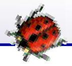
December 2003



MEDICAL GEOLOGY NEWSLETTER

IUGS Special Initiative on Medical Geology

Newsletter No. 7
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CONTENTS

NEW INTERNATIONAL MEDICAL GEOLOGY ASSOCIATION (IMGA)

Participants at the Medical Geology Course, Campinas, Brazil

MESSAGE FROM THE CHAIRMAN, Olle Selinus

INTERNATIONAL MEDICAL GEOLOGY ASSOCIATION, IMGA

Interest in Medical Geology continues to expand worldwide at an increasingly rapid rate, creating numerous opportunities. Our organization has reached the stage of development in which a formal structure is necessary for it to function efficiently. This structure should enable us to better respond to the opportunities, to rapidly pass information to those interested in Medical Geology issues, and to make critical decisions that will benefit the discipline.

To begin this process, we have tentatively selected the name "International Medical Geology Association" (IMGA) for our organization (we invite discussion on this name). The organization formally started on July 1, 2003. Olle Selinus continues in his capacity as Director of this activity. Jose Centeno and Bob Finkelman are Co-Directors. Dave Elliott will continue his work as editor of the Newsletter (see P. 13 for contact information). We have appointed six Councilors to represent the broad geographic distribution of Medical Geology and the wide range of disciplines that are embraced by this topic.

The Councilors are:
Bernardino Ribeiro de Figueiredo (Geologist, Brazil)
Fiona Fordyce (Geochemist, UK)
Zheng Baoshan (Geochemist- China).
Calin Tatu (Medical researcher, Romania)
Nomathemba Ndiweni (Veterinary Biochemistry, Zimbabwe)
Philip Weinstein (Epidemiologist, Australia**)**

We are very pleased that such experienced and competent people are willing to devote their time and efforts on behalf of the Association. Brief CVs and photographs of most Councilors can be found on the web site soon. Three members of this initial group of councilors will serve terms of 1½ and three will serve terms of 2½ years. Subsequently, the councilors will serve terms of 2 two years, will three new councilors starting each year.

The Councilors will be asked to help make decisions concerning all aspects of the Association. For example, each Councilor will be responsible for organizing a committee to study one of the following questions:

- Should we evolve into a formal Society? If so, what should its structure look like?
- What is the best way for us to provide support to regional Medical Geology Working Groups?
- Should we initiate a Medical Geology Journal (virtual or real) or should we affiliate with one or more existing journals?
- Should we organize a Medical Geology Conference or should we affiliate with one or more existing conferences?
- How can we best promote Medical Geology to the science communities, to Decision Makers and to the public?
- How can we raise funds to support this activity?

We will however continue to be a Special Initiative under IUGS for a couple of years at least; the Association and the Initiative working as one entity. IUGS is our parent organisation and we still also need support from IUGS.

We are convinced that the new organizational structure will better serve the interests of the growing medical geology community. We invite your comments on these decisions and recommendations on how we can better serve you.

Olle Selinus Bob Finkelman Jose Centeno

NEW WEBSITE **http://www.medicalgeology.org**

Our website has, for some time, been too small and we now have a new website that will allow us to add more material:

You are welcome to add material: news, information etc., of relevance to medical geology. YOU decide what you want to see on the site. Please send material you want to include to olle.selinus@home.se or olle.selinus@sgu.se (the latter address if you want to send files more than 2-3 MB.

HEALTH EFFECTS OF TOXIC ORGANIC COMPOUNDS FROM COAL: FROM ROMANIA TO POWDER RIVER BASIN, WYOMING

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Introduction

Although medical geology (geomedicine) has only recently emerged as a statuary science, it is as old as humankind. The inherent interaction between primitive humans and the geological environment has translated sometimes into medical conditions, revealed today by archeological research (Bunnell et al., 2002).

Medical geology studies the influence of geological factors on human health. Current research in medical geology is mainly focused on the impact of *geogenic* factors on human health. Compared to the anthropogenic pollutants (e.g., pesticides, various other chemicals), geogenic pollutants result from an undisturbed geological environment. A suggestive example is the leaching of arsenic from the bedrock into the groundwater systems used by communities in Bangladesh or India. Other metals can pose similar problems through excess or deficiency in other parts of the world, and examples can be continue.

Coal in medical geology

Coal has been a major energy source for centuries, but concerns about its detrimental effects on the environment and human health have been seriously addressed only in the last few decades. Apart from mining activity, the effects of undisturbed coal deposits on the human environment are largely unknown, although it is accepted that toxic compounds (such as heavy metals and organic compounds) released from native coal deposits can contaminate water supplies and have detrimental effects not only on humans, but also on plants and animals.

In future, increased reliance on fossil energy resources like coal will likely increase potential exposure of susceptible populations to toxic substances found in this fuel. Research in this direction is required as, except for polycyclic aromatic hydrocarbons (PAHs) and a few other categories of compounds, little is known about the amounts, mobility, and toxicity, of other potentially toxic organic chemicals present in coal. Toxic effects from organic compounds can range from acute exposure resulting in immediate illness, to chronic effects from long-term, low level, exposure, resulting in diseases such as cancer and end-stage renal disease.

Research methodology

In the last few years we have addressed the potential toxicity of compounds derived from coal and their role in disease causation in humans through environmental and geochemical investigations primarily related to a mysterious kidney disease, geographically confined to rural areas of the Balkan Peninsula where low rank Pliocene lignite deposits have been described (see below).

The scientific questions

In the broad frame of the coal-human health interaction project, several major preliminary questions were asked:

1. Does coal contain toxic organic compounds? If so, what are these, in what quantities do they exist, and how do they vary among different kinds of coal?
2. Can toxic organic compounds from coal be mobilized into the environment by: (a) leaching by ground or surface water, or (b) by coal combustion? How does the mobility of toxics from coal vary from coal type to coal type?
3. What are the major parameters affecting the type, amounts, and mobility of toxic organic compounds in coal?
4. What is the impact of toxic organic compounds from coal on human health and environmental quality?
5. Are toxic organic compounds from coal linked to any known instances of human disease?

Answers to these questions were sought by field and geochemical laboratory investigations, as well as by epidemiological and medical approaches.

The objectives
Emerging from the scientific questions, the goals of our project were to:
1. Examine distributions and concentrations of potentially toxic organic compounds in coals from USA and the world.
2. Examine the mobilization of potentially toxic aromatic compounds from coal using simulated laboratory leaching and burning experiments.
3. Develop cause-effect models of potential human health and environmental impact of organic compounds mobilized from coal.
4. Examine links between toxic organics from coal and specific diseases: Balkan Endemic Nephropathy (BEN) and urothelial cancers in lignite-bearing states in USA.

Results and conclusions

To identify the presence of potentially toxic organic compounds, several distinct coal samples were subjected to methanol or water extractions and the extracts were analyzed by gas chromatography/mass spectrometry (GC/MS). The results of such an experiment are shown in Figure 1, representing the total ion chromatograms of three different rank coal samples extracts. As coal rank increases the amounts of organic compounds (including toxics) extractable in polar solvents (methanol, water) decreases, due to decreasing oxygen content and H-bonding ability. The conclusion of such studies is that a lower rank coal can release more compounds and in higher concentrations that in a real life situation could have a bigger impact on human populations and their environment. However, in certain conditions, higher rank coals can have similar polluting effects; such a situation is described below.

From Balkan endemic nephropathy as a disease model in medical geology…
Studying Balkan endemic nephropathy (BEN) as a model for linking toxic organic compounds from coal to human disease has many advantages: well described disease, limited study area, stable population, simple vector model, etc.

The medical description of Balkan endemic nephropathy (BEN) is as a kidney disease resulting in end-stage renal failure, with a high rate of coincidence of urothelial cancers (upper urinary tract tumors).

The disease occurs exclusively among rural villagers (ages 30-70) in discrete areas of the Balkan Peninsula, who have resided in an affected village for at least 20 years.

Its etiology has defied a widely accepted explanation for the last 50 years, since the disease was first described by the medical community, but many of the features of BEN suggest an environmental cause (Tatu *et al.,* 1998). One of the more appealing ideas in the last several years, which was also our working hypothesis for the study of this disease, is that BEN is caused by toxic organic compounds leached into the groundwater from low rank Pliocene coals in the endemic regions, and transported to wells and springs serving as water supplies. The well water containing the toxic organic compounds is used by the villagers for drinking and cooking, exposing them to the toxic organic compounds. Over time (20 years of exposure or longer) these compounds result in BEN, and may also be responsible for the high coincidence of urothelial cancers in individuals with BEN.

During 2000-2002 we performed several field trips in endemic areas in Romania (Drobeta Turnu Severin and Resita regions), Yugoslavia (Nis area) and Bulgaria (Vratza endemic area) (Figure 2) when water and coal samples were collected, along with epidemiological inquiries. The water samples were processed through liquid-liquid extraction with dichloromethane and the extracts were analyzed by GC/MS. Compared to samples from the nonendemic villages, the endemic samples usually showed higher amounts, and higher numbers, of organic components, suggesting that the organic geochemistry of the water may have a role in BEN causation (Figure 3). Similarly, methanol and water extracts of Pliocene lignites from endemic regions in Romania and Yugoslavia, have shown much higher amounts and larger numbers of dissolved organic entities, compared to lower rank coals (Figure 4) and even similar lignites but from non-endemic areas (data not shown) (Orem *et al.*, 2001). However, in spite of our results, a direct link between the presence of the Pliocene lignites in the endemic areas and the etiology of Balkan endemic nephropathy is still missing.

Figure 5 lists a few compounds found in endemic area water samples and having potentially toxic (i.e., nephrotoxic and/or carcinogenic) effects.

…To the Powder River Basin, Wyoming

In the United States, some of the highest mortality rates per 100,000 population from upper urinary tract carcinoma and kidney cancer (cases accounted for between 1970-1994) have been noted to occur in States that have extensive lower rank coal deposits (lignites and sub-bituminous coals). These places also have extensive rural populations relying entirely on groundwater as water supply and a connection with the presence of the coal deposits is not entirely unlikely. A particular situation is encountered in the Powder River Basin, Wyoming, where methane gas formed through bacterial activity inside the sub-bituminous coal underlying the entire area is extracted. A significant byproduct of the *coal-bed methane (CBM)* extraction process is *water,* which is usually discarded on the ground, used for irrigation purposes or as drinking supply for cattle. Inorganic geochemical analyses have been performed in order to establish if the CBM produced water poses a threat to human health and the environment (Rice *et al.*,2000) and as most of the inorganic parameters fell into normal ranges it has been concluded that the produced waters would not have any quantifiable impact on the environment. However, much less is known about the dissolved organic content of these waters. Looking for an explanation for the high incidences of urothelial tumors in those areas, we embarked upon a study of the organic geochemistry of the CBM wells, through similar methods to those employed for the Balkan endemic nephropathy regions. Preliminary analyses have revealed that the produced waters would fall into three categories:

-little or no organics present
-high levels (ug/l) of N- and O- substituted aromatics
-high levels of N- and O- substituted aromatics and PAH's.

