Medical Geochemistry: A Brief Outline of the Problems and Practical Application in the Region of Žiarska kotlina Basin

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Abstract. Characteristics of the state of health of child population aged 0 - 14 in Žiarska kotlina Basin were studied to determine whether they were affected by geochemical agents in the environment. The potentially hazardous areas where the health of the population is endangered were outlined, according to data from State Health Institute in Žiar nad Hronom. In comparison to other areas we observed increased occurrences of malignancy, illnesses of endocrine glands, congenital defects and, up to 1989, also illnesses of the circulatory system. From the point of view of medical geochemistry the abundance of congenital defects and tumor illnesses of the monitored population can be related to increased natural radioactivity of the rocks and waters in the region and also by radon risk. The quality of the drinking water is related to the state of the health of the child population. In particular the concentration of nitrate in public water supplies, as well as in public and private wells is linked to health. The hazard for infants is great, especially in the settlements of Bzenica, Dolná Ždaňa, Piteľová and Lovča. These hazards resulting from the water and soil components of the environment of the Žiarska Kotlina Basin were detected and verified in direction of the river and creeks flats and their adjacent alluvium. From the monitored diseases and the contaminated areas we infer that a causal relationship exists between concentration of fluorine in the environment and the high rate of occurrences of tumors, blood illnesses, illnesses of endocrine glands and circulatory system. We consider these results and the interpretations presented herein as only a first step; the problem requires another more detail investigation.

Key words: medical geochemistry, Žiarska kotlina basin, child population

Introduction

Geographical factors of the distribution of some diseases are well known, practically since the medicine has become a science (Lag, 1992). A study of the history of medicine shows that Hippocrates and some of his fellows dealt with this problem more than two thousand years ago. Later, in the 4th century A.D., the ancient Chinese knew of the influence of environmental conditions on human health, especially regarding the occurrence of thyroiditis (Lag, 1992). Of course, these tracts from Middle Ages did not have any significant influence upon next evolution of this matter. It could be developed more progressively only after fundamental sciences like chemistry, physiology, microbiology and pathology achieved appropriate level.

Even though the medical science had known a long time ago that some diseases are typical for different parts of the world, the medical geography (some authors also use a term geographical medicine) (Armstrong, 1971; Khun, 1998) rose in to the level of a science only in the first decades of the 20th century. Of course, concerning the geographical aspects of the distribution of various diseases they mainly searched for connections with climatic and/or topographic factors. Classical examples of such research includes, for instance, the well known relationship between specific climatic factors (temperature and rainfall) and the occurrences of malaria and yellow fever (Keller, 1988). An example from western Slovakian research is, a study of the distribution of tick encephalitis relative to selected geographical parameters (Krajčír, 1989). However, it is important to mention that a blend of geography and medicine cannot explain casual relations between large geographical differences and the distribution of some diseases. A responsible interpetation of such causality essentially needs geochemical knowledge (for instance, the distribution and forms of occurrences of chemical elements in the geochemical environment, their migration, etc.). This is opening a space for indipendent scientific field – *medical geochemistry.*

Problems of Terminology and the Role of Medical Geochemistry

The term "geomedicine" was used for the first time in Germany in 1931 (Lag, 1992). However, it was applied

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without a clear definition of its meaning only and with remark about its establishment it as an independent scientific field which problems would be addressed to scientists from various fields. The term „geomedicine„ had been used only rarely during the next decades. Moreover the term was not used consistently and in the same context. However, it is not easy to offer a good definition of this term. Geomedicine was defined as the study of the influence of normal environmental factors on the geographical distribution of health problems of human and animals (Lag, 1992). The definition excludes influence of so-called internal environmental factors (for instance, the working conditions) that are objects of research of industrial medicine. The term „industrial medicine„ was used mainly in regard to the international project "Man and the Biosphere", which was coordinated by Norway during 1960 - 1970 and in which a great emphasis was put upon the geomedicine research. Almost simultaneously, activities with similar objectives were started in Great Britain and the USA, where the expression "environmental geochemistry and health" came from (Khun, 1998). At present environmental geochemistry is viewed as a scientific field in which health is considered as an application of geochemistry and geochemical mapping of health condition of plants, animals and humans. Its basic researches were done in Canada, the former USSR, Great Britain, the USA and Scandinavia. For completeness, the term "geosanitation" is used in the former USSR (Lazarev, 1966). This field of study was considered to be a medical prophylactic science and was in close relationship with sciences like geography, geology, geochemistry etc. In the former Czechoslovakia, and now in Slovakia, the term used for research in this field (also as a study subject at the Faculty of Natural Sciences of Comenius University) is the one used in the title of this article. Its definition is as follows: *Medical geochemistry, as a part of geomedicine, is the science concerning the influence of chemical composition of natural and man effected geochemical environment on human and animal health, in the terms of external environmental factors (Khun, 1992).*

Geochemical Environment

The chemical composition of organisms reflects the external geochemical environment to a certain extent. The receiving of elements and substances from the environment depends not only upon the character of the organisms, but in many cases it dependes mainly upon the concentration of elements and on the overall character of the environment, i.e. on the conditions prevailing in the geochemical environment. This environment is not homogenous; trace elements as well as macroelements are distributed unevenly in its different areas. This environment depends upon the geological history of the area, the specific character of soil parent material, and the specific features of soil formation processes and chemical character of the waters. Then the results are, that areas differ from the "standard" by either an increased or decreased concentration of some element or elements. For humans and for all other organisms the range of concentrations of element in the environment is very important; it is called the "protecting geochemical shadow" (Zýka, 1972). This means that organisms can live in health only within a certain range of chemical composition of the geochemical environment. However, the natural environment is to a great extent suppressed in many areas, and in some cases it is entirely suppressed. The last decades are characterized by the formation of a new artificial environment created by the intensive activities of mankind. Today the environment is typified by a general disturbance of the geochemical balance.

