mathematical models to extrapolate down to low concentrations, leading to the establishment of environmental standards. According to risk assessments by the WHO Regional Office for Europe[8] and the U.S. Environmental Protection Agency,[9] which think that asbestos is a carcinogen with no threshold, the lifetime excess cancer risk combining lung cancer and mesothelioma from continuing to inhale asbestos at about 0.1 fibers/liter over a lifetime is about 10^{-5} (1 in 100,000 people).

In Japan, the ambient air quality standard is set so that the lifetime excess cancer risk will be no more than 10^{-5}. Accordingly, it can be said that the current asbestos concentration in the general environment is the same as the level of this environmental standard or slightly higher.

According to the vital statistics of the Ministry of Health, Labour and Welfare of Japan, the number of deaths due to mesothelioma (pleural, peritoneal) was 1,209 in 2010 and is still on an upward trend. In an investigation conducted by the MOE in Hyogo Prefecture in 2006, approximately 16% of persons who died from mesothelioma were ordinary residents with no experience of occupational exposure or occupation-related exposure. Additionally, one worker who was engaged in the disposal of rubble following the 1995 Great Hanshin Earthquake has unfortunately been reported as already having developed mesothelioma, which has been acknowledged in this case as a work-related illness.

Thus, it is extremely important to observe the peacetime working standards as much as possible during the demolition and renovation of collapsed buildings containing asbestos and during the disposal of waste so as to not push the asbestos concentration in the surrounding environment up further.

The measurements of airborne asbestos concentrations conducted by the MOE following the 2011 Great East Japan Earthquake seem to have not identified areas with especially high concentrations. Nevertheless, it is important to take measure to prevent secondary disasters among workers and ordinary residents, including observing working standards during the demolition of architectural structures, controlling the generation of dust by sprinkling water, and preventing the inhalation of dust by wearing dust masks (national assay disposable masks DS2, N95, etc.; small size for children).

Respiratory disorders caused by inhalation of sludge

Sludge may contain seafloor sediment, pathogenic microorganisms (anaerobic bacteria), and heavy metals, chemical substances, oils (polycyclic aromatic hydrocarbons, Polychlorinated Biphenyls (PCBs)), and dioxins that have run off from factory effluent. It has also been pointed out that the tsunami could have swallowed up various pollutants as it moved over the land. In analyses conducted thus far, bacteria that cause food poisoning have been identified from several samples and arsenic has been detected in concentrations exceeding environmental standards for soil. The National Institute for Environmental Studies is currently measuring pollutants in sludge, and we are now awaiting publication of early analytical results.

When sludge remains for a long time, decay advances and opportunities increase for inhaling dried dust, regarding which care is needed, since highly alkaline dust (pH 10–11) causes a strong inflammatory reaction in the upper and lower respiratory tract. Hands should be washed adequately if sludge is touched.

Soma City, Fukushima Prefecture has announced and put into practice a system of countermeasures to health impairment from sludge in Soma.[10]

Health effects caused by inhalation of dust in the 9/11 terrorist attacks in the U.S.

The 9-year cumulative disease incidence rate has been reported for 27,449 out of a cohort of 50,000 people who inhaled harmful dust while engaged in rescue and recovery operations during and after the 9/11 terrorist attacks in the U.S.[11] New York City firefighters, who sustained the greatest exposure, were not included in this report, but it did include ordinary volunteers. The results showed an overwhelmingly high incidence of respiratory symptoms—asthma (27.6%), sinusitis

(42.3%)—as well as depression, PTSD, and panic disorder. Moreover, a high rate of abnormal respiratory function was found, with 3/4 having low forced vital capacity (FVC). These results suggest that inhalation of dust and other pollutants may have respiratory and other long-term effects and also suggests once again the importance of preventing dust inhalation.

Conclusion

There is a high likelihood of inhaling organic dust, bacteria, and chemical substances when cleaning up rubble, decomposed matter, and moldy building materials and removing sludge. Additionally, in order to prevent the carcinogenic effects of inhaling asbestos during the deconstruction and removal of collapsed buildings, it is important to carry out disposal as much as possible in accordance with peacetime manuals, to control the generation of dust by sprinkling water, to strictly observe the wearing of dust masks, and especially to stop the elderly and children from going near such areas.

Since the development of mesothelioma caused by the inhalation of dust during recovery from the 1995 Great Hanshin Earthquake and the report of a cohort study of people who were engaged in firefighting, rescue, and recovery work in the 9/11 terrorist attacks suggest an increase in respiratory diseases, it is important to make use of these lessons in order to prevent secondary accident.

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