A total ion chromatogram for three water samples from the Powder River Basin is plotted in Figure 6 and the total number of organic components identified by mass spectra search for each analyzed sample is represented in Figure 7. Figure 8 shows a few chemical structures excerpted from the database of organic compounds found in the CBM wells water samples.

It is supposed that many of the N- and O- substituted aromatics and the PAHs characterized in the water extracts may be toxic and could likely have some impact when released into the human environment. This situation is becoming of even more interest as many farmers from Wyoming use as water supplies, groundwater from wells that sometime percolate the underlying coal layers. A possible connection with the high rate of upper urinary tract cancers in the area is envisioned but much more field and laboratory study would be required in order to provide a firm scientific support for this statement.

A final word

Although only two potential geomedical problems related to coal and its pollutants have been pictured in this brief paper, there are other thoroughly documented cases where geogenic or combined geogenic/anthropogenic pollution from coal has been linked to human disease (Finkelman *et al.*, 2002). More, similar, conditions are likely to be described in the future, as medical geology will develop into a widely recognized science, and more and more scientists with diverse specialties will bring their contribution on the bridge between medicine and geology. Several decades ago geomedicine was just a "science in gestation". A few years ago, it was embraced by the scientific community as a promising science and a steady progress can be foreseen for the next few years and perhaps decades.

Acknowledgements

Funding for this project was provided through the USGS Energy Resources Program and a USGS Assistance Award (00HQAG0213) to C. A. Tatu, NATO (Collaborative Linkage Grants EST.CLG.975818 and EST.CLG.977806), and the Romanian Ministry of Health.

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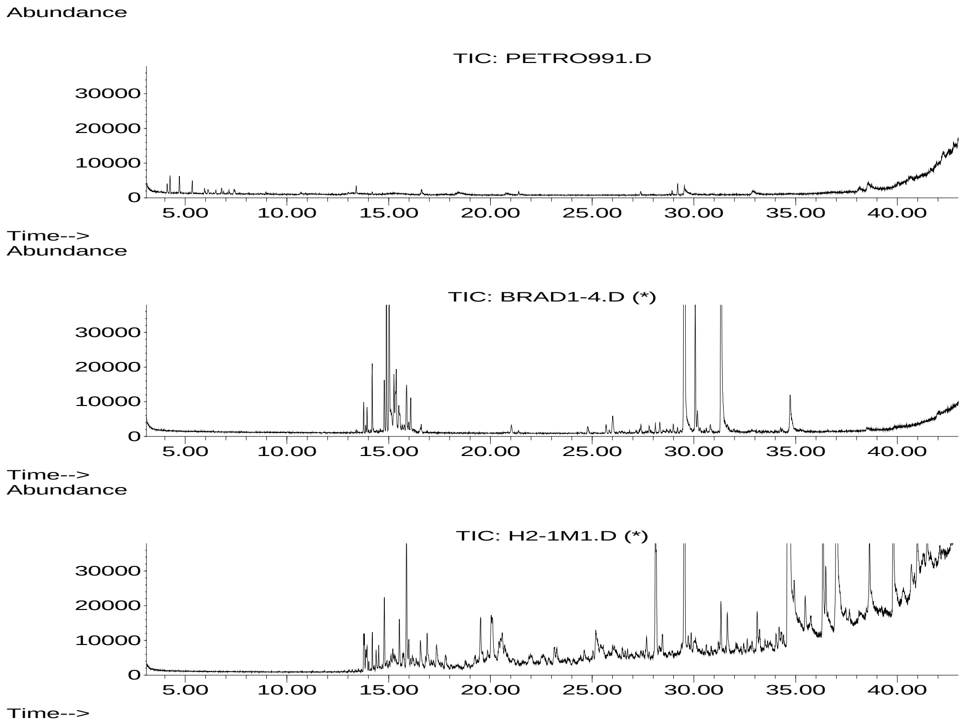


Figure 1. As coal rank increases the amounts of organic compounds (including toxics) extractable in polar solvents (methanol, water) decreases, due to decreasing oxygen content and
H-bonding ability.

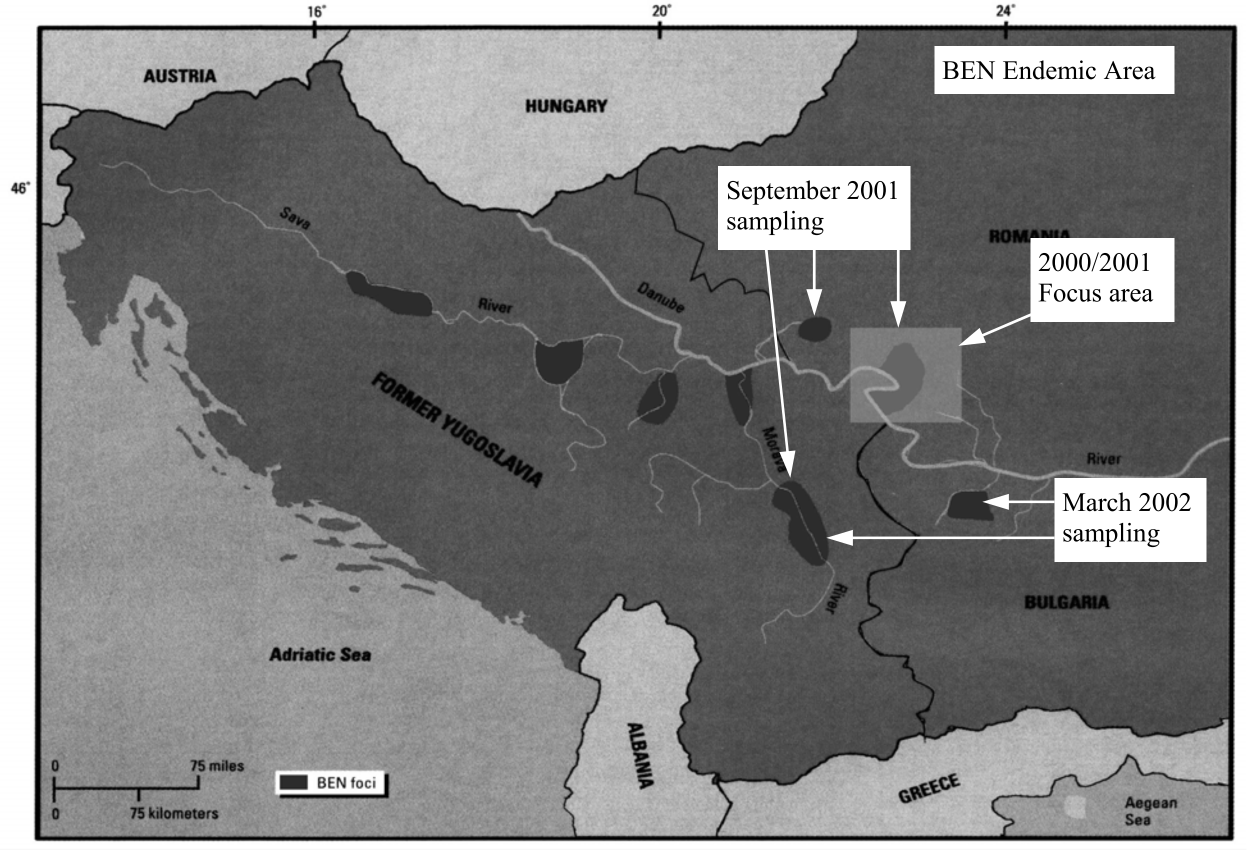


Figure 2. The distribution of the Balkan endemic nephropathy sampling areas.

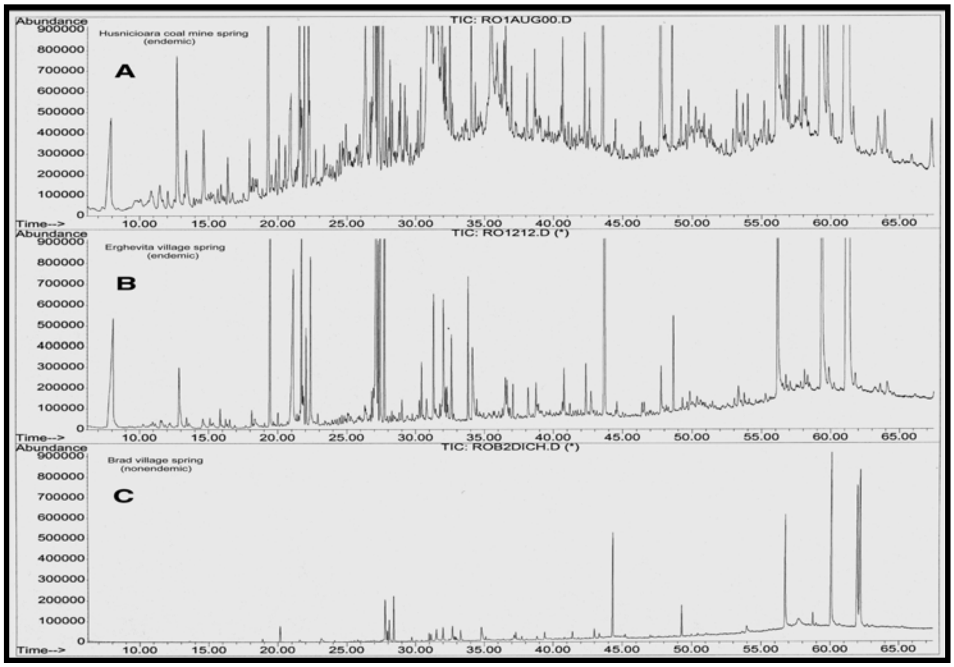


Figure 3. Total ion current (TIC) chromatograms from two endemic areas and one non-endemic area water extracts. A higher number of organic components and higher abundances can be observed in the endemic samples (panels A and B) compared to the non-endemic (panel C) sample.

