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Geographic Health's Way to Prevention of Diseases: A Case Study on Arsenic Spatial Dispersion and Dyspnea in Isfahan Province

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Original Article

ABSTRACT

Background: As geographic science discusses the analysis of environment, human beings and their mutual relations, thus the field of medical geography consists of being inspired from the relations between these two factors, analyzing environmental factors, their identification them and the state of their effects on human health, as well as determining the location of these factors. Some hazards that threat human health are the results of environmental factors and the relevant pollutions. Some important categories of diseases including (Shortness of Breath or, Dyspnea) have considerable differences in various places, as observed in their spatial prevalence and distribution maps.

Methods: The record of patients with Dyspnea diseases were prepared for this descriptive research, for the period of 2009-2011, from the provincial health center, with the questionnaires were excluded patients with a family history of disease and the spatial diagram for disease prevalence was drawn according to the prepared data. The arsenic geographical distribution diagram in Isfahan province was also prepared and then the relation between an element of Arsenic in the province and the Dyspnea diseases were analyzed.

Results: The analyses showed that the highest rate of Arsenic is entered the soil via fertilizers to come eventually into the food cycle of humans. By analyzing the amount of used fertilizers in Isfahan province and the dispersion diagram of Arsenic in Isfahan province, it was found that the highest frequency of Arsenic is in places having agricultural base. The spatial dispersion of Dyspnea diseases also showed that the spreading of Dyspnea diseases is greater in places with higher scale of Arsenic.

Conclusions: This study is a logical justification between the two diagrams to confirm the hypothesis regarding the effect of arsenic on Dyspnea.

Keywords: Arsenic, dyspnea, Isfahan province, medical geography, spatial dispersion

INTRODUCTION

A geographic region is indeed a complicated symbol of physical, biological and cultural processes. By analyze its elements and characteristics one can define the possible diseases that may occur by identifying a small place such as a house or a backyard, or through identifying the immigration route of birds and the viruses that are dispersed by them.[1] Increasing the world population and changing the world economy increase the risk of emergence of diseases, or the immunity against them. Geographical variations have been studied under the intermediate fields of geographical pathology, medical ecology, medical topography, geographical epidemiology, geomedicine, etc.[2] Geographical perspective and method in studying health and illnesses have been considered for 50 years. Ecological perspective of diseases or health maintained its scientific importance, even up to the mid-19th century that the microbic theory was developed.[3] 18th and 19th centuries physicians (Fennec-1792-1795, Fosesh-1853, Hiresh (1883-1886) used the term "medical geography" for the 1st time and had great efforts for describing and organizing data about human diseases, cultures and environments, continued the old method of Hippocrates, indeed.[4,5]

Characteristic skin lesions (keratosis, hyperpigmentation and hypopigmentation) are the hallmark of high exposure to arsenic, and nowadays, pose a public health problem in the world. These lesions may be used as an indicator of high exposure and are quite distinctive in contrast to other clinical manifestations of arsenic intoxication including weakness, conjunctiva congestion, edema, portal hypertension, and hepatomegaly.[6] These skin lesions generally develop 5-10 years after exposure commences, although shorter latencies are possible. Emerging evidence shows that the ingestion of inorganic arsenic may also lead to nonmalignant respiratory effects. Limited epidemiological studies in Chile (not mentioned in other countries, i.e., Japan and Taiwan) have previously suggested an association between arsenic and nonmalignant respiratory effects,[7] and more recently another study from West Bengal, India has suggested that long-term arsenic ingestion can cause pulmonary effects.[8] They used samples of water, and soil then interpolate this data and compute the correlation of Arsenic concentration and number of diseases.

In this paper, we present respiratory system findings from a landmark epidemiological study that was conducted in Iran, focusing on the relation between Arsenic spatial dispersion and Dyspnea diseases which were assessed in the survey.

METHODS

In this study, the first attempt was to gather resources and scientific and applied research in this field. We used information such as statistics of the Dyspnea diseases in Isfahan prepared over 3 years by Isfahan Province Health Center, Map of the distribution of Arsenic in Isfahan province generated from combination of the Mineral Exploration Organization maps and Remote Sensing technique. This map were prepared for the years that the statistics produced by Dyspnea diseases then by using the statistics for ten common Dyspnea diseases in Isfahan, and entering this information by geographic information system (GIS) in Isfahan information maps the spatial distribution of common Dyspnea diseases in the province was drawn and the created maps were adapted and compared with the map of the distribution of Arsenic in Isfahan province.

