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SPATIAL ASSOCIATION OF ASTHMA AND VEGETATION IN KARACHI: A GIS PERSPECTIVE

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Abstract

A number of evidences confirm that the prevalence of asthma varies from place to place due to a variety of factors. This study focuses on the vegetation and health concerns, and assesses the utility of Geographic Information Systems, to investigate the spatial correspondence between asthma and vegetation in Karachi. Natural land-cover has both advantages and disadvantages with respect to health. Sometimes naturally growing or introduced plants can be noxious like some plants that release allergenic pollen or spores so that plant related allergy and asthma may occur. GIS is an effective computer mapping and analytical tool that permits huge quantities of information to be analyzed and explored, GIS and its associated spatial analytical techniques have been used extensively to study public health issues in recent years. The ultimate purpose of this study is not merely to present data, but also to seek association between the prevalence of asthma and plant cover (vegetation) in Landhi and Korangi towns of Karachi city, Pakistan. The populations under study were the residents of the Landhi and Korangi towns of Karachi metropolis. The study was designed to the assessment of asthma prevalence and its relation with the existing vegetation within the study area. A questionnaire was developed to evaluate desired data using a stratified random sampling design with union councils serving as strata for obtaining data with a sampling intensity of 0.1 %. The executed sample frame was based on 987 questionnaires from randomly selected households and collected information about asthma and related issues, later GIS was used for classification of Landcover of the study area with a satellite image and tabulated vegetation cover areas of different union councils, and finally the relationship of asthma and the vegetation cover was evaluated using Microsoft Excel.

The vegetation cover was found to have a significant positive correlation with asthma prevalence. Such a relationship can be attributed to several possible causes. The most important one is that some of the constituent plant species may have allergenic pollen. Previous studies have attributed asthma prevalence to urban life style, with its associated industrial emissions, occupational exposure and certain items of daily use that can cause allergy and consequently affect human health. However, this study provides a direct evidence of a connection existing between the vegetation cover with the prevalence of asthma.

Introduction

Asthma is a chronic disease that is characterized by recurrent attacks of breathlessness and wheezing, and its severity varies from person to person (Anon., 2010). The World Health Organization (WHO) estimates that 300 million people suffer from this chronic disorder and 255,000 deaths per year are associated with asthma (Anon., 2007). In particular, most asthma-related death cases are reported to occur in under-

developed countries with low income (Anon., 2010). The prevalence of asthma is increasing rapidly in Pakistan especially among children (Anon., 2006). It is affecting over six million people in Pakistan, including 10-15% children. Asthma is increasing at an alarming rate in all parts of Pakistan and producing great impacts on public health and the economy of the country. About 8-10% population of Pakistan's largest city Karachi, suffers from chronic asthma, and every 250th death in this city is asthma oriented (Anon., 2006).

Environment plays an important role almost in every aspect of life especially concerning health (Arsalan, 2002), while contaminated or deteriorated environment causes health hazards. There are increasing number of studies suggesting a possible association between allergenic pollen and the expression of asthma (Suphioglu *et al*., 1992; Taylor *et al*., 2002). Climatic conditions have a large influence on the environment and on vegetation, and it appears likely that climate change will affect growth and reproductive cycle of plants and the production of pollen (Amato *et al*., 2005; Beggs & Bambrick, 2005). In addition, other emissions due to nearby industry or vehicular exhausts could aggravate asthma and other respiratory disorders. However, reducing exposure to these substances may offer a realistic chance for primary prevention from asthma (Chrischilles *et al*., 2004).

Natural land-cover though considered useful from health standpoint can often be disadvantageous when there are some plants that produce allergenic pollens, an often quoted example is that of white mulberry trees that release allergenic pollen. Since Islamabad city has green belts mostly dominated by white mulberry it has a high number of asthma cases. Besides, other types of allergy and asthma are also frequent depending on land use which also affects human health. People living near industrial areas or main highways or any other place where human activity is high, could aggravate asthma (Ryan *et al.,* 2008). Harmful commercial activities in residential areas, congestion in streets and highways are some of the common examples and currently many researchers have explored the links among land-cover or land-use with health and such environmental studies also sometimes use GIS to analyze noxious location within these areas (Juliana, 2007; Brauer *et al*., 2003).