The relationship between humans and geochemical environment are closer than it is generally assumed. A sick state of health in humans makes itself felt whenever the balance between the human organism and the factors of external environment is disturbed. This state can be introduced by influence of endogenous factors (condition of human organism itself) as well as by the influence of exogenous factors (influence of the environment). Here then, is the focus of geomedicine research mainly. Unfortunately, the geochemical influence effects the human organism even before its birth. Much data published recently suggest that the character of the geochemical environment codetermines to a certain level the physical and psychical state of an adult person even before his/her birth.

Trace Elements in the Environment and Diseases

In many cases a dependence was observed between diseases and anomalous concentration of certain trace elements in the human organism. In some cases a direct relationship was also observed between the changes of certain trace elements concentrations in some organs, tissue or blood and the occurrence, seriousness, and duration of a sickly state. Although many scientists are skeptical about this matter, it certainly can be a step toward the discovering of any role that trace elements have in pathogenesis of given diseases, and some have, or certainly will also have, diagnostic or prognostic value (Zýka, 1972).

In his numerous publications V. Zýka has divided diseases with regard to the relationship between the concentration of trace elements in the geochemical environment and human health into two groups:

- Diseases induced by a simple deficit or abundance of a given element in the environment.
- Diseases induced by a complex disturbances of the balance of geochemical environment.

In developed countries the occurrence of diseases due to a primary and simple deficit of trace elements is very rare. This is so because the consumed food typically is derived from different parts of a country (even of a continent or among continents) and assures a sufficient supply of diverse elements. Of course, these problems are more frequent in neglected, poor countries where the inhabitants depend upon local supplies. In such cases, the dependence of the health of people upon the local geochemical environment is clear. For instance, miscellaneous deficiency diseases, include ones such as anemia or rachitide (Hopps, 1971). In some cases it is not a matter of a deficit of an element in the environment but of its unavailability for plants from soils caused by its fixation to the soil.

On the other hand, "geochemical" diseases are more frequent in environments enriched with various elements. For instance, a high concentration of Cu in the environment is the reason of various Cu-toxicities. An endemic gout a frequent phenomena in a environment rich in Mo. Exemas and eye illnesses are frequent phenomena in areas with a high clarke of Ni in soils and waters. Excess Mn in environment may be a reason of hypertension. In many cases it is not the matter of a simple effect of an increased concentration of single element but a complex effect of the environment, although the determining factor is an excess of a single element in the environment.

The second group of diseases is more complicated. Their constant increas and spreading is caused mainly, or to certain extent at least, by radical changes in the geochemical environment, i.e., disturbances in the balance of this environment. This group includes such serious diseases as disseminated sclerosis, congenital defects, cancer diseases, diseases of the blood circulation system. For instance, a study in England shows that in the areas with increased concentration of Pb in soils and waters have almost three times higher occurance of the disseminated sclerosis than in the areas with a normal concentration of Pb. On the base of comparison of the illness distribution and geological conditions of the areas (occurrences of galena) also Finnish authors have admitted that there can be direct correlation between frequency of the illness occurrences and increased concentration of Pb in the environment (Khun, 1992).

Some data collected during recent years indicates that some cases various intensity of geographical distribution of congenital defects are significantly effected by the geochemical environment. Distribution of these anomalies was studied in the USA with respect to radioactivity of the environment. An increased occurrenc of all types of congenital defects (except mongolism) was observed in northern New York State, an area in which rocks contain high concentrations of radioactive elements.

Probably the earliest papers treating medical-geochemical research were published in England. The first "geochemical" theory of cancer origin was published by Haviland in 2. half of the last century (collection of works from years 1868 - 1888, in Zýka, 1972; Zýka, 1975). Haviland recorded various level of mortality caused by cancer diseases (the number of deaths per 10 000 inhabitants during 1851 -1860 in 625 registered regions of England and Wales) on a geological map; and he studied the dependence of the distribution of these diseases on the overall character of the various geological - geographical areas. This revealed that the areas with high mortality were predominantly alluvial basins that were seasonally flooded (acid soils rich in organic matter). On the contrary, mountain areas were characterized by low cancer mortality. However, the most interesting discovery was the particulary low rate of mortality in limestone areas. For instance in Hampshire, the limestone area was characteristzed by low cancer mortality. The situation is similar in river flat of Test and Itchen Rivers that come from limestone regions. There are many examples demonstrating the relationship between concentration of some chemical elements in the geochemical environment and cancer diseases distribution (for instance Augustin and Zejda, 1991, in the former CSFR; Piispanen, 1991; Yang and Hung, 1998) but their overall review is not scope of this article. However, if we analyze the results of individual authors concerning geographical distribution of cancer diseases and their relationship to geochemical environment, we can summarize that the areas with relatively low cancer mortality are characterized by well aired and drained soils poor in organic matter, rich in sources of fresh, hard and not chemically treated water and also with sufficient amounts of Ca, Mg, Na, Cu and Mn accessible in water. On the other hand, the areas with high cancer mortality are characterized by high content of organic matter in soils (acid soils), poorly aired and drained soils, soft waters (deficit of Ca, Mg, Na, Cu and Mn) or artificially treated surface water with increased content of some trace elements as, for instance, As, Co, Cr, Ni, Pb, Ra, V, Zn etc.

