ENVIRONMENT AND CANCER

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Today incidence rate of various types of cancers caused by environmental effects is 80-90%. In terms of health, environment can be defined as the physical environment, which includes soil, water and air, and the biological and social environment. They all interact with each other and affect the structure of the genes (Aksoy, 2002). Geological resources provide the major, minor and trace elements to the biological system. The elements in soil are affected by various geological incidents. Depending on the environmental conditions, the plants capture certain elements and thus they are transferred from plants to animals and humans.

Geochemical data are directly related with economic and environmental decisions (mineral exploration and extraction and processing, manufacturer industry, agriculture and forestry, waste storage and planning the use of land). Data base that shows the regional changes in the quantity of the chemical elements in earth plays a significant role in the survey of environmental geology with all its aspects. A data in any part of the world may be essential in solving a problem in another part.

Geochemical Environment

The relation between animal and human health and the distribution of chemical substances in our environment was first suggested by Webb (1964) and has become ever-increasingly the subject of many researches. In recent years the interests in the industrialized countries are focused on the anthropogenic accumulation of potentially dangerous elements (As, Cd, Hg, Pb, and organic components and dioxins such as DDT, PCB). Some of these elements are carcinogenics, neurotoxins or irritants and others may cause defective births and infertility (WHO, 1988). In addition, in domestic animals, problems caused by deficiency of trace elements (I, Cu, Co, Se, Zn) are known. Medical geological studies play an important role in distinguishing between anthropogenic studies and natural resources. The regional geochemical data in the UK, Canada, Scandinavian countries and in other developed countries have revealed the presence of radioactive elements and heavy elements that develop naturally in wide areas and cattle ranges at high levels in addition to the pollution caused by the human activity. Moreover this data showed that the related trace elements exist below the necessary levels (Plant and others, 1996).

The well-prepared epidemiological findings in certain developed countries show correlation between environmental geochemistry and food and diseases. The variety of trace elements in crops reflects the chemistry of the soil on which these crops are grown. However, their effects on the people of the developed countries are masked since these foods are supplied from various sources. In contrast, in developing countries, especially in regions where agricultural activities are carried out, majority of foods are supplied from local resources and the problems are particularly intense (because of the misuse of land, pollution and increase in urbanization). In such places the deficiency or the toxicity of trace elements may be more critical for human and animal health than that of in the developed countries. In this case, the studies on the relation between environmental geology and health are more urgent for developing countries than for developed ones (Plant and others, 1996).

The ways of transfer of all elements to the human body, together with the harmful ones and compounds, are the foods and drinks we consume and the air we breathe. Their transfer via skin is less significant. The composition of air, food and water is directly affected by the geological environment. Nevertheless, air, water and soil continuously change chemically through anthropogenic activities. In addition to oxygen, the air we breathe may contain substances very harmful to our health. The elements that generally have physiological roles and necessary for health are as follows (Jr. Combs, 2005):

1) Bone and membrane structure: Ca, P, Mg, F;
2) Water and electrolyte balance: Na, K, C1,
3) Metabolic catalysis: Zn, Cu, Se, Mg, Mo,
4) Oxygen Carriage (binding): Fe, and
5) Hormone effects: I, Cr.

Chemical Elements:

Geochemistry provides studies not only on the total amount of elements in soil, water and dusts but also on their bioavailability which shows potential for their intake into the human body, and it uses this information for the identification, mapping and monitoring of the elements that are important for health. Geochemical maps that indicate total concentration of chemical elements have an essential role in showing the correlation between diseases and trace element levels

(Thornton&Plant, 1980; Plant&Stevenson, 1985, Plant&Thornton, 1986; Appleton, 1992; Plant and others, 1996). Moreover, the amount of each bioavailable element is more important than the total amount of them. For example, Al which is one of the most common elements on earth can exist both in inert and bioavailable forms, and its potential toxicity depends on its chemical form or speciation. The bioavailability and the toxicity of Al become limited when it is under low or very high pH conditions and when it is with colloids together with organic carbon and silicates (Plant and others, 2003). The toxicity of As and Sb also depends on the chemical form of these elements. While M^{-3} is at its most toxic level, the toxicity decreases in the order $M^{+3} > M^{+5} >$ methyl As/Sb.