Remote sensing, using satellite image to extract data, provide an instrument to monitor the environment in general and particularly detect pollutions. In this research, we used Remote sensing data and techniques to detect arsenic distribution in soil and also in ground waters. Base on Kirchhoff law in physic each material has a unique reflectance in the electromagnetic spectrum ranging from gamma to radio. This unique feature is called spectral signature and using this we can detect and separate different material from each other.

Arsenic

Arsenic is an element in the environment that can be found naturally in rocks and soil, water, air, and in plants and animals. It can also be released into the environment from some agricultural and industrial sources. Arsenic has no taste or smell. Although sometimes found in its pure form as a steel grey metal, arsenic is usually part of chemical compounds. These compounds are divided into two groups:

- Inorganic compounds (combined with oxygen, iron, chlorine, and sulfur)
- Organic compounds (combined with carbon and other atoms).

Inorganic arsenic compounds are found in industry, in building products (in some "pressure-treated" woods), and in arsenic-contaminated water. This is the form of arsenic that tends to be more toxic and has been linked to cancer. Organic arsenic compounds are much less toxic than the inorganic arsenic compounds and are not thought to be linked to cancer. These compounds are found in some foods, such as fish and shellfish. Base on Thornton (1996) the main compounds of Arsenic are arsenates 60%, sulfides 20% and sulfosalts and the remaining 20% includes arsenic, oxides, and silicates. Figure 1 show spectral signature of some of the Arsenic compounds.

Satellite images for arsenic detection

There are different type of satellite images including hyperspectral, multispectral and radar each one has its pros and cons. Hyperspectral sensors collect data with varied features such 20-100 m special resolution and in 50-200 spectrums, compare this with human eye which collect data in just three spectrum to understandability of those sensors to detect and identify different materials. Multispectral sensors collect data in 3-10 spectrum and radar sensors use high wavelength, which can penetrate in surface. In this research, we used target detection algorithms to find Arsenic distribution in Isfahan. In the most cases, there is a mixture of materials in the area and the reflectance of each pixel is related to the proportion of material in that pixel. By knowing the spectral signature of a specific substance, target detection algorithms can detect proportion of that substance in each pixel. We implement the following target detection methods on Esfahan images: Constrained energy minimization, spectral angle mapper, adaptive coherence estimator, match filter, spectral similarity mapper and normalized euclidean distance then combined the result of those algorithms to achieve maximum accuracy. For this purpose, each method trained independently by using the map of Arsenic mines then each pixel considered as contaminated if 4 of 6 algorithms show highly amount of Arsenic and so on. Figure 2 shows the result of target detection algorithms and density of Arsenic in soil.

In the next step, we have to compute the amount of arsenic in underground waters. It is possible to create this map by using a dense sampling network and interpolating data.[9-12] Due to lockage of field data in this research we create the arsenic concentration in groundwater by using a model and calibrate it by available data. The researchers show that the Flow Length Index and the presence of organic-rich sediments and alluvial deposits are the variables most positively correlated with the Arsenic content, while the terrain altitude is highly negatively correlated.[13] Based on these researches we used linear regression to calibrate a model between Flow Length Index [Figure 3], terrain altitude and amount of Arsenic in soil, computed by target detection method, as independent variables and ground water contamination as dependent variable. Figure 4 shows the result of the model.