Medical research for investigating respiratory diseases is not new. In developed countries literature shows that more than 25% cases reported to physicians are related to respiratory problems including asthma. Changing technologies are bringing enhancement in the methods of research. Statistical and computer based developments are enabling to produce new and more relevant findings. These technologies enhance the methods of investigation and new findings in turn are increasing the quality of asthma research as well. Respiratory mechanism, the effects of drugs, host of other extrinsic factors and spatial variation all are contributing to more elaborative research (Dunn *et al*., 1995).

GIS and its spatial analytical techniques have been used extensively to study public health issues in recent years. GIS is an effective computer mapping and analysis technology that permits huge quantity of information to be analyzed and explored within a geographic framework (Kulldorff, 1999; Vine *et al*., 1997). GIS is not just computer hardware and software, it is an incorporated system of components, consisting of information about the real world that has been abstracted and simplified into a digital database of spatial and non-spatial features, that in combination with specialized software and computer hardware, and together with the expert judgment of the GIS user or analyst, produces solutions to spatial problems, matters and queries.

Utilization of GIS include disease mapping, epidemiological inquiries, health services analyses and planning, environmental health analyses, exposure modeling, risk assessments, disease diffusion and cluster analysis studies, health disparities research, and investigations of many other public health issues (Bullen *et al*., 1996; Kulldorff *et al*., 1997; Becker *et al*., 1998; Chakraborty & Armstrong, 1995; Bowman,2000; Schulz *et al*., 2002).

The ultimate purpose of this study is not merely to present data on asthmatic cases, but also to seek the association between the prevalence of asthma and plant environment (vegetation) in Landhi and Korangi towns of Karachi city, Pakistan. This linkage may become a set of information, which is useful for scientists, policy makers and planners to make informed decisions on managing and improving the environment and rectifying the spread of asthma in the city.