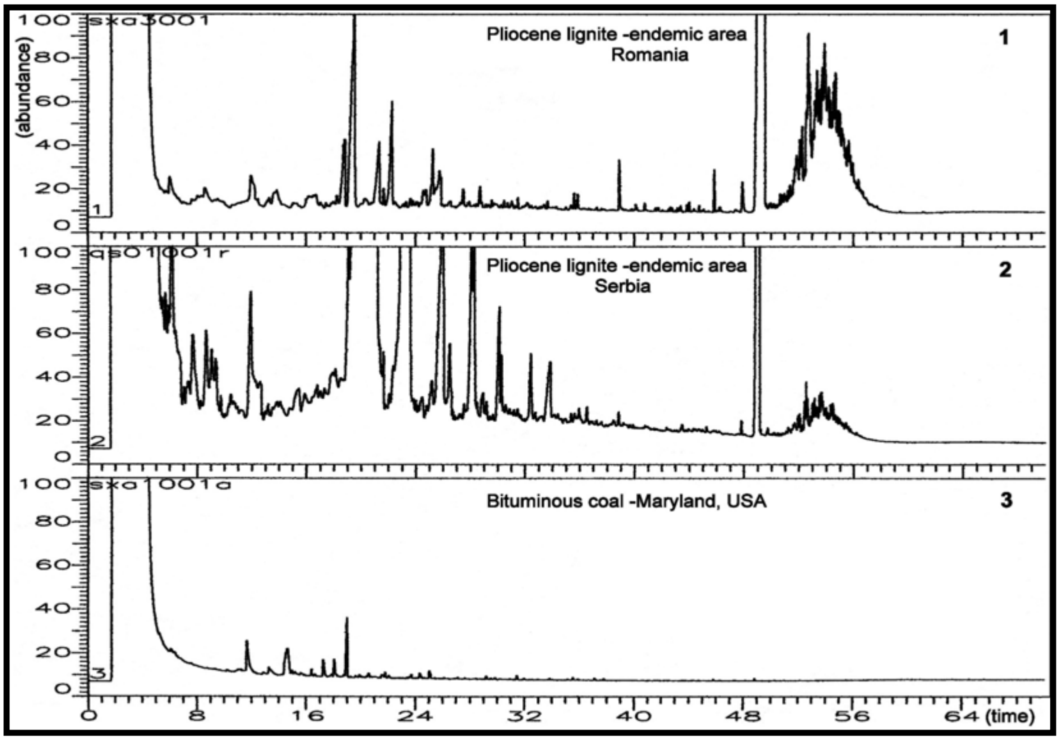
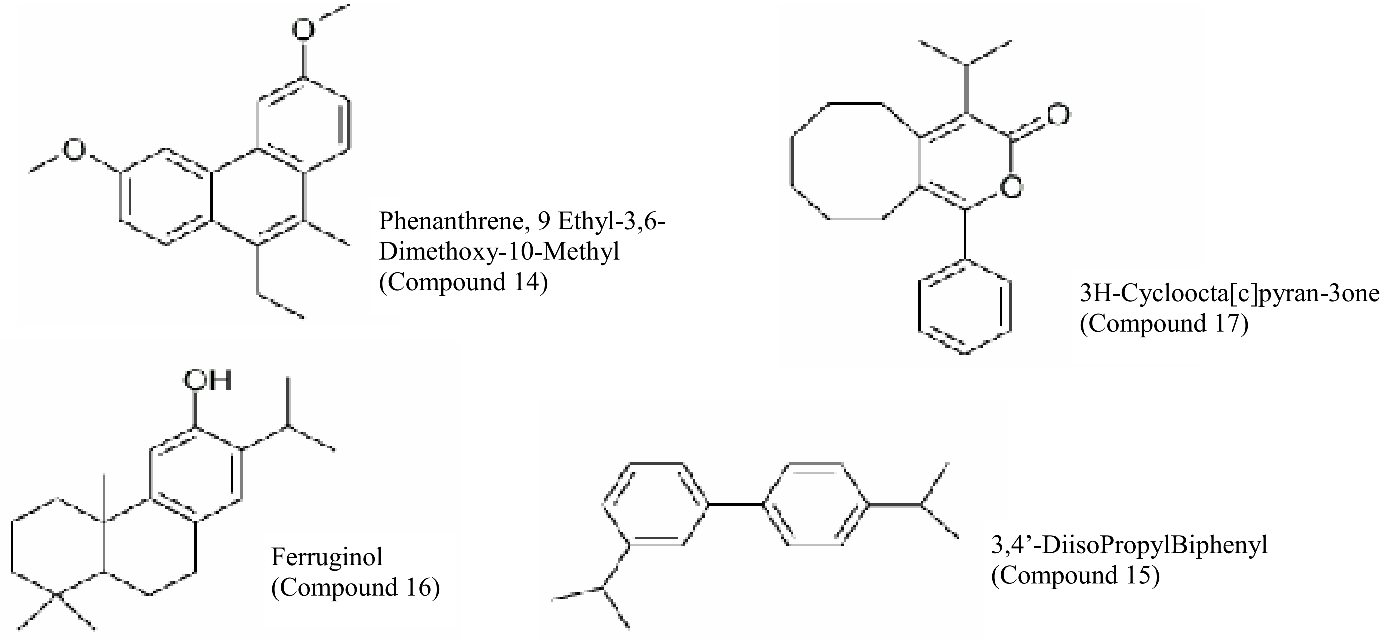


Figure 4. Gas chromatograms of laboratory water extracts of Pliocene lignites from two BEN-affected areas—Romania (1) and Serbia (2)— and of a bituminous coal from Maryland, U.S.A. (3). Peaks indicate the presence of potentially toxic organic compounds.



Phenanthrene, 9 Ethyl-3,6-Dimethoxy-10-Methyl
(Compound 14)

3H-Cycloocta[c]pyran-3one
(Compound 17)

Ferruginol
(Compound 16)

3,4'-DiisoPropylBiphenyl
(Compound 15)

Figure 5. Examples of organic compounds identified in well water from endemic villages in Romania and Yugoslavia, and in water extracts of Pliocene lignites from the Balkans. Concentrations of individual compounds in well water generally range from 10 to 0.1 mg/l (ppb).

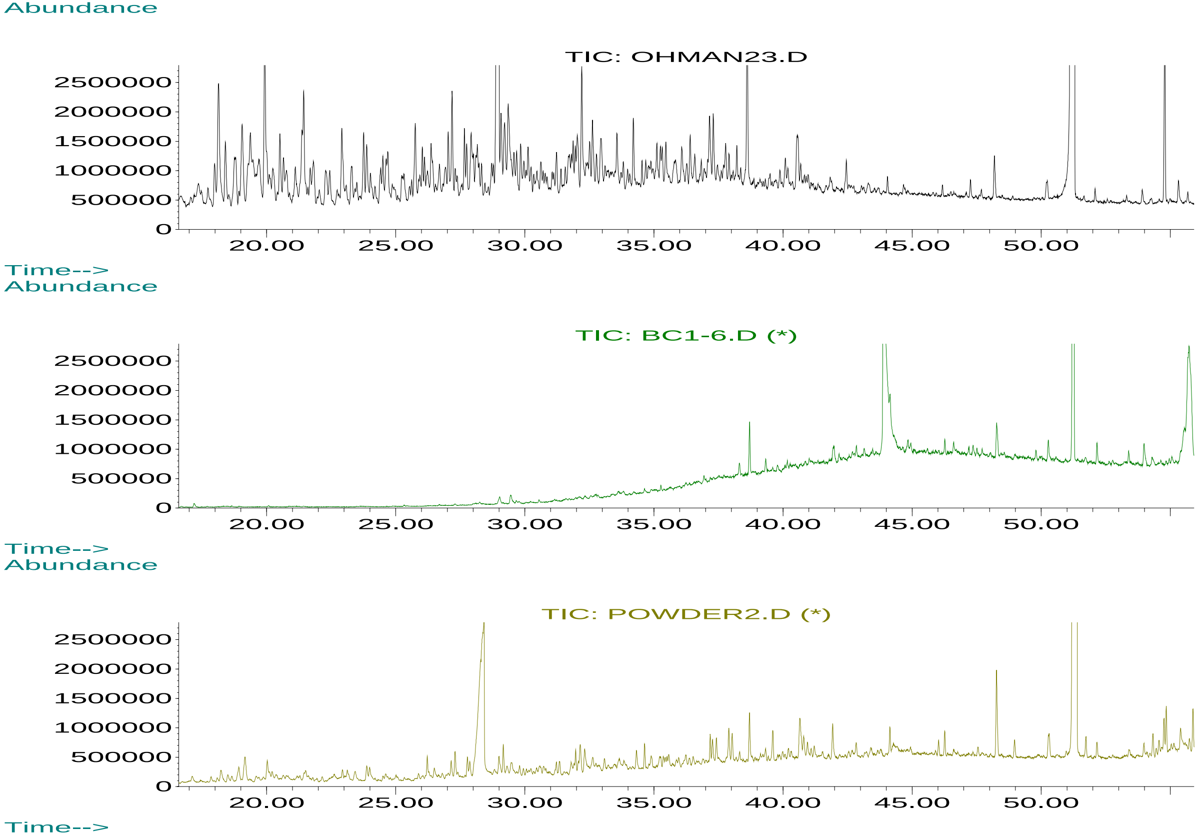


Figure 6. Total ion chromatograms of three CBM wells water samples from the Powder River Basin, Wyoming.

