GEOSPATIAL MAPPING OF ASTHMA AND ITS ECOLOGY IN KARACHI, PAKISTAN

Mohammed Raza Mehdi\textsuperscript{a}, Professor
Mudassar Hassan Arsalan\textsuperscript{b}, Assistant Professor
Imran Ahmed Khan\textsuperscript{b}, Lecturer
Jamil Hasan Kazmi\textsuperscript{b}, Professor
\textsuperscript{a} NED University of Engineering & Technology
Karachi, Pakistan (Post-doc Geosciences, University of West Georgia, USA)
\textsuperscript{b} Department of Geography, University of Karachi, Karachi 75270, Pakistan
razamehdi@yahoo.com
mharsalan@yahoo.com
imranak32@hotmail.com
jkazmi@usa.net

ABSTRACT

Asthma prevalence is intensifying among all age groups throughout the world. Karachi, the biggest city of Pakistan, is facing the same phenomenon of asthma emergence due to serious environmental deterioration, in quality and aesthetics. In this research, we have utilized Geospatial mapping applications to unfold the epidemiological dimensions of this health disorder and its risk assessment within the urban areas of this megacity. The findings are quite alarming as almost 40% of population of the study area lives surrounded by high asthma risk.

KEYWORDS: Asthma, Karachi, Geospatial, Risk, Epidemiology.

INTRODUCTION

Asthma is a chronic inflammatory disorder that is characterized by persistent attacks of respiratory symptoms including coughing, chest-tightness, breathlessness, and wheezing. Another component of the disease is that the airways become hyper responsive to a variety of stimuli from surroundings environment. Over time, asthma symptoms changes depending on certain environmental factors, the asthma patient’s activities, and management practices.

It is a serious global health problem as people of all age group, colors, geographic locations, and socioeconomic status groups all over the world are affected by this chronic disorder that can be ruthless and sometimes fatal. It occurs in all countries regardless of level of development. However, over 80% of asthma deaths transpire in very low and lower-middle income countries (WHO, 2006a). The estimated numbers of asthmatics have been doubled throughout the world in last two decades (WHO, 2010). Mostly poor have been at greater risk and especially industrial workers have ever been more prone to this disorder than others (Ingrid and Lehnen, 2001).

There are many established reasons that cause and exacerbate asthma including the indoor and outdoor environment (NIH NHLIB, 1997; Clark et al., 1999; Beggs and Bambrick, 2005). It has both genetic background and environmental factors that play roles in its expansion. Scientific studies have verified strong link in connecting environmental factors and there are many triggers that provoke or precipitate an inflammatory response and airflow obstruction that is an asthmatic attack. Environmental factors such as air pollution, pollen, mold, dust, pets, cigarette smoke, and certain respiratory illnesses are common triggers of asthma attacks (John et al., 2009). However, the answers to ‘where’, ‘why’ or ‘how’ people get asthma is still to be explained and requires resources for investigations and there is still a great deal and more to be learned about what causes and exacerbates this disease on location basis. This is particularly called for in the developing countries.

As a city of a developing nation, Karachi’s landscape is littered with garbage and its open air burning, dust and air pollution on roads, uncontrolled industrial pollution in form of gases, liquids and solids, sewage on streets and in open drains etc. that serve as an ideal condition for different diseases especially asthma. This study explores the role of ecological indicators in spread of asthma due to environmental degradation process in Karachi.
Study Area

This research is executed in two administrative towns of Karachi City, including Landhi and Korangi Towns (Figure 1-1). In the towns, two largest industries are located: Korangi Industrial Trading Estate (KITE) and Landhi Industrial Trading Estate (LITE). Generally both towns were planned schemes of Karachi Development Authority, however by the time some squatter settlements have also been developed nearby these planned schemes as a result some environmental tainted factors are introduced that cause asthma and other respiratory diseases (Arsalan et al., 2008).