Material and Methods

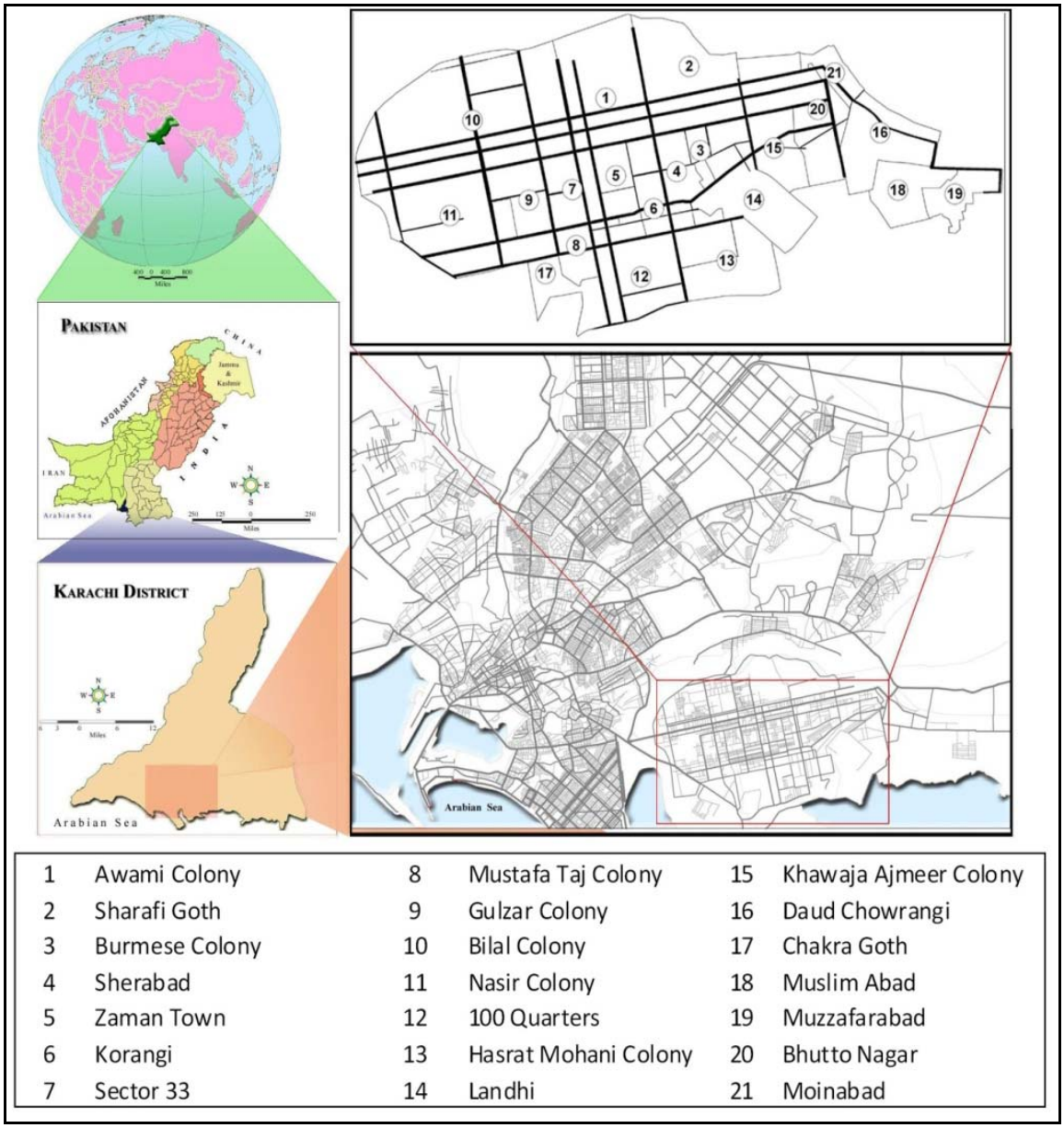
Study area: Karachi is the financial capital city of Pakistan, and it is experiencing rapid growth in recent years. It is adjacent to the Arabian Sea, and the Indus River flows in its west. The Karachi City has 18 administrative towns that cover an urbanized area of 1,300 km^2 over its total area of 3,600 km^2 (Qureshi, 2010). Approximately 16 million people live in the city, and 95% of population resides in urbanized areas (Arsalan *et al*., 2008; Anon., 2007). However, there are few studies that investigate the health status of Karachi residents, particularly focusing on asthma.

The area of study constitutes two towns of Karachi City District i.e., Landhi and Korangi Towns**.** These two towns reflect the overall environment of Karachi, such as its industrial area, commercial markets, planned and unplanned residential localities, climatic conditions, physiographic undulations, proximity to Arabian Sea, and the seasonal, waste water carrying Malir River. According to the City District Government Karachi (Anon., 2007), approximately 1.9 million people live in these two towns and 99% of the population resides in the urbanized areas of the towns (Arsalan, 2002). Fig. 1 illustrates the location of Landhi and Korangi Towns. Study area is administratively sub-divided into union councils (UCs) viz., 12 in Landhi and 9 in Korangi towns. These UCs were taken as basic geographic unit for managing survey and analysis.

Study design

a. Spatial asthma indices through questionnaire: Spatial asthma prevalence was evaluated through a questionnaire. The questionnaire used in this study is a modified version of International Union against Tuberculosis and Lung Disease (IUATLD's) used in 1984 later validated by researchers (Burney *et al*., 1989). Stratified random sampling design was adopted with a sampling intensity of 0.1% (N = 987) of total households. All of the 987 respondents were asked to complete an observational, cross-sectional questionnaire regarding asthma symptoms, medication, as well as behaviors toward asthma. Finally UCs wise asthma prevalence rate was evaluated.

b. Base mapping: Satellite images are the useful source to define the real position of a particular area especially in terms of land-cover and land-use. In this study, we used a Landsat ETM+ satellite image of March 2003 to develop the maps for the study area in GIS format. Published town boundary maps were used and Geo-referenced, leading to the development of a base map.