Chronic arsenic (As) poisoning has become a worldwide public health issue.[14] Most human as exposure occurs from the consumption of drinking water and respiration containing high

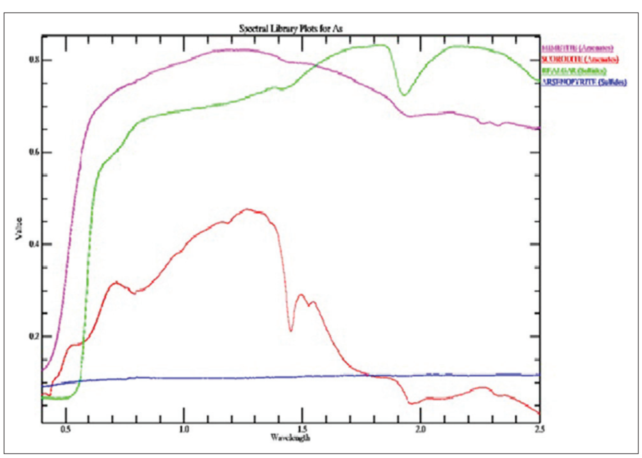

Figure 1: Difference between spectral signatures of arsenic compounds

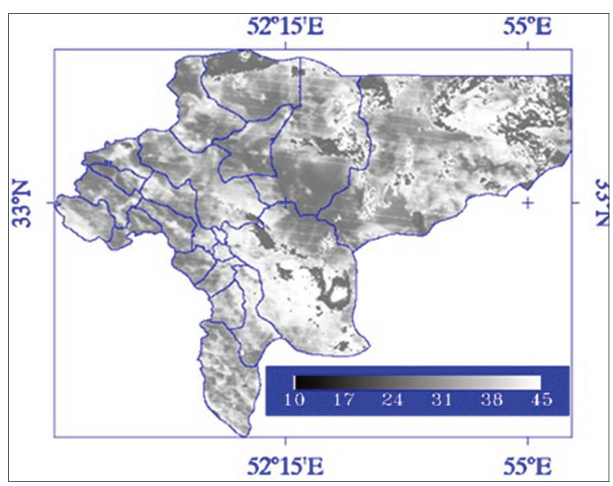

Figure 2: Density of arsenic in soil (g/kg)

amounts of inorganic As (iAs). Chronic effects of iAs exposure via drinking water and respiration include pulmonary lesions and Dyspnea disease, neurological effects, hypertension, peripheral vascular disease, cardiovascular disease, diabetes mellitus, and malignancies including skin cancer.[10,15]

RESULTS

The population includes 16,238 medical records to patients suffering from Dyspnea diseases in the Isfahan province. The period studied, according to the number of samples is sufficiently reliable, and over 3 years (from 2009 to early 2011) was considered.

Mapping the distribution of Dyspnea diseases is presented in Figure 5. This figure showed that the cities of Isfahan, Ardestan, Kashan, Naeein, and Natanz have been allocated the highest Dyspnea diseases. As shown in Figure 5, the rate of Dyspnea diseases, consistent with the distribution of Arsenic in the province, and we can say those two parameters are related with square function and Dyspnea diseases is reduced by leading away from areas containing Arsenic.

Health Criteria Values for inorganic arsenic are summarized in Table 1. The oral Index Dose (ID oral) in Table 1 is based on the UK drinking-water standard for arsenic. This dose is estimated to be associated with an excess lifetime respiratory disease risk of around 40-400 in 100,000. An ID oral derived on the basis of minimal risk in accordance with the principles described in the toxicological framework report would lie in the range of 0.0006-0.003 μg/kg bodyweight (bw)

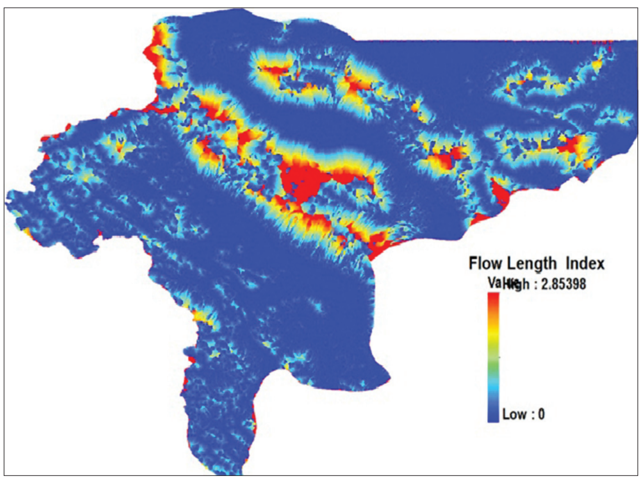

Figure 3: Flow length index computed from digital elevation model using arc geographic information system