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, waste water drained Malir River, Cultivation, poultry and dairy farming; and fishing villages in neighborhoods. According to the City District Government Karachi (CDGK, 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). Figure 1-1 illustrates the location of Landhi and Korangi towns. Study area is administratively sub divided into union councils (UCs), (12 in Landhi and 9 in Korangi towns). These UCs were taken as basic geographic unit for managing survey and analysis. Figure 1-2 shows the land use patterns of the study area. Almost 20% area is covered by Industrial land use (see central ribbon of the Figure).

Figure 1. Distribution of land use in study area.

MATERIAL AND METHODS

In combination with Quickbird 1, 2007 satellite image, the CDGK planning maps were also utilized to develop more detailed base map. The map consists of the major infrastructure of the project area such as roads, localities, water bodies and administrative boundaries. The map was developed through the following workflow as shown in the figure 4-2. GPS was extensively used to collect ground control points, identify survey location for air, soil, and water sample sites.

Each union council bounded by roads. Most of the main roads (Arterials and collectors) extended to several UCs and across the towns. Road is the major source of pollution in form of noxious gases and dust, which are the main triggers of asthma. Overall roadways in study area usually go through the maintenance process in every 5-10 years. During maintenance it creates dusty and unclean atmosphere which remain continued for several months. As a result many respiratory diseases are emerged during these periods.
Remotely sensed data of the earth surface is analyzed to extort helpful thematic information. Multi-spectral classification is one of the most practicing methods for information extraction. 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.

Landsat ETM+ of March 2003 and QuickBird 2007 image was used for land-cover classification, later the areas were tabulated union council-wise. These images were classified through supervised classification method in ERDAS software. Classes were appropriately identified and training sites were prepared. After classification through the algorithm of parallelepiped with maximum likelihood as tie breaker, accuracy was determined with 95% confidence level.

The published Korangi, Landhi township maps were scanned and geo-referenced through ArcGIS software. Blocks of parcels were digitized and land use of each block was determined through planning maps. For updating land use a survey was conducted and recent land use (of year 2008) was collected. The predominant land uses found on ground are residential, commercial, transportation, industrial, health facilities, educational, open spaces and parks.

In the study area, the municipal services, such as water supply and sanitation, drainage of water, treatment and disposal of wastewater, management of solid and hazardous water, supply of adequate and safe food and housing are poor. All these could lead to an increase in the risk of respiratory diseases. In the study three main sources of pollution were analyzed that is air, soil and water. Water and soil were analyzed to trace the toxic elements such as Lead (Pb), Cadmium (Cd), Arsenic (As) and Mercury (Hg). Soil and water data was collected from twelve (12) sample locations, which is distributed as four (4) samples from residential, four (4) samples from industrial neighborhood and four (4) samples from commercial areas. In air criteria pollutant (CO, SO2, NO, NO2, NOx and TSP) were obtained from 10 sample locations. Sample locations were selected at major road intersections and industrial neighborhoods. TSP (dust) was further investigated for trace element in air that is Lead (Pb) and cadmium (Cd).

Demographic data of the study area was collected from the government source http://www.karachicity.gov.pk

Some updated demographic summaries were also collected from town bureaus and UC offices. However the split of demography and socio-economic information of the study area is not available from any published source. To overcome the data scarcity issue a questionnaire based survey has been designed and executed.

For the GIS modeling of asthma ecology, only the proved causes of asthma (asthma etiology) have been selected. These asthma triggers are classified into physical and social environment. Physical environmental related factors further alienated into outdoor and indoor environment. In, outdoor environment air, soil and water pollution, biodiversity and land use/land cover aspects are included, whereas in indoor environment, neighboring surroundings of living place its conditions, in house circumstances i.e. kitchen fume, ventilation, moisture, insects, rodents and plants are considered as already proved asthma causing variables which are obtained by a questionnaire. Another indoor parameter in same regard is working conditions (e.g. specific pollutant that could be harmful suddenly or gradually, or congestion that reduces ventilation and unhealthy conditions that aggravate asthma symptoms).