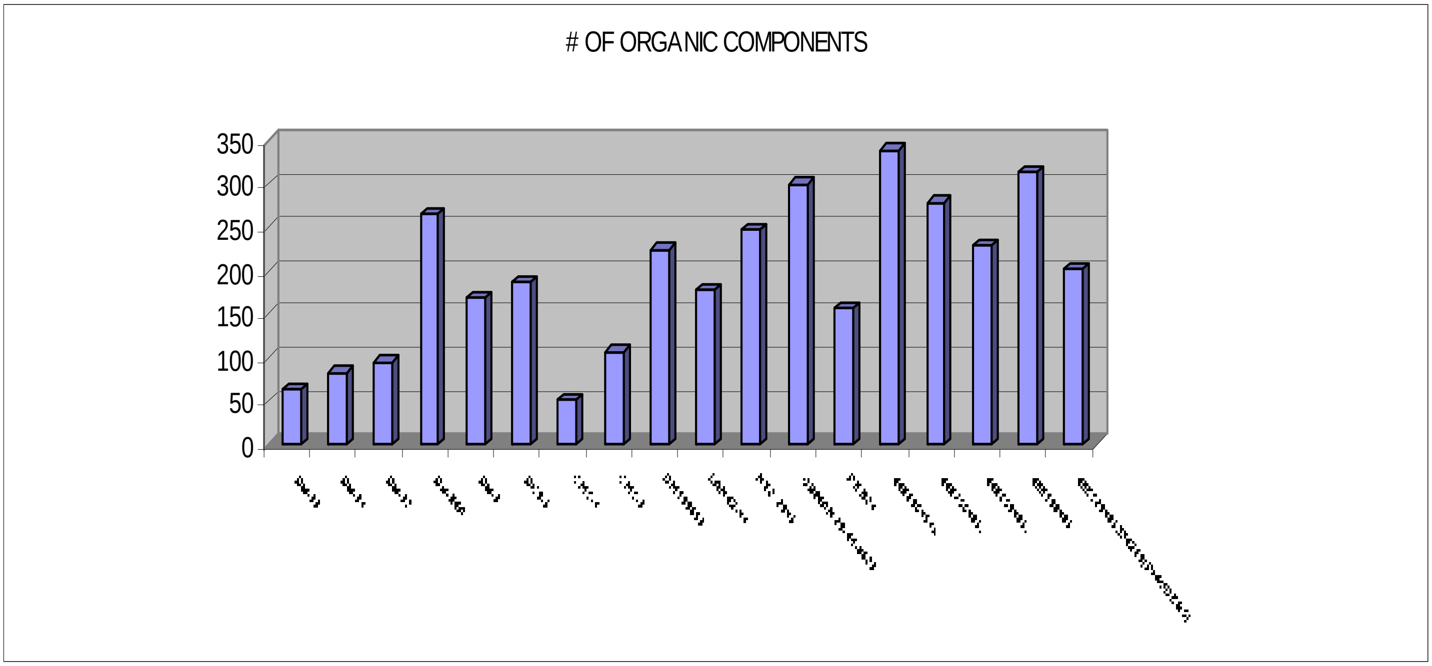
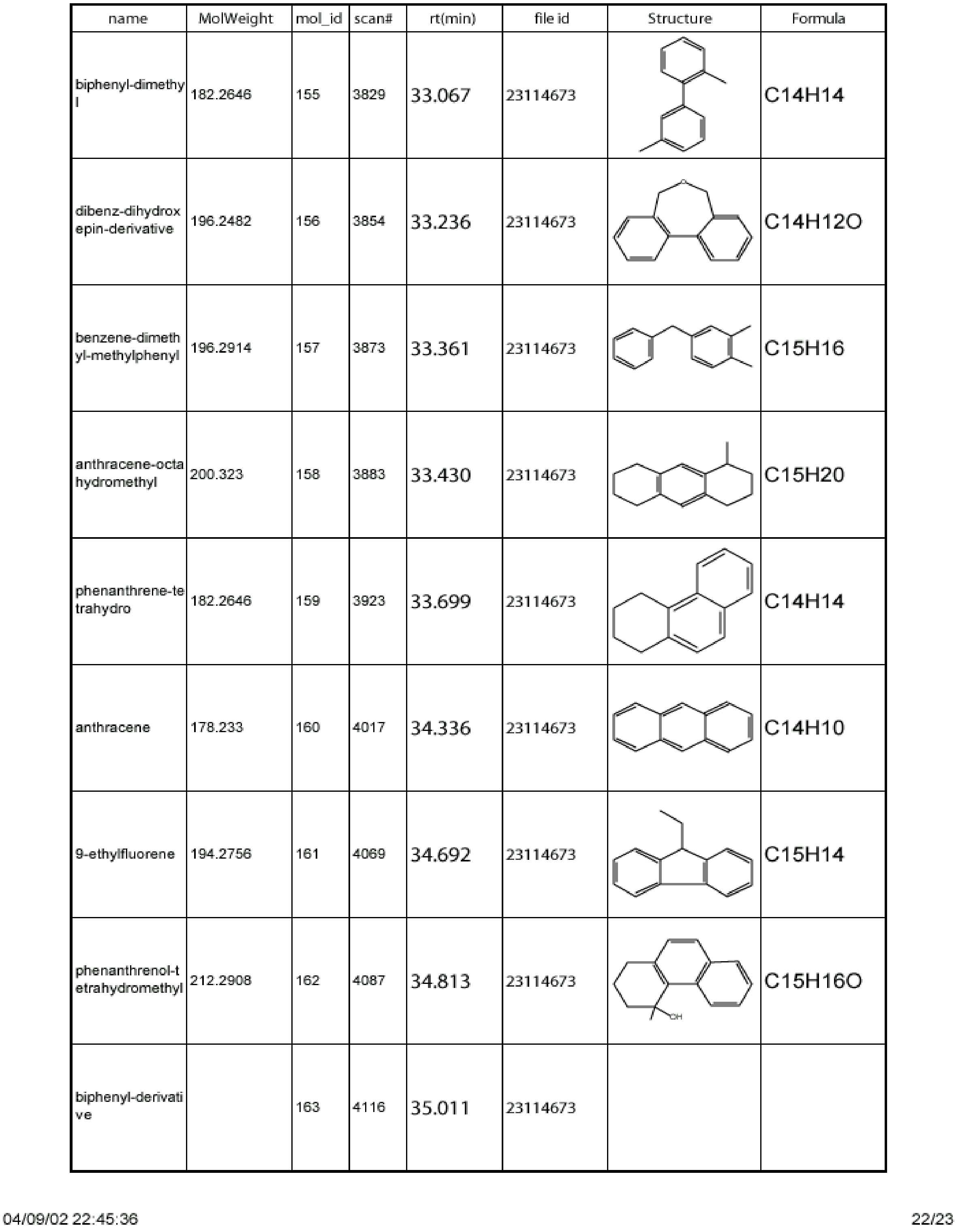


Figure 7. Plot of the number of peaks(organic components) in GC-MS TIC's versus well number for produced waters from CBM wells, Powder River Basin, WY.



name	MolWeight	mol_id	scan#	rt(min)	file id	Structure	Formula
biphenyl-dimethyl	182.2646	155	3829	33.067	23114673		C14H14
dibenz-dihydroxepin-derivative	196.2482	156	3854	33.236	23114673		C14H12O
benzene-dimethyl-methylphenyl	196.2914	157	3873	33.361	23114673		C15H16
anthracene-octahydromethyl	200.323	158	3883	33.430	23114673		C15H20
phenanthrene-tetrahydro	182.2646	159	3923	33.699	23114673		C14H14
anthracene	178.233	160	4017	34.336	23114673		C14H10
9-ethylfluorene	194.2756	161	4069	34.692	23114673		C15H14
phenanthrenol-tetrahydromethyl	212.2908	162	4087	34.813	23114673		C15H16O
biphenyl-derivative		163	4116	35.011	23114673		

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Figure 8. Examples of organic structures identified in methylene chloride extracts of produced waters from coalbed methane wells in the Powder River Basin, WY. A series of polycyclic aromatic hydrocarbons (PAH's) from naphthalene through pyrene were observed in about one third of the produced water samples.

PRELIMINARY ASSESSMENT OF THE IMPACT OF PETROLEUM REFINERY, KADUNA, NORTHERN NIGERIA ON THE ENVIRONMENT AND HUMAN HEALTH

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Introduction

This study focuses on the impact of Kaduna refinery (Fig. 1) on the chemical and physical qualities of the surrounding soils, surface, and groundwater with the resultant effects on human health using the content of seven heavy metals and visual observations as preliminary measuring parameters.

The area of investigation is covered with lateritic clayey, silty, sandy soil that varies in appearance from yellow to reddish brown, cellular, concretionary type and in consolidation from loose to hard. Groundwater in the area occurs mostly within the laterites. Hand-dug wells draw water from this unconfined aquifer. (Olugboye, 1975). Deeper aquifers are encountered within weathered and fractured Basement complex rocks.

Methodology of Investigation

Visits to areas of environmental hazards, sampling of soils, surface and groundwater were undertaken (Fig.2). Sub-surface water was recovered from nine hand-dug wells in the refinery's vicinity and one well up gradient of the refinery to provide background information. The samples were analyzed for Pb, As, Mn, Fe, Cu, Cr, Zn with by atomic absorption spectrophotometry.

Results and Interpretation

The results of analyses of the surface and groundwater samples indicate that the concentrations of Cu, Mn and Zn were below the WHO guideline values for drinking water. However, in all the five surface water samples, the concentrations of Pb (0.0325 to 0.1600) mg l^{-1}, As (0.50 to 10.50) mg l^{-1}, Fe (1.60 to 28.00) mg l^{-1} and Cr (0.50 to 52.30) mg l^{-1} were above the WHO guideline values with all the water samples exceeding the recommended limits for Pb (0.01 mg l^{-1}), As (0.01 mg l^{-1}), Fe (0.30 mg l^{-1}) and Cr (0.05 mg l^{-1}) .

The likely sources of iron are from the dissolution of soils rich in iron minerals along the stream and river channel (Health, 1987; Hamill and Bell, 1986) and from the refinery (Forstner and Wittmann, 1983). Lead input could be from anthropogenic enrichment from the refinery effluents containing compounds added to improve the antiknock properties of gasoline (Kakulu, 1985) and the dissolution of soils rich in Pb minerals. The highest concentration of Cr in the study area (52.30) mg l^{-1} was detected from contaminated stream containing effluents from the refinery indicating an anthropogenic source of contamination (Forstner and Wittmann, 1983). The source of As in the surface water is likely to be natural (from the soil and weathered rock of the area).

The pH of the surface water samples range from 4.76 to 8.94 indicating an acidic to alkaline condition. Twenty percent of the sub-surface water samples exceeded the WHO (World Health Organization Standard) of 7.0 – 8.5.

In the groundwater samples, the concentrations of Pb (0.0325 - 0.1600) mg l^{-1}, As (0.0 - 9.00) mg l^{-1}, Fe (0.0 - 2.50) mg l^{-1} and Cr (0.50 – 3.95) mg l^{-1} were above the WHO guideline values with all the water samples exceeding the recommended limits for Pb (0.01 mg l^{-1}), As (0.01 mg l^{-1}), Fe (0.30 mg l^{-1}) and Cr (0.05 mg l^{-1}). A natural source is strongly suspected for Pb, Fe, Cr, and As contamination in the groundwater. This is because the concentration of the heavy metals in the control samples collected up gradient of the study area is equally beyond WHO guideline values. In addition, there is no clear cut reduction in the heavy metal content of the control samples when compared with the other groundwater samples. However, the possibility of anthropogenic enrichment cannot be ruled out totally, and may occur as a result of infiltration of effluents rich in these heavy metals especially Pb and Cr.

The pH of the groundwater ranges from 7.16 to 8.76, indicating a neutral to alkaline condition (aerobic) normally obtained from younger aquifer in semi-arid regions. The groundwater is universally oxidizing and generally characterized with redox potentials and dissolved oxygen (Smedley et al., 2000). This is a favorable geological environment for the occurrence of As in groundwater. Arsenic correlates positively with pH (r^2 0.44) in the groundwater samples examined. This correlation is similar to the one obtained from La Pampa Province, Agentina as reported by Smedley et al., 2000.

The concentrations of heavy metals in the nine soil samples were below normal in uncontaminated soils when compared to greater London council, Netherlands standards as cited by Curtin et al. (1997) and Alloway (1990). The soil pH values range from 2.50 to 6.13 indicating an acidic condition.