The importance of chemical speciation in terms of its correlation with health was first suggested by the agriculture researchers through geochemical data (Underwood, 1979, Lander, 1986). The speciation of chemical elements affects the element distribution, its activity and toxicity. The control mechanisms on the trace element speciation and activity are hydrogen ion activity (pH), oxidation-reduction potential (Eh), heat, the surface features of the solids, potential ligands, the speciation of main cations and anions, the presence or absence of dissolved and / or organic material particles and biological activity. The factors that directly affect activity and dissolvability are Eh and pH. While the anions and oxyanions (elements such as Te, Se, Mo, U, As, P, B) are very active under high pH conditions, most of the cations (elements such as Cu, Pb, Hg, Cd) are less active; the opposite prevails under low pH conditions (Plant and others, 1996). Speciation is very important in the absorption of the trace elements and potentially dangerous elements both in natural environment and in the gastrointestinal way (WHO, 1984, 1994). Speciation studies are particularly important in regions where fertility of the soil decreases, forests are cut up and burned or where pollution caused by urbanization, industrial activities and mining is observed. These kinds of geochemical studies may be used in optimizing the improvement strategies of the said regions and in developing the experiences in management. Data on the factors that control speciation in various regions may be used as a guide in places where geochemical data exist and where trace element support is needed for crops. Ideally, environmental geochemical researches should base on chemical speciation especially in tropical areas which are exposed to intensive chemical decomposition.

Elements that are Necessary for Health and Dangerous Chemicals

The below chemicals classified under three groups are dangerous for health:

1) Inorganic Pollutants: Ozone, carbon, nitrogen and sulfur oxides, heavy metals (Cd, Cr, Cu, Hg, Ni, Pb, Zn); other metals and inorganic pollutants (Al, Be, F), radionuclides, mineral fibres and particles (such as asbestos, silica mineral and coal dust) are also pollutants (Alloway&Ayres, 1997)

Elements: The elements necessary for animal health are Fe, Mn, Ni, Cu, V, Zn, Co, and Cr, Mo, Sn, Se as well as K, Na, Ca, P, Cl, S, and N. The necessity of boron for animals is not indicated yet, however boron is essential for advanced plants. In contrast, the potentially dangerous elements (Ag, As, Be, Cd, Hg, Pb, V and the decay products of some of them and probably Ce and Gd from the REE) have harmful physiological effects even with small degree. Al is harmful for animals and plants and it is known that it causes certain neurological diseases in humans. If received or inhaled at sufficient amounts at certain levels and during long periods enough all trace elements are toxic. F, Mo and Se, the deficiency and toxicity levels / concentration intervals (at a few $\mu g\ g^{-1}$ levels) of which are narrow, can be example to this.

Radionuclides: Radioactive substances are formed by nuclear reactions, whether naturally or consciously or as a result of human activity. The radionuclides that are developed naturally are ^{40}K, $^{235,\ 238}U$, and ^{232}Th and their decay products. The radionuclides caused by human are ^{137}Cs, ^{95}Zr, and ^{131}I (Plant and others, 2003).

Mineral Fibres and Particles: These enter the environment as crystalline inorganic composites, particles or fibres. In most cases they remain as fibres or particles and reveal their potentially dangerous effects in this form. They generally become chemically decomposed in various degrees depending on the type of the mineral and environment. For example quartz particles are durable against decay but calcite particles are dissolved rapidly in humid and acidic environments. Certain minerals such as metallic ore minerals are among the other pollutants and their basic effects are caused by their emission during the decay of the metal ions in water and soil (Alloway & Ayres, 1997).

Asbestos fibres are generally used in the thermal insulation of the buildings, pipes and storage tanks, in fire insulation and in the reinforcement of construction materials. The health hazards posed by mineral fibres and particles are not brought about by the outcomes of the biochemical toxic reaction but by its irritational effects associated with the size, shape and surface features of the minerals. This situation causes inflammation in body tissues especially in the lungs and may result in scar tissue or cancer. The risk of lung cancer caused by asbestos increases seriously by smoking, and larynx, pancreas, esophagus, colon and kidney cancer develop (Thompson&Mason, 2003). The respiration of separated dry fibres in air is a great danger. While the fibres are attached together they are less hazardous because there will be few free fibres around. Moreover worn-out thermal insulation materials and materials that contain asbestos concentrated or wasted away in the factory or other mineral fibres constitute great danger (Alloway & Ayres, 1997).