Cardiovascular illness was relatively infrequent at the beginning of the 20th century, while in present it is main cause of mortality in the industrial countries. Also some interesting recent studies indicate that the geographical differences in cancer mortality are linked to geographical differences of trace elements concentrations in soils and waters, respectively, with disturbances of balance in the geochemical environment (Bada et al., 1998). The geographical distribution of mortality due to circulatory illnesses was studied in many countries: Japan, USA, Great Britain, Ireland, Switzerland and others where a very interesting interrelationship between mortality and the character of geochemical environment was observed. Special interest was paid to the chemical composition of drinking water – i.e. hardness of drinking water (Zielhuis and Haring, 1981; Bernardi et al., 1995; Bada et al., 1998), but less research projects were focused on the possible relationship between mortality and chemical composition of soils and atmosphere.

After the Second World War the stroke (apoplexy) was the main reason of mortality in Japan. The mortality caused by this disease was also high in comparison with that one in the USA, Great Britain and Germany at this time. However, in Japan there are remarkable geographical differences in this mortality. In north-east (NE) Japan the river water carry more sulfate (waters with dominant of SO_4^{2-} ions or acid waters, characterized by the presence of a free sulfuric acid). This geographical distribution of river waters coincide with an increased rate of stroke mortality. The relationship between the geographical distribution of the high mortality and ratio of SO_4^{2-}/CO_3^{2-} in river waters is very significant. River waters of provinces distinctive for their high stroke mortality have the ratio greater than 1.8 (the NE provinces), while in provinces with lowest rate of mortality the ratio is less than 0.3 (western Japan provinces). Zýka (1972) summarized the results concerning the circulatory system illnesses observed in various countries, regions and cities and he found that ilness occurrences and mortality caused by this illness increase with decreasing water hardness, with a decreasing concentration of Ca in the drinking water, respectlively.

Several of the above mentioned examples of the influence of the geochemical environment on human health point out the importance of this problem witch was neglected in the past. However, recently there has been increased interest in this field – the establishment of The Society for Environmental Geochemistry and Health (SEGH) in London, which is also publishing a journal "Environmental Geochemistry and Health".

Here we publish the preliminary study of the Žiarská Kotlina Basin as a demonstration of the knowledge of medical geochemistry. The conclusions reached in this study represent the results of the research project "Evolution of the carrying capacity of the Žiarska Kotlina Basin " in the topic of "Characteristics of health state of the child population in the Žiarská Kolina Basin". The project was sponsored by Ministry of the Environment of Slovak Republic, under the Division of Nature and Country Conservation, assessment of influences on the environment and interdivisional relations.

The Ecological and Veterinary Laboratories Ltd. of Spišská Nová Ves were the contractor of the project. Within the frame of the project, the health - sanitary loads of the population were analyzed with respect to geochemical assessment of individual environmental agents. The data about the health state of the child population of the studied region originated from annual reports of health care of treated children aged 0-14 years during 1987-1995 in the former Žiar nad Hronom district (according to administrative organisation of districts in Slovakia). The data from pediatric clinics of hospitals of the four tributary areas: Žiar nad Hronom (ZH), Nová Baňa (NB), Banská Štiavnica (BŠ) and Kremnica (KR) were available. Data from year 1991 were available only from ZH and BŠ and data from year 1987 were available only for infant children (0-6). With respect to „10[th] Revision of the International Classification of diseases MKCH-10„ following groups of diseases with their following numerical and descriptive identification were monitored:

I. Infectious and parasitary diseases (diagnoses A00-B99)
II. Tumors (diagnoses C00 - D48, for instance, malignances and carcinomas in situ, malignances of lymphatic, hematopoethic and related tissue)
III. Diseases of blood and hemopathic organs and some defects of the immune mechanism (diagnoses D50 - D89)
IV. Disease of the endocrine glands, nutrition and metamorphism (diagnoses E00 - E90)
V. Mental retardation and defects of behavior (diagnoses F01, F03-F99), for instance, mental retardation
VI. Diseases of the nerve system (diagnoses G00-G99), for instance infant brain illness
VII. Diseases of the circulation system (diagnoses I00 - I99), for instance hypertension and other diseases of the hearth, brain and veins
VIII. Diseases of the respiration system (diagnoses J00 - J99), for instance asthma
IX. Diseases of the digestion systems (diagnoses K00 - K93), for instance ulcerous illness of stomach
X. Diseases of the skin and subcutaneous tissue (diagnoses M00 - M99), for instance atopic dermatitis