Indoor and neighborhood environment is evaluated through a questionnaire. This General public questionnaire contains nine major parameters that are linked with asthma and other respiratory diseases as many studies suggested. In this study several factors have been jointly examined, they are: demographical factors, domestic water sources, economic factors, house size, indoor environment, and Land cover at union council stratum, level of education and perceived triggers of asthma by number of asthmatics. Each parameter is further divided into batch of variables, totally eighty two (82) variables have been included in this analysis. These variables are further discussed and evaluated into physical and social grouping. This questionnaire based assessment is additionally characterized with social aspect. Concerning social environment as asthma triggers that are attested by various research studies are household size, its socio-economic class, the time spending in an activity or its profession, quality of food, standard of living, sports activities and addiction to certain drugs, smoking or any type of tobacco.

Later for analysis and modeling, multi-criteria analysis is employed. Nine focused parameters were selected with 82 variables viz., Demographic Factors, Domestic Water Source, Economic Factors, House Size, Indoor Environment, UC Level Land Covers, Level of Education, Occupations and Habits, Perceived Triggers of Asthma by No of Asthmatics.

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**Table 1. Summary of Parameters and Variables**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Indoor</th>
<th>Outdoor</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical</strong></td>
<td>32</td>
<td>13</td>
<td>45</td>
</tr>
<tr>
<td>House Covered Area</td>
<td>5</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Indoor Environment</td>
<td>17</td>
<td>-</td>
<td>17</td>
</tr>
<tr>
<td>Land Cover</td>
<td>5</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Perceived Triggers of Asthma by No of Asthmatics</td>
<td>10</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td><strong>Social</strong></td>
<td>8</td>
<td>29</td>
<td>37</td>
</tr>
<tr>
<td>Demographic Factors</td>
<td>-</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Domestic Water Source</td>
<td>-</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Economic Factors</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Indoor Environment</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Level of Education</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Occupations and Habits</td>
<td>4</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>40</td>
<td>42</td>
<td>82</td>
</tr>
</tbody>
</table>

**RESULTS AND DISCUSSION**

Spatial distribution of the outdoor and indoor variables was converted into useful mapping format and finally evaluated the human population at risk (table 2) through Multi Criteria Evaluation (MCE) technique. Taking into account, the significance of correlation among variables with asthma indices, a final risk map has been prepared.

**Table 2. Population proportion at risk**

<table>
<thead>
<tr>
<th>Risk</th>
<th>Population</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Risk Area</td>
<td>470,000</td>
<td>40</td>
</tr>
<tr>
<td>Medium Risk Area</td>
<td>218,000</td>
<td>18</td>
</tr>
<tr>
<td>Low Risk Area</td>
<td>527,000</td>
<td>42</td>
</tr>
</tbody>
</table>
Previous clinically and policy review studies for Karachi (Hyder et al., 2006) had suggested that unhealthy environment causes respiratory diseases, especially due to environmental pollution. Approximately more than a million vehicles on the roads of Karachi are found that emits pollutants. Along with exhaust discharge in form of smoke, nitrous oxide, carbon monoxide etc, considerable amount of heavy metals are pumped into the air that caused asthma and several respiratory diseases. The high level of pollution in old city area has resulted in an increase in patients with respiratory infections coming to the hospital. The air, soil and water pollution levels in Karachi have exceeded the environment quality standards and pose severe threat to the lives of 12 million people of the metropolis (SUPARCO, 2006 and 2009). The missing perspective in all previous studies for Karachi is spatial reference and connection with a number of factors. Studies such as this, with spatial perspective may provide clear etiological relations that are difficult to be known otherwise.

CONCLUSIONS

We found strong positive correlation among asthma prevalence with vegetation covered area, toxic elements, poisonous gases, several socio-economic variables and house hold density. This urban mapping study revealed that the asthma prevalence is occurring in densely inhabited area especially near commercial streets and busy roads of Landhi and Korangi towns of Karachi city.

The results of the study are very alarming as almost 40% population lives in high asthma risk environment, whereas overall awareness of asthma is found very low. A multifaceted approach is urgently needed using policy development and increasing community’s awareness through health and environmental education. This approach could propose a viable solution achievable in short term and later merged into a more strategic national approach for long term sustainability.
ACKNOWLEDGEMENTS

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REFERENCES