1	Awami Colony	8	Mustafa Taj Colony	15	Khawaja Ajmeer Colony
2	Sharafi Goth	9	Gulzar Colony	16	Daud Chowrangi
3	Burmese Colony	10	Bilal Colony	17	Chakra Goth
4	Sherabad	11	Nasir Colony	18	Muslim Abad
5	Zaman Town	12	100 Quarters	19	Muzzafarabad
6	Korangi	13	Hasrat Mohani Colony	20	Bhutto Nagar
7	Sector 33	14	Landhi	21	Moinabad

Fig. 1. Study Area (1 to 21 are Identifications for Union Councils)

c. Image classification for land cover: Remotely sensed data of the earth surface may be analyzed to extract useful thematic information. This raw data is then transformed into information. Multi-spectral classification is one of the most practicing methods for information extraction. This information is the best source of available, updated and synoptic land-cover information that can be conveniently derived. The scale of details and accuracy depend upon the image resolution, accuracy of algorithms along with their limits and expertise of the users. The land-use pattern is usually employed to analyze distinctiveness and environmental quality. The process also verifies different activities that utilize land in the urban or rural areas. Land-use patterns could be identified through satellite images by supervised or unsupervised classification, keeping ground realities of the study areas in consideration. Landsat ETM+ of March 2003 image was used for land-cover classification, later the areas are tabulated union council-wise. This image was classified through supervised classification method in ERDAS imaging software. Classes were appropriately identified and training sites were prepared. After classification through the algorithm of parallel piped with maximum likelihood as tie breaker, accuracy was determined with 95% confidence level.

d. Statistical analysis: Since, the analytical process of this research is focused on association of asthma and land-cover including vegetation covering the area. However, firstly, creation of themes of collected and linked data was undertaken and later all outcomes were examined. The correlation coefficient was generated by using Pearson's Correlation Coefficient (r).

The Pearson's product moment correlation r is computed as:

$$r = \frac{\text{cov}(x,y)}{\sqrt{s_x s_y}} = \frac{s}{t}$$

Results and Discussion

The results clearly show that the occurrence of asthma varies from one union council (UC) to another, possibly due to a number of factors (Table 1). Many comprehensive surveys encompassing public, patient and professional's knowledge and behavior towards respiratory diseases including asthma have been conducted in recent years, exposing issues such as their prevalence, frequency, severity of symptoms, emergency care, its triggers, quality of life, and quality of care concerns (Kevin *et al*., 2009; Edward *et al*., 1994; Wenzel *et al*., 2009; Bousquet *et al*., 2008). Asthma prevalence in study area varied considerably while the highest values were found in for two union councils vi., Awami Colony and Sharafi Goth and not surprisingly these two union councils have greater vegetation area as well (Table 1).

Asthma triggers are factors that start asthma symptoms or an asthma attack by irritating the airways or worsening the inflammation in the airways. These triggers can provoke attacks in individuals who already have a tendency to asthma, but they are not necessarily part of the causing that tendency. Pollens produced by plants and the spores produced by such organisms as fungi can cause asthma symptoms or trigger an asthma attack. It is well-known that orientation and type of geographical phenomena could affect human health either helpfully or negatively. History suggests that all ancient human settlements and big cities were found where geographical conditions of the area favoured human activities and good environment for his health. Life style and land-cover are allied in terms of creating environmental conditions, human activities and geographical conditions that are associated with each other.