I. Diseases of the muscular and skeletal systems and mesodermal tissue (diagnoses M00 - M99), for instance juvenile arthritis
II. Diseases of the urinal and genital systems (diagnoses N00 - N99), for instance inflammatory illness of the kidnies
III. Congenital defects, deformations and chromosome anomalies (diagnoses Q00 - Q99), for instance congenital defects of the circulatory system

A comparison of the percentage of the tributary areas of the former Žiar nad Hronom district result the facts, from which the following are the most significant:

a) A significantly increasing trend of tumor occurrences in the tributary ZH area (Fig. 1).

b) An indication of increasing trend of blood diseases since 1993 (Fig. 2).

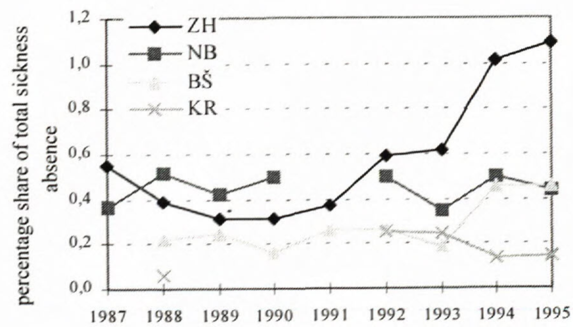

Fig. 1: Diseases II. - tumors

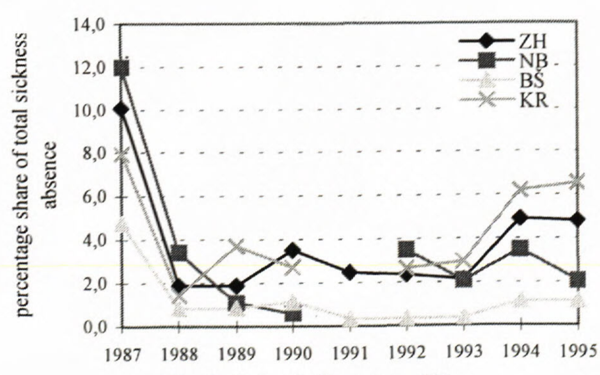

Fig. 2: Blood diseases - III.

c) The distribution of endocrine gland illnesses in the ZH is markedly greater than in the other tributary areas (Fig. 3). Thyroid tumors frequently occur in former ZH district in comparison with the Slovakian average (Khun et al., 1996).

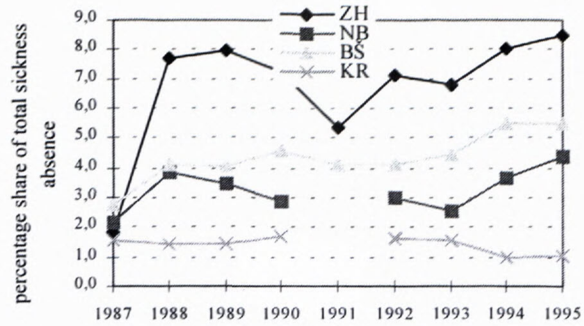

Fig. 3: Diseases of endocrine glands - IV.

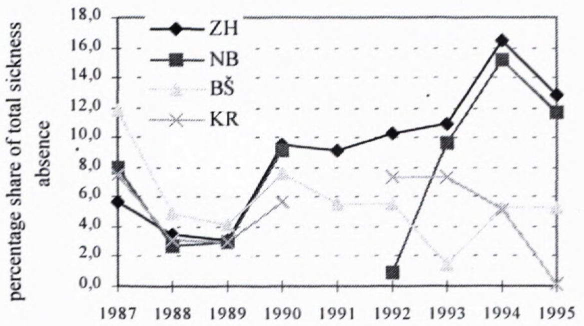

Fig. 4: Diseases XVII. - congenital defect

d) The rising trend of congenital defects since 1990 exceeds those in other districts (Fig. 4).

The result of the environmental-geochemical evaluation of the collected data is compiled on "The map of potential hazard in term of population health in Žiarská Kotlina Basin" at a scale 1:50 000 (adapted on Fig. 5) in which an assessment of various parts of Žiarska Kotlina Basin is given for the health of the child population. The influences of specific agents are summarized as follows: .

Rocks

From the stand point of possible influence of rock environment on health of monitored population the higher importance has a group of sedimentary rocks (in comparison to neovolcanoes) with wider range of toxic elements (As, Cd, Pb, Se, Sb) that have high potential ability to enter the environment (soils, water). In term of elements in food chain the fluvial sediments and deluvium - fluvial sediments (Holocene, Pleistocene) are characteristic by association of 4 toxic elements. They virtually reflect their geochemically anomalous distribution from 5 source areas (Méres et al., 1998): The northern part of the monitored area is characterized by the source areas of creeks Rudnica and Lutilský Potok. Water of Rudnica Creek springs in Kremnica ore field (anomalous contents of Zn (max. 1 107 mg.kg^{-1}), As (max. 47:3 mg.kg^{-1}) or Hg (max. 0.352 mg.kg^{-1})) and possible negative influence on settlements Stará Kremnička and Pitelová. Lutilský Potok Creek has anomalous concentrations of As (50.7 mg.kg^{-1}) and it threatens part of village Lutila and town Žiar nad Hronom. The southern part of the monitored area is characterized by sources areas of Teplá Creek (land cadastres Sklenné Teplice, Lehôtka pod Brehmi, Hliník nad Hronom, Repište) and Vyhnianský Creek - the area with polymetallic minealization (remarkable concentrations of Hg, max. 0.774 mg.kg^{-1}, As 43.2 mg.kg^{-1}).