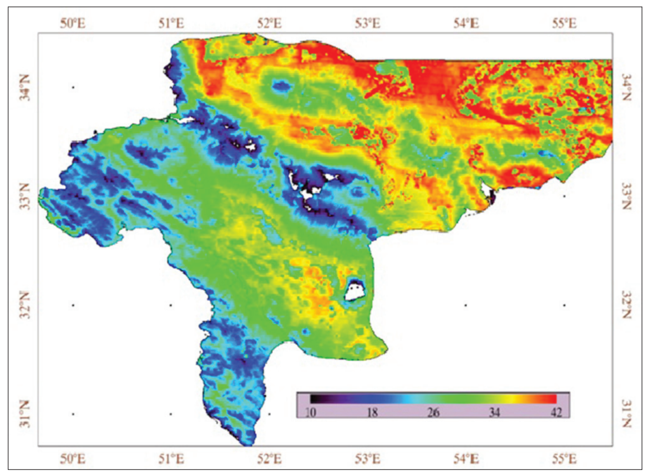

Figure 4: Ground water contamination with arsenic computed by model

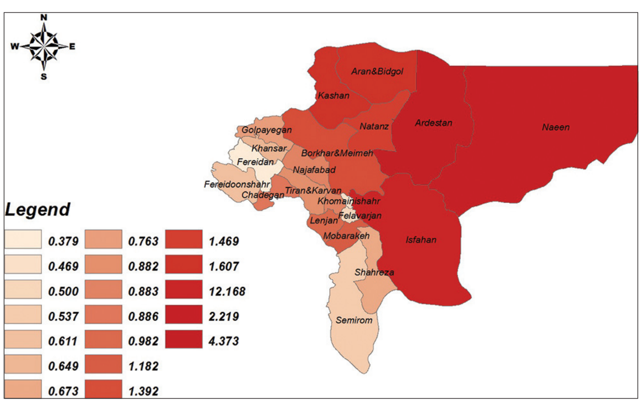

Figure 5: Spatial distribution of Dyspnea diseases in case study per 10,000

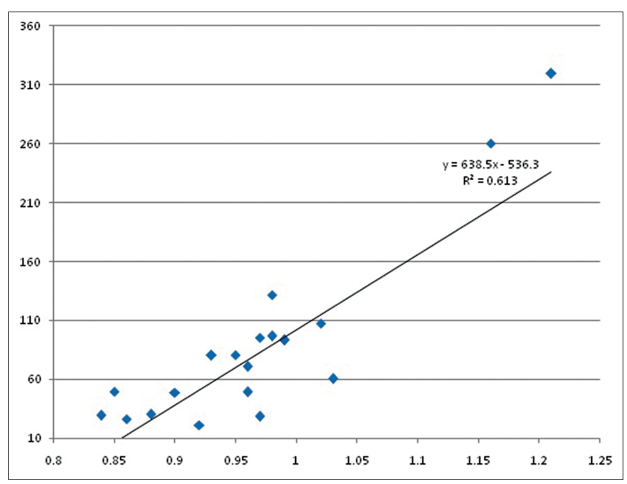

Figure 6: Correlation between arsenic concentration in soil (X-axis) and proportion of patients to population (Y-axis)

day-1. However, the UK drinking water standard for arsenic of 10 μg/L is equivalent to a higher intake of approximately 0.3 μg/kg bw day-1 [Table 2].[16]

As it can be realized from the above table, most of the fertilizers are in the regions that the rate of Arsenic dispersion is higher when compared to other areas. This could explain the reason for such frequency, to some extent [Table 3].