The sources of silica mineral particles are especially the quarries, rock crushing areas and ceramics. Other forms of fine grained quartz and silica accumulate in the lungs and cause silicosis. Less than 12% content of coal, which is an organic polymer, is inorganic. Inhaling coal dust for long periods causes pulmonary fibrosis and a very serious respiratory distress, especially for the workers in the mines.

The length and diameter of fibres is very essential in cancer incidence (Jaenicke, 1982; WHO, 1986). It is argued that the asbestos fibres that do not cause mesothelioma and the unnatural fibres are longer than 8-10µm and their diameter are smaller than 0.25µm (or 1.5µm) (Stanton and others., 1981; Timbrell, 1984; Pott and others., 1997; Miller and others., 1999). The clinical studies indicate that the diameter of fibre is approximately 0.5µm or smaller for the incidence of mesothelioma (Timbrell, 1983).

2) Organic Pollutants: These are pollutants such as smoke, methane and other hydrocarbons the sources of which are coal and oil, organic solvents, organohalides, pesticides, PCBs and dioxins, natural organophosphorous compounds and carbonate pesticides and odors (Alloway & Ayres, 1997). Most of the carbon based synthetic organic chemicals are generally manufactured by the chemical industry. We have little information about 75% of these chemicals. In addition, other chemicals that develop as byproducts may have an impact on the environment. Special attention should be paid to organic materials that are resistant, that can be carried away in long distances and especially the ones that can be bioaccumulated in the food chain (Plant and others, 2003).

3) Indoor Pollution: These are pollutants such as vaporized organic compounds, ozone, nitrogen oxide, carbon monoxide, other gaseous oxides, cigarette smoke, asbestos fibres, lead and radon (Alloway & Ayres, 1997).

Geochemical Environment and Cancer

According to the data of WHO, the environmental pollutants are the cause of more than 70% of cancer cases in human. The direct and definite correlation is the lung cancer and it is generally observed among people living in polluted regions. At the same time the changes in the benzo(a)pyrene concentration in air always affect the lung cancer mortality. IARC issued a list of carcinogens composed of 783 items. Limited number of metals and metalloids has been classified as carcinogenic for humans by IARC/WHO (for example chromium(V), As and its inorganic compounds, nickel and its compounds, cadmium and its compounds and beryllium and its compounds (Komatina, 2004). On the other hand, numerous metals are carcinogenic for animals.

Declaration of scrotum tumor in a chimney sweeper in 1775 by P. Pott can be recognized as the first observation of occupational carcinogenesis. While cancer in Scottish miners was announced by A. Scott, urinary bladder cancer in people working in the German chemistry industry was reported in 1895 (Komatina, 2004). The beginning of the epidemiological mode of thinking is R.Stern's study of compiling the statistical data of mortality rate of cancer cases in Veronica in 1842. The geographical distribution of cancer has attracted an ever increasing attention in the second half of the 19th century, and finally in 1915 Hoffman wrote in his book the geographical pathology of cancer and cancer mortality rates throughout the world. In the last half century, registry of diseases and mortality has ensured, with a wider approach, the understanding of local or regional distribution of the diseases.

Today, researches are based on the hypothesis that unless otherwise is proved, environment may be effective in cancer incidence, and this shows the vital role that geochemistry plays in the etiology of the diseases (Dissanayake & Changrajith, 1999). The best example to this is the pollution of drinking water with nitrogenous substances (such as human and animal waste and fertilizers that contain nitrogen) in developing countries. In such places methemoglobinemia develops together with stomach and esophagus cancers in the excessive presence of nitrate.

Latest studies indicated that cancer is the greatest fatal disease after cardiovascular diseases in many industrially developed countries and that they are generally caused by environmental factors. About 5 million people in the world, half of whom are in developed countries, die of malignant tumors (Komatina, 2004). Among many factors that cause development of malignant tumor (chemicals, radioactivity and other pollutants in soil, air, water and foods), diet and use of cigarette are the major causes of cancer with 35% and 30% rates respectively.