The alluvial sediments of the Hron River flat contains already contaminated industrial material with anomalous concentrations of elements and determinate quality of another abiotic agent of the environment, that affect the settlements of Šášovské Podhradie, Ladomer, Dolná Ždaňa, Bukovinka, Revišťské Podzámčie, partially Lehôtka pod Brehmi and Bzenica.

Deficit in certain elements can also have a deliterious effect on the health of a population living in, or getting its food from the area of the deficit. The local rock types – quartzite, rhyolite, rhyodacite, slate and andesites - are low in Ca, Mg and P. These deficits can also have a negative effect on the health of a population. For example, the absence of Ca and Mg in the environment may by related to increased occurrences of malignancies. For instance, there is the "Magnesium theory" of increased incidence of malignancy or the "anticarcinogenic" influence of environments rich in Ca (Khun, 1992). Similarly, increased concentrations of As, Cd, Co, Cr, Pb in the environment are related to increased mortality due to cancer.

Soils

From the medical-geochemical aspect there are important sloppy fluvisoils of the Hron River and Lutilský Creek flats witch have a remarkably high content of organic matter that can have an influence on the occurrence of cancer. It is well known from the literature (Tromp and Diehl, 1955; Zýka, 1972) that areas with a high cancer mortality have characteristically high content of organic matter in soils (acid soils rich in organic matter), bad aeration and drainage (swampy). This relationship can be approximately illustrated by Figure 1. The graph on the figure indicates the highest occurrence of tumors in the child population, aged 0 – 14, right in the area of Žiar nad Hronom - in the monitored area. The soils in the Hron River flats are the most contaminated soils with heavy metals (contents reaching indication values B and C, Decision of Ministry of the Agriculture of the Slovak Republic No. 531/ 1994; Vozár, 1998). For instance, the contents of arsenic is within the range of C values (50 mg.kg^{-1}) in area of cadastres Lutila, Lovčica, Trubín, Stará Kremnička, Šášovské Podhradie, Ladomer, Vieska, Hliník nad Hronom and Repište. In the case of this element its carcinogenic, mutagenic and teratogenic effects are subjected to intensive medical research; however, in most cases it is the matter of professional exposure. For instance, increased occurrences of lung cancer among mines in the Schneeberg was caused by a high concentration of As - about 1% in mine dust (Khun, 1992). Its highest accumulation in human bodies is in hair