Crude oil spilled into river Romi and on the farm lands. Abandoned flow line of spilled oil was observed from the refinery towards Rido (locations of samples 4s, 5s and 6s as illustrated in Fig. 2). The inhabitants depend on farming for economic subsistence. However the spillage of crude oil on farm lands over the years has led to the reduction in soil fertility and corresponding decrease in crop yield. This resulted in the absence of fish and reptiles for example, crocodile in the surface water of the study area examined. These organisms were present before the construction of the refinery and the residents engaged in fishing, but presently, the fishing industry is extinct and fishermen have migrated elsewhere. Crude oil and petroleum products spillage into groundwater occurred in Gidan Kapam, Rido and Chiduru. Occasional air pollution occurs and black residues of hydrocarbon materials are found on trees at Gidan Kapam and Chiduru. About twenty children were born with rickets deformities (bow legs) in the communities investigated. Rashes on the heads of some children are common. These ailments were noticed after the refinery was constructed.

Conclusions

From the results of field observations and laboratory

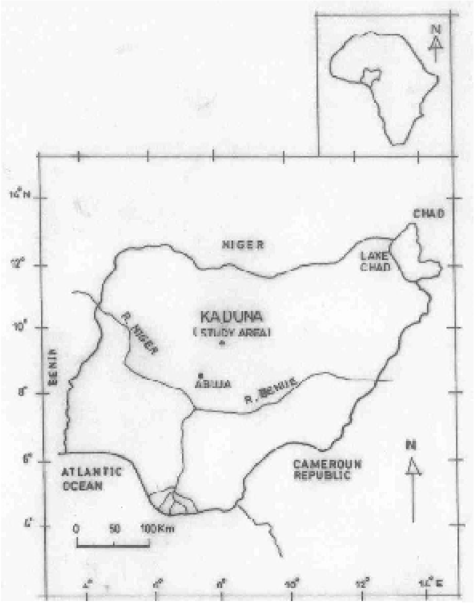

Figure 1. Africa and Nigeria showing the Location of Kaduna (Study Area).

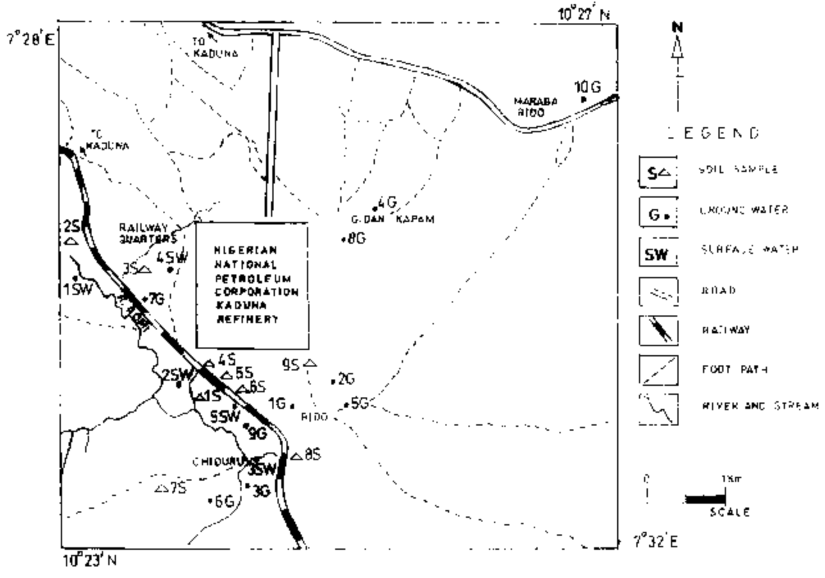

FIG. 2 MAP OF THE STUDY AREA SHOWING SOIL AND WATER SAMPLE LOCATIONS

Figure 2 The Study Area showing Soil and Water Sample Locations.

analyses, the improper disposal of effluents, occasional spillage, infiltration of crude oil and petroleum products in the communities surrounding the Kaduna refinery have been found to affect the chemical qualities of soil, surface and groundwater in terms of their excessive concentrations. It has also affected crop yield, animal and human health. The surface and groundwater is contaminated with lead, arsenic, iron and chromium. However, the possibilities of a natural source of input exist. The inhabitants, who depend solely on groundwater retrieved from hand dug wells for potable supplies, are endangered.

Recommendations

1) Alternative sources of water for domestic supplies such as rain harvesting and drilling into deeper aquifers should be explored and adopted.
2) Effluents and waste-water should be treated before disposing into surface water.
3) All spilled crude oil on surface water and soils should be cleansed with the use of appropriate technology.

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DISTRIBUTION OF SOME RESPIRATORY DISEASES WITHIN THE MINSK OBLAST (REGION)

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This study assessed a dependence of distribution of respiratory diseases within the Minsk region on environmental conditions and the character of industrial and agricultural specialization of administrative districts. The subdivision by administrative districts was chosen based on medical statistics on the morbidity of the Belarusian population. This significantly complicates a detection of possible relationships between diseases and environmental conditions, because the borders of districts do not reflect spatial distribution of landscapes, geochemical and hydrogeochemical provinces, etc. Those diseases were chosen, which practically exclude the influence of viral and bacterial agents, for example, bronchitis and bronchial asthma. The "geography" of the acute respiratory diseases is also of great interest, but because of difficulties with the collection of data, reflecting social conditions (residential conditions, energy consumption per capita, municipal waste output, ect.), this is not considered here. The level of morbidity in the unique urban area Minsk, is also not considered.

The study area occupies 40.8 thousand km^2 with a population of 1,700 thousand, in the center of Belarus. The region is characterized by alternation of uplands and lowlands, the central part being the Belarussian Highland (absolute altitude, 180–300 m).

The major landscape types include: secondary fluvial-glacial plain (28.2% of the region), hilly-moraine erosional (16.2%), secondary moraine plain (15.2%), lacustrine- and peat-bog lowland (7.3%), undissected river valleys (7.1%), and others.

The territory of Minsk region is rather homogeneous in terms of agricultural land use. Predominant agricultural activities are meat- and milk cattle, pigs, and potatoes. Agricultural production is more intensive in the SE part of the region, in Stolbtsy, Nesvizh, Kletsk, Kopyl and Slutsk districts.

The predominant industrial activities include light industry, food, building material, and local industries. The exceptions are Minsk, Borisov and Molodechno, where the machine-building, metal-working and chemical industries concentrate.

The analysis of the distribution of chronic bronchitis cases (Fig. 1) shows that the areas with the highest levels of morbidity tend to be the large industrial centers, the cities of Minsk and Borisov. Geochemical study of emitted dust particles [1] shows considerable decrease (3–5 times) in the level of technogenic contamination even at the distance of 10 km from the industrial zone. Nevertheless, much wider influence of these cities on the level of morbidity is explained by the atmospheric transfer of contaminants. Such a transfer is especially intensive in the river valleys of Svisloch and Berezina, characterized by high levels of bottom sediment and water contamination.

A definite correlation is seen between the morbidity level and distribution of peat-bogs. The relationship between the transportation load and morbidity level was not determined, although it might be found by more detailed mapping. It is possible that the quality of drinking water influences the level of chronic bronchitis morbidity (perhaps through other pathologies, such as cardiovascular ones), but an absence of more detailed data does not allow for a more certain conclusion.

No definite relationships have been shown for the distribution of bronchial asthma (Fig. 2), , possibly due to the predominantly allergic nature of the disease, that requires a more precise and detailed analysis of social structure and environmental conditions.

1. Lukashev V.K., Okun L.F. Contamination of the Environment of Minsk by heavy metals, IGS, Minsk, 1996.

RESPIRATORY DISEASES WITHIN THE MINSK OBLAST Cont.

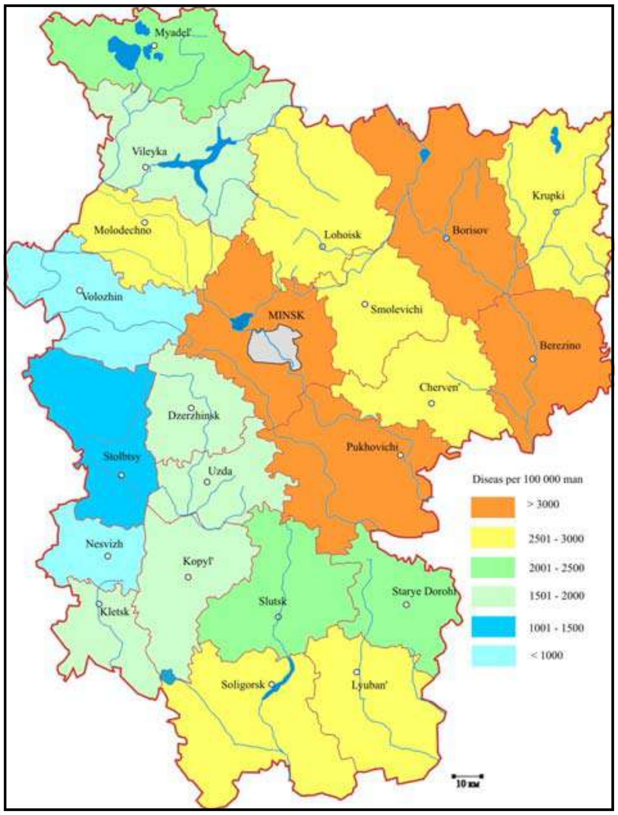

Figure 1. Distribution of chronic bronchitis diseases in the Minsk Oblast

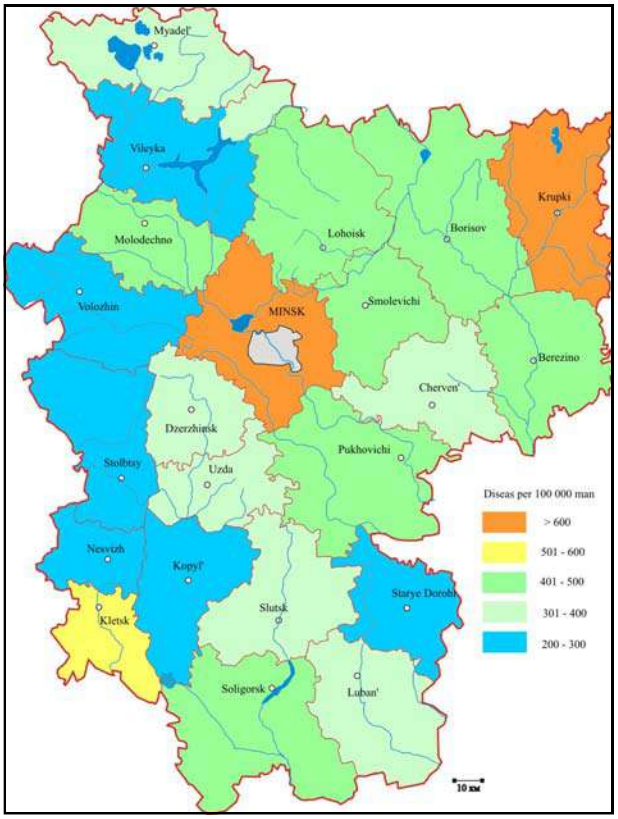

Figure 2. Distribution of bronchial asthma diseases in the Minsk Oblast

HIGH FLUORIDE IN GROUNDWATER CRIPPLES LIFE IN PARTS OF INDIA

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Introduction There has been tremendous progress in rural water supply infrastructure after setting up of the Rajiva Gandhi National Drinking Water Mission in 1986, but the goal of providing safe drinking water to all is still to be achieved. Ever-increasing population and the increased need for agriculture and industries has resulted in water scarcity. The rural, and even the urban, population depends upon water from local tanks and tube wells, and the use of untreated water, for all purposes. To look into water quality and related health problems, water quality data from nine States: Jammu and Kashmir (J&K), Himachal Pradesh, Rajsthan, Haryana, Bihar, West Bengal, Chattisgarh, Orissa and, Maharashtra, covering almost the entire nation has been reviewed.