Examples to the Diseases Caused by Elements:

Arsenic has been used as a dye since the Bronze Age and the recognition of its toxicity goes back to ancient times. Drinking well waters that contained high amounts of arsenic was the main reason of the skin lesions and cancers that affected millions of people especially in Western Bengal and Bangladesh. The patients were commonly recommended to use Fowler's solution that contained potassium arsenite however it was understood in the late 18^{th} century that Fowler's solution causes first peripheral neuritis and then subsequent skin lesions and cancer (Davies and others, 2005). Anawar and his friends showed in their researches (2002) that various skin lesions, gangrene in legs, skin, lung, urinary bladder, liver and kidney cancers observed in Bangladesh correlate with the 0.20 mg/l arsenic amount in drinking waters.

In one of the first studies on gastro intestinal cancers, because of the uranium-rich black shale in Wales, in northern Montgomeryshire (Millar, 1961), the relation between the disease and environmental radioactivity was indicated. However there is not a direct finding to support this hypothesis and the study remained statistically debatable.

In 1960, the number of deaths from cancer in certain villages of Tamar Valley in the west of England was strangely high while in some villages it was surprisingly low (Davis, 1971) and it was understood that the main reason for this difference is the use of different water resources. Although this study is statistically debatable, it is important for suggesting the correlation between cancer and environment.

The studies on "chemoprevention", which has become a growing field in oncology, have been increasing in recent years. A sample study on preventing cancer in human with selenium was carried out in Qidong, the north of Shangai where liver cancer is frequent (Lindth, 2005). 15 ppm selenium was added as sodium selenite to the table salt used by 20.847 people living in urban areas and these people consumed about 30 to 50 micro grams of selenium per day for 8 years. This experiment resulted with a decline in liver cancer.

Volcanic ash may contain a fibre-like zeolite that includes erionite. Such asbestos minerals correlate with the incidence of endemic pleural disease and mesothelioma at high rates (Rohl and others, 1982). The evidences about exposure to high levels of radon and the evidences about the ever accumulating lung cancer risk increases. US EPA estimates that radon in drinking water causes 168 cancer-related deaths per year. The cancer caused by radon in drinking water is 89%, 11% of which is stomach cancer because of drinking water that contains radon. Radon which is generally released and inhaled from tap water involves more risk than that of posed by the amount taken from drinking water (NRPB, 2000).

Depending on its resources, drinking water contains fluoride at different concentrations that change from region to region. High fluoride concentration, which is caused by the disintegration of rocks as well as by geothermal sources, may be observed mostly in underground waters. There are certain places in the world where underground water contains high amounts of fluoride (Argentine, Northern China, India, Mexico, Western USA, Sri Lanka, and many countries in Africa). Long periods of exposure to fluoride in drinking water results in dental fluorosis in excess of 1.5 mgL-1, skeletal fluorosis in excess of 4 mgL-1 and in fluorosis in excess of 10mgL-1. Other health problems caused by over exposure to fluorisis are defective births (Hamilton, 1992) and cancer with less certainty (Marshall, 1990).

Many studies indicated correlation between various diseases including cancer and water hardness. The relation between cancer and water hardness was reported in Finland and Taiwan, and the relation between various age-related cancers in Northern Finland and the geochemical composition of underground water was revealed (by comparing the geochemical maps that show the hardness of water, iron, nitrate and uranium amounts contained and the maps that show the distribution of diseases by regions) (Piispanen, 1991).

Examples to the Diseases caused by Minerals

177 malignant lung cancer and 44 patients with pleural tumor presented to the Diyarbakır Phenomenal Diseases Hospital between 1968 and 1976. The geographical distribution of the tumors indicated an etiology related with exposure to environmental asbestos. As a source of asbestos, there are many exposed ores that contain tremolite asbestos in the environs of Çermik Village and they are used by the local people to whitewash their houses (Yazıcıoğlu and others, 1980). Whitewash contains fibre-like and non-fibre-like minerals such as talc, antigorite, lizardite and chlorite. The researchers attributed the diseases (pulmonary fibrosis and malignant tumors in lungs) in these regions to tremolite asbestos.