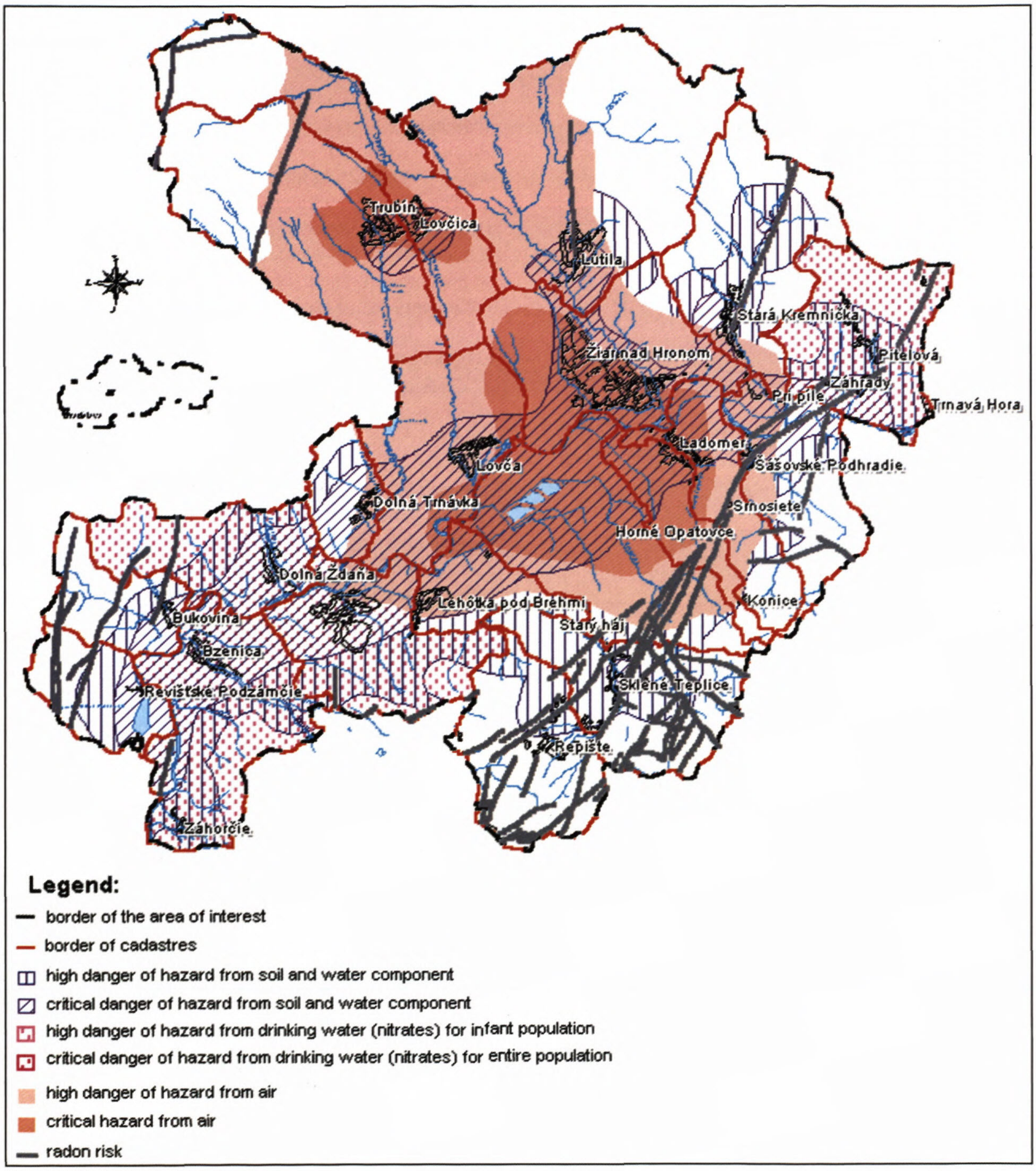

Fig. 5 The map of potential hazard in term of population health in Žiarska kotlina Basin

and nails, doses of 5 - 50 mg per day (the toleration is different from human to human) are toxic, a lethal dose for a human is 100 - 300 mg per day (Bowen, 1979). From the environmental point of view, the physical properties of As compounds are very important. For instance, methyl arsenic (a very poisonous substance) comes into existence during regeneration of soils contaminated with As, however, it is quickly oxidized in the presence of sunshine. Receiving As from plants ("food chain") depends upon the concentration of soluble As in soils, soil type and plant sort. Data by Šalgovičová et al. (1992) also revealed, that high concentrations of As were detected in the vicinity of Žiar nad Hronom in samples of animal origin.

Waters

The state of health of children (mainly infants) and the overall population is related to the quality of drinking water especialy concerning the nitrate concentrations of public water supplies, as well as in public or private wells (Fig. 6) (data from State Health Institute in Žiar nad Hronom, 1996). On the basis of nitrate concentrations

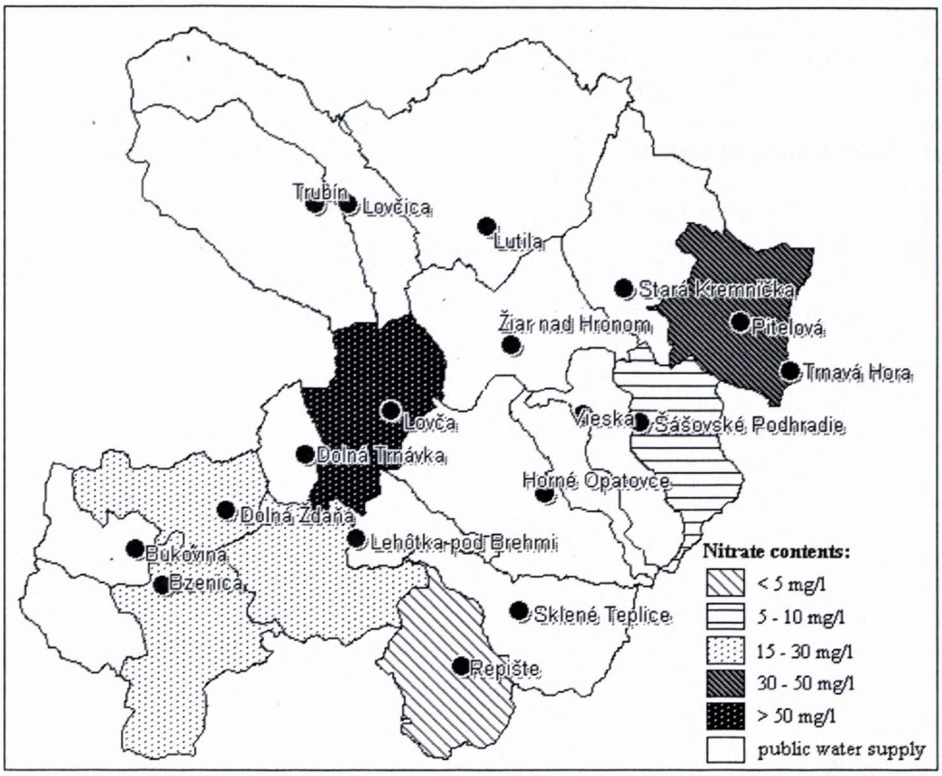

Fig. 6: Scheme of nitrate occurrence in public and private wells according to results of laboratory tests of the State Health Institute in Žiar nad Hronom (y. 1996)