Results Surface, subsurface and thermal water sample analysis show fluoride concentrations from <0.2 to 18 ppm in the States of Jammu & Kashmir, <0.2 to 6.5 ppm in Himachal Pradesh, >1.5 ppm in Rajsthan, 0.2 to 0.6 in Haryana, 0.35 to 15 ppm in Bihar, an average 12 ppm in West Bengal, 15 to 20 ppm in Chattisgarh, 8.2 to 13.2 ppm in Orissa and 0.7 to 6.0 in Maharashtra; that except in Haryana, fluoride concentration is very high; up to 20 ppm.

Discussions Probable source of high fluoride in Indian waters seems to be that during weathering and circulation of water in rocks and soils, fluorine is leached out and dissolved in ground water. The concentration varies greatly, and depends on the source rock. Among the various minerals responsible for high concentration of fluoride, Fluor-apatite, $Ca_5 (PO_4)_3F$ and Fluorite, CaF_2, are important, the most important being Fluorite, and leaching from metamorphic rocks, hornblende gneiss of Proterozoic age.

The ill affects of high fluoride content in water are manifest as 'Endemic fluorosis', an acute public health problem in India. Around 25 million people of 150 Districts are affected by this disease (Survey report, Rajiva Gandhi National Drinking Water Mission, 1993). Medical advice is that drinking water should not contain more than 1.5 ppm of fluoride. Concentrations of fluoride below 1.5 ppm are helpful in prevention of tooth decay, and in the development of perfect bone structure in human and animals. However, doses of fluoride above 1.5 ppm increase the severity of tooth mottling and induces the prevalence of osteoporosis and collapsed vertebrae. Fluorosis has no treatment and is considered to be a deadly disease. A high fluoride content in water even causes change in shape and colour of fruits and vegetation.

Unlike bacteriological pollution, the effect of the excess chemical constituents (such as fluoride in groundwater) is chronic and manifest after consuming water over a long period of time. Long term ingestion of drinking water with more than 1.5 ppm fluoride leads to dental and skeletal fluorosis as well as non-skeletal manifestations. The left hand side picture, below, shows a person with normal teeth, and the right hand side, one suffering from dental fluorosis from Orissa State having brownish yellow mottled teeth, a common feature in high fluoride States.

It is unfortunate that millions of people in India and neighboring States have no access to safe drinking water and are compelled to consume the untreated water that is easily accessible to them without knowing the ill affects of such consumption.

Recommendations High fluorine consumption leads to fluorosis of the bones which is common in Asian regions but is more acute in India. Hence, the possibility of reducing the high fluorine content of groundwater by a defluorination process/dilution with surface water is one very simple way to appreciably decrease the fluoride concentration, which appears to be a more suitable solution to high fluoride problem in an otherwise water scarce India. In areas of high concentration. easily available local raw materials, such as clay, serpentine, and marble can be used to reduce the fluoride content if geological and geochemical investigations are carried out prior to the implementation of water supply schemes.

Caution : A much elevated concentration of fluoride, ranging from more than 1.5 ppm to 20 ppm in surface, subsurface and thermal waters in nine States in India, is beyond the permissible limit fixed by the WHO for human beings, the consumption of which is bound to yield the deadly Fluorosis disease. It may also cause harm to the ecosystem and vegetation, if used for irrigation.

Normal Teeth

Dental Fluorosis Mottled Teeth

GROUNDWATER: RESOURCES AND QUALITY IN LITHUANIA

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Groundwater as a natural resource, with its economic and ecological value, is of vital importance for the future development of Lithuania. The country is dependent on groundwater for its drinking water supply, but this resource is increasingly threatened by pollution from industrial and agriculture activities. It is therefore necessary to formulate and adopt long-term policies and procedures to protect the groundwater and soil. The required protection measures include monitoring and mapping of groundwater, ecogeological assessment of the impact of industrial and agricultural activities on the environment, regulation of such activities and establishment of groundwater protection strategies through territorial planning and land-use management.

Lithuanian territory is rich in groundwater resources suitable for drinking water supply. Regional assessment of Lithuania resources of fresh groundwater, carried out in 1972–1978, showed that potential resources in Lithuania reach up to 3.177 thousand m^3/day (Table 1). About half of the evaluated groundwater resource is related to Quaternary deposits including alluvial sands. The remaining half is in bedrock represented by Cretaceous, Permian and Devonian layers.

In 1989, when the consumption of groundwater reached the highest level, urban consumers used 50–75 per cent of explored resources. With a decrease in potable water consumption, in 2001 only 20–30 per cent of underground water resources were used. Hence, water use data indicates that only a small fraction of available resources are currently used. Therefore the quantity of fresh groundwater resources is not regarded as a problem in Lithuania. The problems may arise due to quality of drinking water.

Whereas the geological environment determines the chemical composition of water, the groundwater formed in natural environment is often ferrogenous and contains much manganese or ammonium compounds (Table 2). Though iron and manganese are

Aquifer and complex of aquifers	Geological index	Prognostic reserves*		Natural reserves*	Water Use in 2002
		Potential	Perspective		
Riparian (river bank) aquifers	Qprup	1474	809.7	–	75.9
Intermoraine layers	Qtmr	626	383.0	–	181.5
Upper Cretaceous	K_2	56	169.0	150	11.0
Lower Cretaceous	K_{2-1}	14	21.0	14	3.1
Jurassic	J	–	5,0	–	3.5
Upper Permian + Famenian	P_2–D_3fm	449	237.0	608	32.6
Stipinai	D_3st	36	97.0	19	14.5
Fransian carbonate	D_3fr	101	–	–	6.9
Upper–Lower Devonian	D_{3+2}šv+up	421	480.0	3220	62.7
Totally		3177	2201.7		391.7

Table 1. Distribution of regional groundwater resources by aquifers (thousands m^3/d)
** See Editor's note on terminology, page 20*

ascribed to the indicative-organoleptic indices that deteriorate water quality, they are not injurious to health, but still present the biggest problem to water consumers. Incidentally, often the iron content in public water supply systems increases when consumption of potable water decreases, providing favourable conditions for iron bacteria to vegetate because of a slow water current in the water-supply system. Because of the reasons mentioned above, only about a quarter of the water that is used fully meets the hygienic requirements.

Sometimes in groundwater the permissible concentrations are exceeded by the above-mentioned natural ammonium and fluorine, and the technology of their removal may be complicated (Table 2). Though the concentration of nitrate and nitrite in public water supply networks did not exceed permitted concentration, an increasing trend was observed in some of them.

Following the 50 year Soviet period, Lithuania has many sources of pollution that threaten the groundwater resources and thereby the water supply. Many of the point pollution sources are believed to be well known, while the scale of diffuse pollution is still little known. However, not only man-made pollution is causing problems for the water supply, but the natural composition of groundwater (poor quality) is causing problems in large parts of Lithuania.

Serious problems are facing us in drinking water supply in rural areas. Today, thousands of shallow dug wells supply drinking water for little less than 1 million of Lithuanian inhabitants. According to investigations of the Hygienic Centre and Geological Survey, 51% of examined dug wells in Lithuania do not meet the requirements for the bacteriological quality, while 48% of them are polluted by nitrogen compounds. Since 2003 the requirements for the quality of potable water are stricter. A number of compounds harmful to human health but not studied up to now, such as chlorinated organic compounds, pesticides, etc., should be controlled.

The results of groundwater investigations in observation wells of the national monitoring network and in wellfields arouse anxiety. In the shallow water of agricultural fields, orchards, in the environment of former and present storages of pesticides, various pesticides and products of their degradation are found. In wellfields, even in deep aquifers, traces of chlorinated organic compounds sometimes occur. This means that in this decade we shall encounter the difficult problems of the preservation of healthy potable water. Eventually people ought to understand that it

Parameters	Analyte	Allowable amount HN (98/83/EC)	Number of incompliance	Concentration from-to
Chemical	Nitrate, mg/l	50.0 (50.0)		
	Nitrite, mg/l	0.1 (0.5)	17	0.55–24
	Fluoride, mg/l	1.5 (1.5)	223	1.5–6.0
Indicator	Aluminium, mg/l	0.5 (0.2)	2	8.8–12.3
	Ammonia, mg/l	2.0 (0.5)	21	2.02–22.5
	Chloride, mg/l	350.0 (250.0)	5	360–494.4
	Iron, mg/l	1.0 (0.2)	374	to 4
	Manganese, mg/l	0.2 (0.05)	8	0.32–37.7
	Perm. index, mgO_2/l	6.5 (5.0)	15	6.56–17.2
	Sulphate, mg/l	450.0 (250.0)	5	450–700

Table 2. Chemical and indicator parameters exceeding requirements of Hygiene Norm in the aquifers.

is becoming more and more difficult to preserve non-polluted water when the environment is being polluted. Already, potable water is expensive, but in future it will be even more expensive and will require more attention.

The Geological Survey of Lithuania (LGT) at the Ministry of Environment of the Republic of Lithuania is a special state institution for investigation and regulation of the use of the subsurface. LGT was established in 11 March, 1991, and acts according to The Underground Law. One of its main functions determined by the statute is to organise and carry out investigations of the subsurface of the territory of Lithuania (onshore and offshore), providing necessary knowledge on structure, geological processes, and resources of subsurface, hazardous natural phenomena and those induced by human activity.

The main current duties of Geological Survey of Lithuania in the sphere of groundwater and soil protection are:

- Permanent groundwater monitoring in the State groundwater monitoring network (carried out systematically since 1946);
- Mapping and assessment of regional resources of groundwater;
- Hydrogeological mapping at a scale of 1:50 000, with particular attention to shallow groundwater
- Inventory of potential sources of pollution of underground;
- Groundwater vulnerability mapping, scale 1:50 000;
- Basic geomorphological and Quaternary geological mapping, scale 1:50 000;
- Soil geochemical mapping, scale 1:50 000;
- Maintenance of National Geological Information System (data bases: Boreholes, Hydro- and geochemistry, Pollution sources; Mineral resources etc);
- Provision of data for territorial planning and land use management, environmental, and public health protection authorities.