The pulmonary diseases, including mesothelioma that develops due to asbestos were reported also in Çaparkayı village (Barış and others, 1988 a,b). Although there is not an asbestos mine near the village the whitewash used by the villagers is rich in tremolite and contains very thin fibres. According to Barış, high percentage of mesothelioma and specific pleural and parenchymal anomalies were caused by exposure to tremolite fibres. Mesothelioma, which was a fatal cancer, was considered in previous studies to be a significant signal associated with the inhale of asbestos (Wagner and others, 1971; Wagner & Pooley, 1986).

It was understood in the first years of 1970 that the diseases that were previously defined as tuberculosis are in fact malignant pleural mesothelioma (Barış et al., 1978; Artvinli & Barış, 1979; Barış and others., 1979; Barış, 1991). In 1970-1974, 24 new mesothelioma cases were observed in Karain village (with the then population of 575). The mortality rate was 42.9% and it was rather strange for mesothelioma. The highest mesothelioma mortality rate since then has been 9.75% among the asbestos workers in the USA. In three subsequent years, meaning 1974-1977, 18 additional mesothelioma cases were reported in Karain village. According to Barış, 62 deaths out of 175 were caused by mesothelioma in this village. Then, Barış and his friends expanded their studies to include other villages in the region (Tuzluk, Karlık, Karahıdır and Sarıhıdır). In a population of 5000 people and during 17 years they all found 94 mesothelioma cases. The age interval for this disease is 27 to 71. The period between the symptoms and death is only 1.5 to 2 years. There are geological young volcanic ash deposits (tufa) in the region. These rocks are easily processed by hand. The local people living in the villages construct their houses and other buildings in these geological formations or they use these rocks as building stones or for whitewashing. The geological researches proved that the tufa in these regions first contained volcanic glass, feldspar and other silica minerals and then they transformed because of the effects of underground waters and turned into intomontmorillonite and zeolite minerals in alkaline lakes. Zeolite minerals are clinoptilolite, chabazite and erionite. Morphologically, erionite is fine-grained and acicular and the same examples of these fibres were observed in the lung tissues taken from patients with mesothelioma (Pooley, 1979; Sebastien and others, 1981).

Separate from the examples above, other places in which diseases caused by the inhale of asbestos are most frequent in Turkey are (Barış, 2002) Mihallıççık districts and villages of Eskişehir province, Halkapınar and Ayrancı villages of Konya Eregli, Ilgaz and Şabanözü villages of Çankırı province, Sorgun district and villages of Yozgat, Yıldızeli and Şarkışla villages of Sivas, Ergani and its villages in the west of Diyarbakır, Maden and Palu districts and villages of Elazığ and Siverek district of Urfa. Malignant mesothelioma associated with asbestos and erionite minerals is a very serious problem and genetic-epidemiological researches indicate that genetic heritage may play an important role in the development of mesothelioma (The Asbest Legacy, 2001; Emri and others, 2002; Emri and Demir, 2004).

Another example about asbestos minerals is northwest *Greece*. As regards the use of whitewash that contains tremolite asbestos by the local people for their houses, six cases that involved bilateral pleural plaques, thickening, limited lung functions and mesothelioma were reported (Constantopoulos and others, 1987).

Conclusion

Together with the population growth and economic developments, misuse of fields, urbanization, adverse effects of pollution, the environmental problems cause an ever-increasing concern. Among all environmental problems, pollution constitutes the greatest threat against the health and welfare of human and the balance of the global ecosystem.

There are many direct or indirect examples that can be given for the correlation between the cancer incidence rate and environmental conditions. The maps showing the regional distribution of different cancer types and the geochemical maps that indicate the concentration of chemical elements are very important. The studies on the geographical and geological conditions associated with the incidence of the disease are carried out extensively in onco-geographical researches. Nevertheless, in order to solve today's greatest puzzle cancer, multidisciplinary work is a must and it is necessary to understand better the natural (geological) and anthropogenic factors that cause the disease. Progress in this field can only be ensured through medical geological (geochemical, eco-geological) researches.

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