exceeding the allowed critical values, the potential negative influence and critical hazard can be predicted for cadastres and the wider surroundings of the Žiar nad Hronom. A great hazard for the infant population is from drinking water (15 - 50 $mg.l^{-1}$ of nitrate, recommended value for infants is less than 15 $mg.l^{-1}$); it is also a critical hazard for the whole population where drinking water contains nitrate in excess of 50 $mg.l^{-1}$, such as was observed in the settlements of Bzenica, Dolná Ždaňa, Pitelová and Lovča (the critical hazard with respect to Slovak Technical Criteria for Drinking Water - STN 75 7111). It is important to mention that the average was counted from individual values, which means that in a given cadastres there are locally also values of NO_3^- even greater than 15 $mg.l^{-1}$. These facts are important mainly because the infant organism is 100 x more sensitive to NO_3^- than the adult organism. In the intestine flora nitrates (NO_3^-) are reduced to nitrites (NO_2^-) that is actively bonded to blood hemoglobin instead of the oxygen. As the result, there is insufficient oxidation in the infant organism and the occurrence of nitrate alimentary–methemoglobinemy (Sattelmacher, 1962; Shuval and Gruener, 1972). Nitrates also damage children liver. The accumulation of these residues and their further metabolism (mainly the origin of nithrosamine) contribute to the origin of cancer; a possible relationship in the tributary areas ZH (Fig. 1), blood diseases (Fig. 2), respectively. Noteworthy is also the fact, that in the case of adults the nitrates can be changed to nitrosamine and nitrosamide that are carcinògenous (Škárka and Ferenčík, 1992). There is a remarkably higher mortality rate due to tumor diseases of the inhabitants of the former Žiar nad Hronom district in comparison to the rest of Slovakia (Turčanová, 1994).

The danger from water and soil component was investigated and verified on the base of the negative influence of various components having a toxic effect, which migrate towards the river and creeks flats, and their adjacent alluvial plain in the area of Žiarska Kotlina Basin. The hazard is influenced by climatic changes, changes in structural - mechanical soil properties, land form, time etc. The high hazard is identical with the 2A category of the load of water components and critical hazard is identical with the 2B category of the load of water components, when water as a component of the environment, is strongly disturbed, contaminated and endangered as a natural water source. It is characterized by a high exceeding of limits set for elements and components important for sanitation and water management. There is exceeding of limits defined by standards and law regulations. In the studied area there are point and area sources of water contamination that have not been eliminated yet (Vrana, Kúšiková, 1998).

Radon

Radon is one of the important indicators of environmental assessment of the state of the environment (for instance in urban environment).The radon radiation from building walls, waters and rocks was studied in detail in Žiarska Kotlina Basin (Lučivjanský, 1995, Čížek, 1995, Daniel et al., 1997). Radon migrates in rocks along neotectonic zones by diffusion and convection and its distribution and the values of volume activities are influenced by climatic changes. The hazard from this element migrating from underground layers into residences depends on the value of its volume activity in the soil air and on the structural-mechanical properties of the

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foundation ground, which are defined by standard (STN 73 1001 - Construction Foundation). The radioactive decay of radon causes an inner exposure which increases the danger of occurrences of malignancy and permanent damage of genetic information. The probably hazardous areas can be predicted within or near (especially within 5 m) of the vicinity of the tectonic zones (verified or inferred faults) i.e., zones containing young faults and places where these tectonic lineaments cross each other. In some buildings more than 11 % exceeding of the critical limit for concentration of radon in the environment (according to STN 73 1001 - Construction Foundation, in air of rooms assigned for human activities there must be equivalent volume activity of radon less than 200 $Bq.m^{-3}$ per year on the average) was detected. Samples with increased values of volume activity of ^{222}Rn were taken from waters along tectonic lineaments trending NE - SW (the settlements Sklené Teplice, Stará Kremnička, Šášovské Podhradie, Bukovinka, Pitelová, partially Lutila, cadastre of Repište). Since 1990 Žiarska Kotlina Basin has shown an increased share of sickness (congenital development defects of children, tumors) in comparison to overall Slovak average (Khun et al., 1996). Thus, increased attention must be paid to this problem with monitoring in apartments.

Fluorin and health problems

The enterprise for Al production „ZSNP„ in Žiar nad Hronom with its emissions does only not effect the near vicinity but the entire Žiarska Kotlina Basin. Here fluorine is the most dangerous pollutant. The highest pollution of fluorine in the factory vicinity occured in the 60^{ies}. The village of Horné Opatovce had to be moved. In the 70^{ies} when absorbers were introduced into the technology of Al production, the average annual emission of F dropped from 8 $\mu g.m^{-3}$ in 1973 to 3 $\mu g.m^{-3}$ in 1987, which was still three times greater than the acceptable limit. In the effected area deleterious influences were observed mainly on the soil cover, flora, fauna and, what is worse, on the child population. These effects were demonstrated by the more frequent problems with the respiratory systems, stains on teeth, changes in skeletal tissue and blood. The increased content of F in all monitored tissues was seen in the entire indigious population.