We analyzed correlation, among UC-wise asthma indices with UC-wise land cover categories. Fig. 2 shows the land-use patterns of the study area. We found that vegetation cover area was significant positively correlated ($p<0.05$) with the prevalence of asthma (Fig. 3; Table 2). There may be several possible reasons for this relationship. It seems that among the constituent species of the vegetation there are some species that produce allergenic pollen grains while small crop-fields in some union councils might be sprayed with pesticides that may be toxic with allergic potential, or the soils may be contaminated with toxic heavy metals like lead and cadmium with harmful dust. Recently, it has been shown that pollen themselves rupture after rains, releasing a large number of starch granules in the atmosphere that are capable of causing asthma (Suphioglu, 1992). Similarly, Taylor *et al*., (2002) demonstrated that fragmented pollen cytoplasm particles (0.12 to 4.67μm) loaded with group 1 allergens form respirable aerosols after moist weather and they are responsible for causing asthma, particularly for rye-grass.

Table 1: Spatial Distribution of Asthma and Land Covers

UCs name	Area (Km^2)	Asthma prevalence (%)	Land Cover Distribution (Km^2)			
			Vegetative	Built-up	Vacant land	Water
100 Quarters	31.9	0.8	7.6	18.8	5.4	0.2
Awami Colony	70.7	5.1	23.5	33.5	11.9	1.8
Bhutto Nagar	41.8	0.9	16.1	20.2	4.5	1
Bilal Colony	117.9	0.6	31.8	56.1	26.4	3.6
Burmese Colony	5.8	0.9	1.1	4.3	0.4	0
Chakra Goth	31.8	0.9	7	19.3	5	0.5
Daud Chowrangi	30.2	1.3	7.4	16.6	5.4	0.9
Gulzar Colony	17.3	1.1	3	12.5	1.8	0.1
Hasrat Mohani	36.3	0.9	8.8	20.3	6.9	0.2
Khawaja Ajmeer	18.2	0.2	6	10.2	1.7	0.3
Korangi	13.2	0.6	2.8	7.9	2.3	0.2
Landhi	29.2	0.5	9.7	14.8	4.4	0.3
Moinabad	8.7	2.1	2.8	5.3	0.5	0.1
Muslim Abad	18.9	1.6	3.6	12	3.1	0.2
Mustafa Taj Col.	16.6	0.9	3.1	11.8	1.3	0.3
Muzzafarabad	12.7	1.4	1.7	9	1.9	0.1
Nasir Colony	43.4	0.4	5.8	24.2	12.6	0.9
Sector 33	20.7	0.6	4	14.1	2.4	0.2
Sharafi Goth	38.6	2.5	22.6	12.2	3.3	0.5
Sherabad	14	1	2.8	9.2	1.8	0.2
Zaman Town	20	0.3	4.4	12.6	2.8	0.3

Table 2: Pearson's Correlation Coefficient (r) Matrix for Asthma and Landcover

	Asthma prevalence	Vegetative area	Built-up area	Vacant area	Water area	UC area
Asthma prevalence	1					
Vegetative area	0.43	1.00				
Residential area	0.16	0.82	1.00			
Vacant area	0.10	0.77	0.97	1.00		
Water area	0.21	0.84	0.95	0.93	1.00	
UC area	0.24	0.91	0.98	0.96	0.96	1