All information collected in the State Geological Information system as well as Geological Archive of LGT is accessible for all interested visitors.

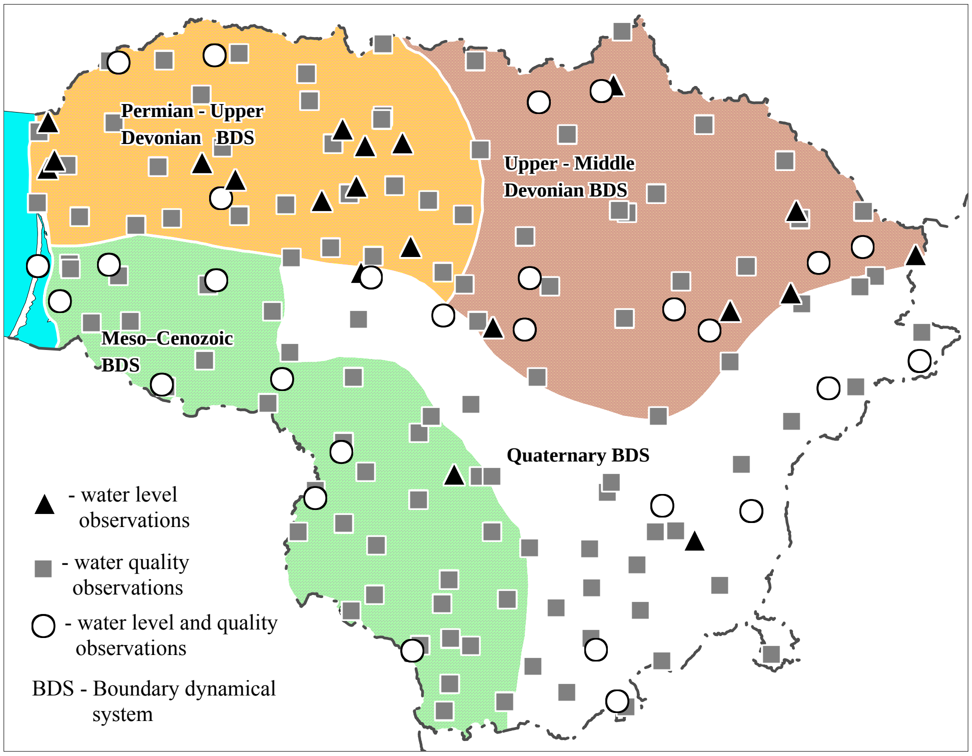

Figure 1. National Groundwater monitoring network and delineated groundwater bodies (BDS)

DRINKING WATER: SAFETY ISSUES IN LITHUANIA

Ilona Drulyte, Head of Drinking Water Division, National Nutrition Center of the Ministry of Health for Lithuania.

The World Health Organisation stated that 50 % of our health depends on nutrition, 20 % on environment, 20 % on genetic status, and 10 % on medical care. Drinking water is the main food product consumed, at 1.5-2 litres per day, and it is also part of the environment. Drinking water quality is very important for our health.

The main source of drinking water in Lithuania is groundwater. However, due to different environments and water supply technologies, a great variety of drinking water quality is observed.

The great majority of the population are consumers of publicly supplied artesian groundwater. However, the quality of drinking water is sometimes getting worse due to cases of insufficient treatment in water plants or old water pipes in the distribution system. As a result, quite a high level of iron has already been determined in about a half of tested samples. The manganese concentrations and turbidity of drinking water are pretty high.

Different fluoride levels in drinking water of different regions in Lithuania (Fig. 1) also raise public health problems. Artesian water of the North West and West part of the country has too high fluoride levels (from 1,5 to 5 mg/l). About 90,000 people are exposed to excessive fluoride concentrations in drinking water, a reason for the prevalence of higher dental fluorosis. Drinking water of the East and South East part of Lithuania has low fluoride levels and therefore, the incidence of dental caries among the population is almost 100 percent.

Over a million people (mainly the inhabitants of suburbs and rural areas) are not supplied by the public drinking water system and the main source of drinking water for them is the shallow groundwater from dug wells. This individually supplied water is often affected by chemical contamination of nitrates (Figure 2) (about 30 per cent of samples exceeded the maximum allowed level) as well as microbiological contamination (almost half of water samples from wells were identified as having increased microbial pollution).

The Lithuanian Parliament has adopted the Drinking Water Law, which will be in force from 1 July, 2003. The Drinking Water Law describes the responsibility for drinking water quality. In the case of public supplied water, it lies mainly on municipalities and drinking water suppliers; state control is under the responsibility of the State Food and Veterinary Service. Parameters for drinking water quality are assessed according to the regulations of the European

Editor’s Note. Reserves and Resources Terminology

The authors of the article, Groundwater: Resources and Quality in Lithuania use the terminology “Prognostic Reserves” and “Natural Reserves”. The authors did not define these terms

The Editor’s practice is in the evaluation of oil and gas reserves and resources in which “Reserves” and “Resources” are strictly defined. This is a major issue in the estimation of natural resources. The usage is probably:

Natural Reserves—those volumes that have been identified and can be produced with current technology.

“Prognostic Reserves” - Resources that may or not have been identified and that may or may not be produced with current technology.

Discussion (or correction) on natural resources terminology and evaluation would be welcome,

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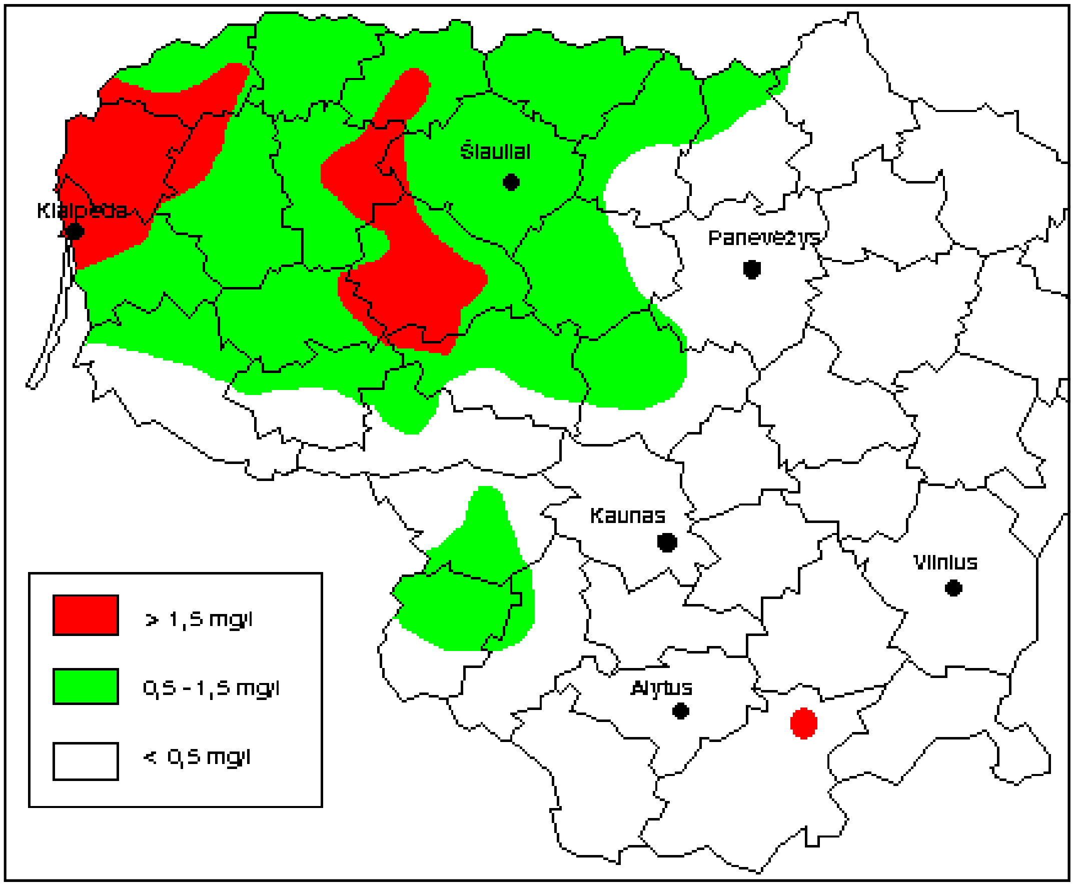

Figure 1. Fluorine in Public Supplied Drinking Water in Lithuania

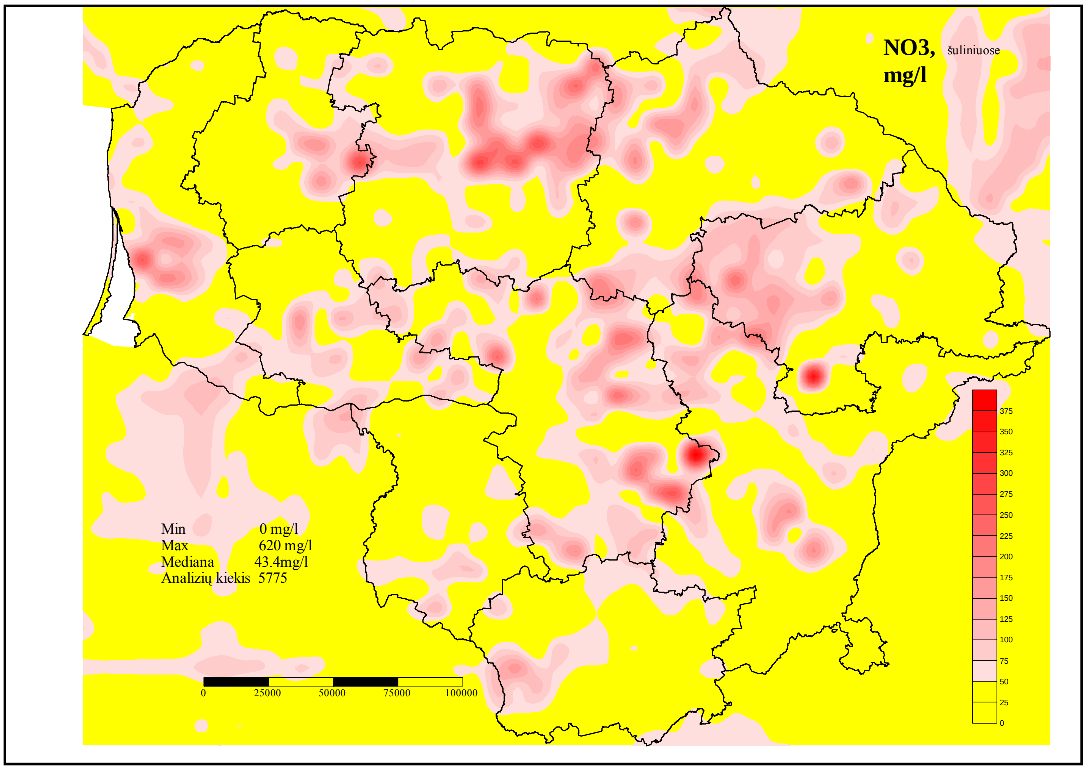

Figure 2. The concentration of nitrates in shallow dug wells

Book Review: GREEN CHEMISTRY IN AFRICA

Green Chemistry Series No. 5
Co-Editors: Pietro Tundo, Liliana Mammino
Published by INCA, Venice, Italy.
Publication date: July, 2002, ISBN: 88 88214 07, 214 pages
Available for download on the net free of charge
Reviewed by Theo C. Davies
Eldoret, Kenya

A primary objective of this book is to highlight the major roles of chemistry in the study of the problems that were lined up for discussion at the World Summit on Sustainable Development in Johannesburg, South Africa, 26 August - 04 September, 2002 and in the design of valuable solutions for those problems. The core text comprises six parts.