Aluminium was originally obtained from Al_2O_3, after adding the fluorosalts cryolite and aluminum fluoride. Enormous amounts of fluoride are released into the environment by this technology. Since the beginning of this operation of the factory in 1953 about 13 000 t of emissions were released annually into atmosphere, in which F was present in about 400 compounds. However, since the beginning of 70^{ies} the improvement of operation technology has decreased the pollution as follows (Kiss, 1992):

Time period	emission (t)
1970 - 1975	16 091
1975 - 1980	14 460
1980 - 1985	13 500
1985 - 1990	12 100

The situation has been changed by modernization of production operation after year 1990. In 1991 another decrease of released pollutants was reached - 10 871 t, from which 7.1% represents gas and solid fluids. New technology established in 1995 has reduced the concentration of fluoride in exhaust below the limit 1 $\mu g.m^{-3}$ which is not harmful for the environment.

While fluorine is not an essential element for human well being, it is required for healthy development of young organism. The optimal daily intake of fluorine is considered to be 2 mg. Its lack causes increas of dental defectiveness - dental caries (Škárka and Ferenčík, 1992). An abundance of fluorine in the environment can cause serious defects in organisms. Acute poisoning cases are rare; they lead to irritation of the respiratory system leading to lung aedema (lung swelling), they are usually caused by professional exposure. Chronic poisoning – fluorosis - is caused by inhaling dust containing F. Problems with F in the environment are connected with demineralization (change of hydroxyapatite to fluoroapatite) of bones and teeth (Turčanová, 1994). The most significant intake of F is orally, in comtaminated areas by aspiration of F-bearing dust. About 10 - 20% of the F is deposited in the organism, mainly in bones. In the case of increased intake osteosclerosis can occur, mainly in the spinal column. However, there are also defects of blood production, blood pressure, and disturbances of metabolism (Schwartz et al., 1997). Another negative affect of F there are changes of thyroid gland (Fig. 3); the rate of mortality due to malignant tumor of thyroid gland in this area is the highest one in Slovakia (Khun et al., 1996). Other deleterious effects of chronic exposure to increased doses of F were described on myocardium. A daily intake of 3 - 4 mg F over long time period can be poisonous dose for human. Beside antropogenic activities resulting in increased input of F into the environment (production of Al, freons, artificial fertilizers act.), the hazardous factors include increased consummation of mineral waters and tea (Turčanová, 1994, Schwartz et al., 1997), use of fluoride tooth pastes (in case of young children) and smoking (in case of teenagers).

Conclusion

The input data are about the population of children aged 0 – 14 that was collected from pediatric clinics of hospitals (ZH, NB, BŠ, KR) during 1987 – 1995. In almost the entire area of Žiar nad Hronom (ZH) our study demostrates an increase of malignant tumors, illnesses of endocrine glands, congenital defects, and since 1989, also diseases of circulatory system in comparison with NB, BŠ and KR.

Concerning medical - geochemical aspect, since 1990 the increase in the number of tumor illnesses and congenital defects of monitored child population in Žiarská kotlina Basin could be in causal relation with increased natural radioactivity of rocks and waters and with radon hazard as well. It is possible to predict a potential hazardous areas around tectonic faults in the studied area. In 1996 there was recorded 268.8 congenital development defects per 10 000 live born children, while in Slovakia in 1995 it was 236.3 (State Health Institute in Žiar nad Hronom, 1997).

The quality of drinking water has a relationship with health state of the child (and adult) population; of particular concern is the concentration of nitrates in public water supplies as well as in public and private wells. High danger of hazard was observed in settlements Bzenica, Dobrá Žďaňa, Pitelová a Lovča. The danger of hazard from water and soil components of the environment of the Žiarská kotlina Basin is verified by negative influence of various toxic components migrating towards the river and creeks flats and their adjacent alluvium.

With respect to concentrations of F in components of the environment from monitored groups of diseases of children population aged 0 - 14 in former Žiar nad Hronom district (considering tributary areas of 20 cadastres of Žiarska kotlina Basin) the following can be assumed:

- ⇒ High share of tumors (see, for instance, high incidence and mortality due to tumors of thyroid in adult population of former district Žiar nad Hronom in time period 1968 - 1984, or high rate of mortality due to not specified tumor diseases in time period 1983 - 1992 in comparison with overall Slovak average)
- ⇒ Blood diseases (for instance changes of hemoglobin values)
- ⇒ Diseases of endocrine glands, mainly changes of thyroid where displacement of iodine by fluorine as main element can be assumed
- ⇒ Diseases of circulatory system

It is important to realize that in mentioned components of the environment and in rocks as well, the most important factor is the form in which the element occure, i.e. its accessibility for living organisms. From this point of view the simple comparison of observed concentrations of chemical elements with limits given in particular standards (in the case of rocks with clarckes of earth crust) is more or less routine process, mainly for purposes of medical geochemistry. We have realized this and thus we consider the presented interpretations for the first approach only. This problem requires another more detail research, for instance, sequential analyses.

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