DISCUSSION

Spatial distribution Dyspnea diseases commonly found in Isfahan province and the most common diseases in Isfahan province showed that the distribution Dyspnea diseases have been consistent with the scatter of the arsenic in these points and these findings could represent a connection between the arsenic and the frequency of Dyspnea diseases [Figure 6]. These are caused by industrial pollutants, fertilizers and other agricultural items into the environment by humans. The distribution of arsenic in the areas where the population and human activities are higher, will be more evident and the main reason can be contaminated by industrial pollution from vehicles, used in producing gasoline, lead-acid batteries, electronic components, cable sheathing, ammunition, glass, ceramics, lead pipes, paints, alloys, connections and joints in roofs as a sealant for protection against rain, cited, inadvertently enter the environment. Barrett1 in 1980 depicting the spatial distribution and etiology of the disease began surveying the course of the disease explained. He said for the 1st time that representing a geographic area is a place, and a symbol of the complex physical, biological and cultural process. If someone finds out, it is able to analyze the elements and patterns, it is possible that the disease can be determined, and spatial distribution of the disease can also be traced. This fact is true everywhere, identification of a small place like home to the intercontinental migration of birds and the viruses that are released by them. The world population growing up and the world economy changing, increase disease risk or protection[18,19] Since the most basic principles of combat and noncommunicable diseases, including Dyspnea diseases, is the change in lifestyle, It seems for achieving this important result, providing cheap and reliable data, using remote sensing and GIS, for decision maker is necessary. In order to create an environment that promotes appropriate behavior and healthy lifestyles and in the community with proper intervention, many factors can influence the risk of reduced or destroyed.[14,20,21] Even the minor changes can bring big benefits to be had, (Butterfly Effect).[22-24] Prevention through community intervention against risk factors for Dyspnea diseases is possible by identification of harmful elements in the environment and by their distribution or the distribution of environmental contaminants or at least use them as well as other environmental variables. The best strategy is the prevention of exposure. Reduction of Arsenic in products industries, improvement of work environments and health education among the people is necessary. Similarly, for situations such as Isfahan collaboration between geographical

Table 1: Recommended health criteria values for inorganic arsenic[16]

Parameter	Arsenic
ID oral, μg/kg bw/day	0.3[2]
ID inh for deriving SGV, g/kg bw/day	0.002

bw=Bodyweight, ID=Index dose, SGV=Soil guideline value

Table 2: Cities of Isfahan province with the most consumed chemical fertilizers during 2009-2010[17]

Average of fertilizers (ton/year)	Ardestan	Naein	Natanz	Aran and Bidgol	Khomeinishahr	Isfahan	Kashan
Phosphates	1200	1900	500	450	370	4541	800
Nitrates prostates	470	750	460	150	300	2000	880
Sewerage sludge	65	15	654	154	742	15,422	1308

Table 3: Average amount of fertilizers (ton/year)[17]

Township	Ardestan	Naein	Natanz	Aran and Bidgol	Khomeinishahr	Isfahan	Kashan
Phosphate fertilizers	1200	1900	500	450	370	4541	800
Nitrate and phosphate fertilizers	470	750	460	150	300	2000	880

and medical sciences, health workers, legislators and the community is needed. Planning and using a system acceptable to the consumer should be made. Government and professionals must ensure to be punctual and have the scientific and practical problems in dealing with the difficulties. To solve the global problem, the soil resources should be evaluated and tested periodically. In the case of toxic poisoning of the soil to such elements, preventive measures should be considered such as using the filters, lime and other things to prevent the entry of sewage into rivers and freshwater resources and the soil, up to the desired stage that its value can be compared and accepted to the standards defined by the World Health Organization and prevent further spread of disease from Arsenic poisoning. Health warnings should be given to people at risk. Cultivation of plants that absorb toxic elements that are suspended in air or soil, effectively, for example, Borage or Ox tongue plant, one element of soil containing Arsenic, is refined and in these areas should not be used in food.[25,26] The use of air filters can be very effective in cleaning the air in the house.

CONCLUSIONS

The findings of this study underscore the importance of preventing the exposure to Arsenic, and to control Arsenic products industries, to improve work environmental health and to increase the health professionals and public knowledge in this regard. In this research, we used combination of remote sensing and field date to extract Arsenic concentration map and then used this map and water samples of wells to model Arsenic concentration in underground waters. In Esfahan province there are several structural project including two industrial town and a huge water canals and as we shown in our study there is a relation between the number of repository disease and arsenic contamination so at first we recommended authorities to consider arsenic concentration map in their decision making to prevent health problem and then restrict or increase population in polluted area.

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MH, R: Drafting the work or revising it critically for important intellectual content.

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