In Part 1, "General Aspects" the introductory paper 'Green Chemistry in the International Context' adequately sets the scene and describes how the project was conceived and carried out. The next paper entitled : 'The Moral Basis of Green Chemistry' is highly philosophical and starts by justifying the inclusion of this paper in the book and why Green Chemistry practitioners should take cognizance of the moral implications of their work. The final paper in this Section, a discourse on 'Science Partnerships for Effective Green Chemistry Programme: A Framework for Ngumzo' is at times philosophical, at times scientific, at times even religious. On the whole, these papers bring out the message quite well, though the language used at times appears dated.

Part 2 on "Catalysis" provides convincing evidence of the remarkable role of catalysts in the propagation of Green Chemistry and offers several examples on pollution prevention and waste minimization in industrial chemical processes. However, some repetitions in the text tend to hamper the flow of the narrative, e.g., the work of Ryoji Noyori and William Knowles is introduced several times in van Ree's paper. There is also some incomplete referencing, e.g., in Mdoe and Mubofu's paper, titles of articles are not indicated for references (6), (8), and (30); and volume numbers are not given for references (5) and (10). According to these authors' (Mdoe and Mubofu) definition of a catalyst, '… it should remain unchanged in chemical composition at the end of the reaction…'; but the piperidine catalyst in the Knoevenagal reaction has the disadvantage of non-recoverability, as it is consumed in the reaction (page 70). So, does this really fit the definition of a catalyst?

In Part 3 on 'Natural Products' the terms, 'flavonoids' and 'flavanoids', are used interchangeably throughout the text of the two constituent papers and is confusing to the reader. One senses an apparent contradiction, too, when, after Mdoe and Mubofu's assertion (in Part 2, page 73) of the appropriateness of palladium (and other transition metal catalysts) in Green Chemistry, Mashimbye and Mudau conclude in Part 4 that '… most metal catalysts used in synthetic organic chemistry are poisonous…' (page 105).

Part 4 deals with "Energy" in the Green Chemistry context. In a clear and intelligible discourse, Lwenje discusses the 'green' chemistry and technology involved in the production of biogas from organic waste and shows why replacing firewood and fossil fuels with biogas as energy sources is environmentally friendly. Sankaran gives a good summary of the role of solar energy in powering our lifestyle. A chief example used is the production of electricity through photovoltaic cells deriving energy from sunlight.

Part 5 looks at "Technologies". Using lots of relevant examples, Mubofu brings out the features of organic solvents that have hitherto favoured their use instead of water, in various technologies. Certainly these advantages must be there, otherwise they would have long been replaced wholesale by water. Ogola gives a good account of hazards and risks involved in

GREEN CHEMISTRY IN AFRICA Cont.

mining and mineral processing industry with indications of how associated negative impacts can be minimized or eliminated. But, apart from sections on ‘Acid Mine Drainage’ and ‘Mine Tailings’, little is given on the chemistry of mining processes and associated technology and how this chemistry can be ‘greened’. Miertus ends this Part with a useful account of the relevance of Green Chemistry programme to sustainable development. However, since the chapters are not numbered, his reference to Figure 1, Chapter 6 is not easily to locate.

In the final Part on “Education”, Mammino presents an account of why pre-university students should be made aware of chemical processes and technologies in industry and what measures should be taken to ‘green’ these operations for the sake of maintaining environmental integrity. The author advocates for the inclusion of Green Chemistry in school curricula and for adequate training of teachers as well as the provision of other resources (training manuals, laboratory equipment, other teaching materials) for teaching students the virtues of Green Chemistry.

The book reads at first a bit like a collection of disparate papers, but the editors’ attempt to integrate these and structure the book somewhat succeeded for the theme of Green Chemistry runs through the narrative. Some editorial linking text to knit the parts together would have been a welcome addition.

It is invidious to single out particular contributions; but those that most opened my eyes were the sections on “Catalysis” and “Natural Products”. These papers seem to have succeeded in illustrating how “the invention, design and application of chemical products and processes can be made in such a way as to reduce or to eliminate the use and generation of hazardous substances”. The editorial work could have been a bit more thorough; there are at least two spelling errors in the index page alone, e.g., ‘fremework’, ‘responsable’ and there are minor variations between some of the titles given in the index and those appearing in the text. One finds a number of incomplete referencing, with missing titles and/or volume numbers, etc.

Apart from these minor criticisms, “Green Chemistry in Africa” is professionally written, with a large number of relevant and interesting illustrations tied well to the text. This is a very useful compilation that should be on the shelves of every African University library and sold at a price affordable to all students and practitioners of environmental chemistry.

SHORT COURSES ON MEDICAL GEOLOGY

We continue with our short courses. In 2003 we have had 5 courses, all over the world. The new website contains extensive information on all courses including plans and circulars for all new courses:

Recent Short Courses

May	2003	Lithuania, Vilnius
September	2003	Great Britain, Edinburgh
October	2003	Brazil
December	2003	Australia
December	2003	Malaysia

Future Short Courses

April	2004	Hungary
June	2004	South Africa
August	2004	Italy (at IGC)
December	2004	India and Australia
February	2005	Tanzania

Also possibly Taiwan in 2004

THE BOOK “MEDICAL GEOLOGY”

We have at last reached the final stage of our book “Medical Geology”. The final manuscripts and it will be printed in spring 2004 by Academic Press and will be 800-900 pages, in full colour! The price will be kept under 100 USD! For more information see the website soon. Meanwhile, here are the contents:

Introduction (Olle Selinus)

0.1 Medical geology . **Olle Selinus**
0.2 Medical Geology: Perspective and Prospective, **Brian Davies**

Section 1 (Ulf Lindh)

1.1 Introductory chapter, **Ulf Lindh**
1.2 Natural background, **Robert Garrett**
1.3 Anthropogenic sources, **Ron Fuge**

BIOLOGY OF THE ELEMENTS

1.4 Uptake and rejection of elements from a chemical point-of-view, **Robert J.B. Williams**
1.5 Uptake and rejection of elements from a biological point of view ,**Ulf Lindh**
1.6 Biological functions of the elements ,**Ulf Lindh**

NUTRITION AND DIET

1.7 Geological impacts on nutrition, **Gerald Combs**

BIOLOGICAL RESPONSES

1.8 Deficiencies and toxicities of elements, **Monica Nordberg**, **Prof Cherian**

Section 2 (Ron Fuge)

Pathways and exposures

2.1 Introductory chapter, **Ron Fuge**
2.2 Volcanic emissions and health, **Philip Weinstein, Angus Cook**
2.3 Radon in air and water, **Don Appleton**

Water, **Pauline Smedley**

2.4 Arsenic in groundwater and the environment,**Pauline Smedley**, **D.G Kinniburgh**
2.5 Fluoride in natural waters – occurrence, controls and health aspects, **Mike Edmunds**, **Pauline Smedley**
2.6 Water hardness and health effects, **Eva Rubenowitz-Lundin, Kevin M. Hiscock**

Soil **(Brian Alloway)**

2.7 The bioavailability of trace and major elements in soil, **Brian Alloway**
2.8 The Natural Environment - Selenium Deficiency and Toxicity – Process Related Diseases, **Fiona For.dyce**
2.9 Iodine Geochemistry, Soils and Iodine Deficiency, **Ron Fuge**
2.10 Geophagy and the involuntary ingestion of soil, **Peter Abrahams**
2.11 Natural aerosolic mineral dusts and human health: potential effects ,**Ed Derbyshire**
2.12. An overview of the ecology of soil-borne human pathogens, **Mark Bultman, Frederick S. Fisher, Demosthenes Pappagianis**
2.13 Animals and medical geology, **Bernt Jones**

Section 3 (Jose Centeno)

3.1. Introductory chapter, **Jose Centeno**
3.2. Environmental epidemiology, **Jesper B. Nielsen, Tina Kold Jensen**
3.3 Environmental medicine, **Jefferson Fowles, Philip Weinstein, Chin-Hsiao Tseng**
3.4 Environmental pathology, **Jose Centeno**, **Florabel G. Mullick, Paul B. Tchounwou, Joseph Pestaner, Teri J. Franks, Michael N. Koss, Daniel P. Perl, Allen P. Burke, Kamal G. Ishak**
3.5 Toxicology, **Tee L. Guidotti**
3.6 Speciation of Trace Elements: Methods and Public Health, **Bernhard Michalke, Sergio Caroli**

Section 4 (Bob Finkelman)

Techniques and tools

4.0 Introduction, **Robert B. Finkelman**
4.1 Using Geographic Information Systems (GIS) Databases for Human Health Studies, **Joseph E. Bunnell, Alexander W. Karlsen, Timothy M. Shields, Robert B. Finkelman**
4.2 Use of Remote Sensing and Geographic Information Science Techniques in the Study of Vector Borne and Zoonotic Diseases, **Steve Guptill, Chester G. Moore**
4.3 Mineralogy of bioapatites: Bones, Teeth and Pathological Deposits, **H. Catherine W. Skinner**
4.4 Inorganic and organic geochemistry techniques **Mitko Vutchkov, Gerald Lalor, Stephen Macko**
4.5 Histochemical and microprobe analysis in medical geology, **Jose Centeno, Todor Todorov, Joseph P. Pestanov, Wayne B. Jonas**
4.6 Modeling Ground-Water flow and Quality **Leonard F. Konikow, Pierre D. Glynn**

SUMMARY

APPENDIX: REFERENCE VALUES Peter Bobrowsky)
International reference values, EPA values, WHO values etc