ANALYSIS OF SPATIAL DISTRIBUTION OF SOIL CONTAMINATION AND POTENTIAL LINKAGES TO MULTIPLE DISASTERS: A CASE STUDY IN NAGOYA, JAPAN*

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1. Problem and Its Significance

There is growing evidence that natural hazards can exacerbate soil contamination threats by exposing hazardous chemicals, relocating them, spreading them, or by making them air borne or contaminating groundwater[1,2,3,4]. A recent epidemiological study of public health impacts of floods and chemical contamination in England showed that during floods chemical materials may contaminate homes or can be remobilization in the environment[5]. The study found that health hazards were greater when industrial and agricultural land adjoining residential areas were affected. This could be the case in Japan, particularly in areas of high population density and mixed land use such as the city of Nagoya.

Fast economic growth in Japan, mainly by industrial activities after the World War II, resulted in rapid urbanization, often without much land use planning or consideration of environmental pollution issues. Since 1967, the Japanese government has passes numerous environmental laws to protect human health from environmental pollution. However, despite these efforts, Japan continues to face air, water and soil contamination problems[6].

The dangers posed by soil contamination problems in Japan were first recognized in conjunction with contamination of food and other agricultural products containing heavy metals, DDT, dieldrin and other toxic organic chemicals. Thus, in 1970 the Agricultural Soil Pollution Prevention Law was passed. In the 80s and 90s several incidents involving soil pollution cases by hazardous materials in urban areas mainly from industrial activities called attention of government officials of the danger of hazardous chemicals left behind by former industrial plants or hazardous waste dumps[6]. To address these problems the new Soil Contamination Countermeasures Law was passed in May 2002.

It is estimated that in Japan there are as many as 928,000 sites that need to be investigated for possible soil contamination[7], more than 100 of these sites are located in Nagoya. If this threat is coupled with the high natural hazard risk and high population density in the region, it is clear that a very dangerous situation may exist. In this study we analyze the distribution of soil contamination sites in Nagoya versus natural hazard risk (e.g., risk of earthquakes, flooding, and landslide) and determine if there are areas that require special attention because of their high potential to cause human health impacts and environmental damage. Current soil contamination prevention and clean-up policies in Nagoya are evaluated as well as other hazard mitigation and socio-economic policies to see how they influence the current state of affairs.

2. Background

The identification of soil contamination as a threat to public health and the environment occurred fairly recently following the

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human and environmental disaster at Love Canal in the City of Niagara Falls in New York State (United States) in 1978. Following extensive rains and one of the worst blizzards ever to hit the region, residents at Love Canal began to notice chemical odors in the basement of their homes. 235 families were found to be living on and around a leaking landfill site containing chemicals known to produce cancer in humans, birth defects, and other health problems[8].

Following the events at Love Canal, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund, was passed in the United States in December 1980[9]. Other countries followed suit. Syms[10] observes that government officials, environmentalists and professionals did not completely grasp the danger posed by soil contamination in the United Kingdom until the 1980s and 1990s. In Japan, as was noted previously, soil contamination issues were mainly targeting land for agricultural use until the passing of the new Soil Contamination Countermeasures Law (Law No. 53)[7]. (Aoki 2003).

Interestingly, although the events at Love Canal and some other major soil contamination problems have been exacerbated by natural hazard events, the relationship between natural hazards and soil and water contamination problems have received less attention. A recent paper by Howe and White[11] notes this lack of research, particularly concerning the relationship between flooding, agriculture, and pollution.

There is growing evidence however that natural hazards can aggravate soil and water contamination. A study of pesticide exposure following extensive flooding caused by hurricane Mitch in Honduras, revealed elevated levels of pesticides in soil samples and strikingly high levels of chlorinated pesticides in adolescents three weeks after the storm. Researchers believe that human exposure may have occurred through multiple pathways including ingestion of food and water, inhalation of dust and air, and dermal contact with soil[1]. The recent Asian tsunami disaster of December 26, 2004 serves as another example of severe environmental contamination caused by flooding and disruption of contaminated soils. An environmental assessment report undertaken by the United Nations Environmental Program[2] indicates that toxic chemicals from coastal dumpsites of nuclear and hazardous wastes in coastal regions of Somalia contaminated groundwater and caused health and environmental problems to the surrounding local fishing communities.

There is evidence that earthquakes can stir up contaminants in the environment as well. Ogoshi et al[3] found elevated levels of arsenic in the Inagawa River following the great Hanshin earthquake. The authors believe the arsenic contamination was caused by topographical change after the earthquake resulting in the rerouting of contaminated groundwater. Earthquakes may also strip up contaminants by triggering large clouds of dust from landslides, ground settlement, and building collapse. The Northridge earthquake in California in 1994 triggered thousands of landslides, generating dense clouds of dust containing fungal spores that were blown by strong winds into populated areas resulting in an outbreak of valley fever (coccidioidomycosis)[4]. Earthquake triggered dust clouds of contaminated soil could result in severe health effects.

Finally, earthquakes have the potential to cause settlement or liquefaction at contaminated sites underlain by loose sand or soft silt or clay. This is particularly dangerous at reclaimed waste landfills and Brownfield redeveloped areas, and certain contaminated areas with high groundwater tables underlain by sand formations. By analyzing the geographical distribution of potentially contaminated sites and their risk concerning natural hazards it will be possible to take prevention and mitigation actions before an event occurs and reduce the risk to people, property and the environment.

3. Proposed Approach and Expected Results

Data for the study is obtained from a review of more than 100 fact sheets of potentially contaminated sites in the city of Nagoya, and three Soil Contamination Law Designated Areas[12]. This information is open to the public, and can be viewed at the City of Nagoya's municipal office. Interviews with government officials in charge of soil pollution prevention and clean up serve to better understand how they are dealing with problems concerning the adoption and enforcement of the new soil contamination law. The information collected is geo-referenced so that is can be stored and queried on a geographical information system. A map of contaminated soil sites is created, and is super-imposed on earthquake, flooding and landslide hazard maps for Nagoya City and Aichi Prefectures. Information concerning demographics, sensitive target groups (e.g., schools, homes for the elderly, hospitals),

land use, lifelines and critical infrastructure, as well as political boundaries and water bodies are mapped as well. The maps not only indicate areas of conjoint hazards, but also serve to identify populations groups at higher risk, and socio-economic characteristics of these areas.

The analysis of the distribution of soil contaminated sites in Nagoya versus natural hazard risk (e.g., risk of earthquakes, flooding, and landslide) will help identify those areas that may pose the greatest risk of pollution and human health impacts during the next natural disaster event. Government officials, NGOs and the community could benefit greatly from this information in designing hazard prevention plans, determining potential emergency medical needs to treat potential intoxicated victims, and for overall disaster preparedness planning. In the light of these findings, land use planning, industrial pollution prevention and risk management programs, and economic development policies are evaluated. An attempt is made to identify policies or practices which could help reduce the incidence of conjoint natural disasters and accompanying contamination problems in the future.

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