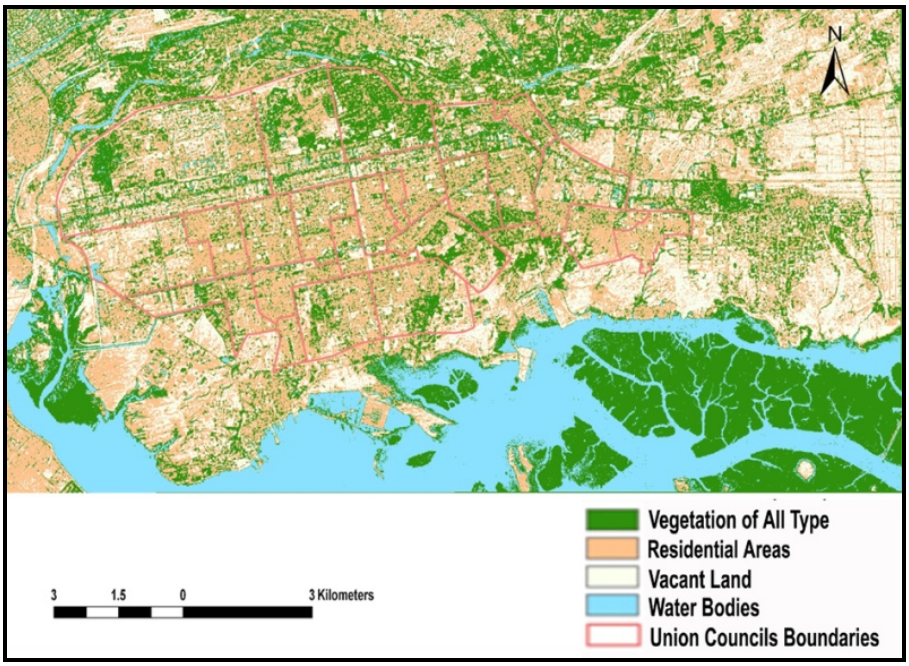


Fig. 2. Land-cover within the study area.

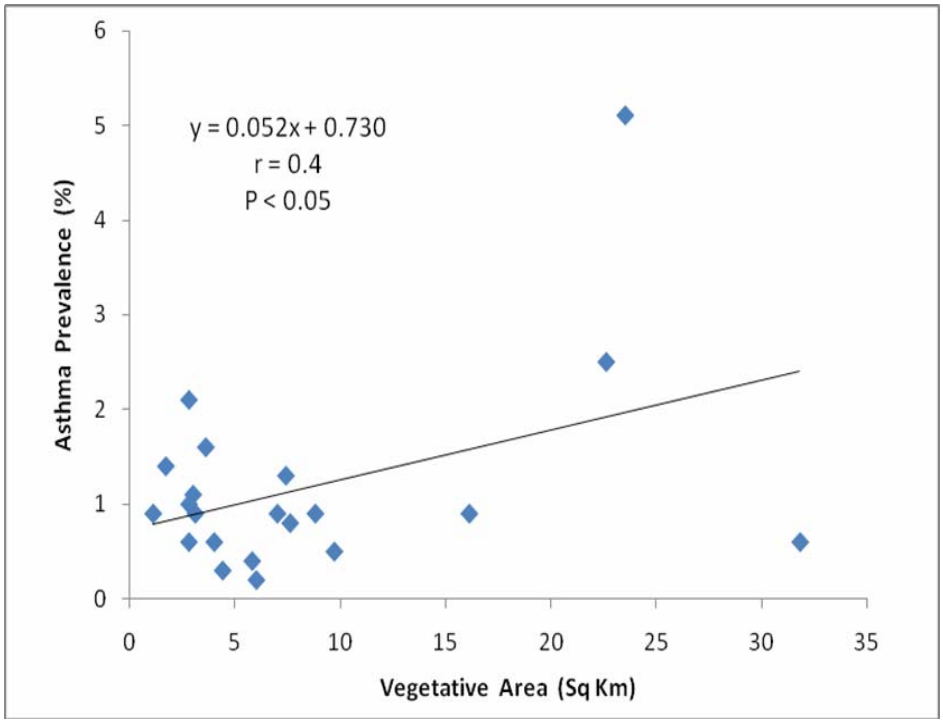


Fig. 3. The relationship between asthma and the vegetation for all UCs.

Conclusion

In this study we analyzed some of land cover categories, viz., open or vacant land, built up land (residential), water area and vegetative land (natural and crop land). Previously asthma studies say that urban life style, in which industries emission, occupation and daily use goods could affect on health, while in this study we try to put in the connection of vegetation covering area with asthma indices. We analyzed correlation, among UC wise asthma indices with UC wise land cover categories and found the vegetation cover area is having significant positive relation with asthma prevalence.

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