A community survey method with GIS for improving ambient air pollution risk monitoring service

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Air pollution and its adverse effects on public health have led to legislations for air quality management. While proper policies can be set only when the pollution change trends are correctly monitored and adequately understood. Shenzhen, the study area we investigate, has been setting up an optimized air monitoring network to record the air pollutant level since 1992. Those station records, after scientific analysis, generally better our understanding of the environmental changing trends and are often cited when researches on environmental protection, public health, and policy analysis are carried out home and abroad. However, those data work better at the macro-level (e.g. district level) rather than the grass-root level (e.g. community level), for both the indicator limitation and geographic distribution limitation. There have been studies on improving the monitoring service with mobile platforms and remote sensing. We solve the problem the other way around. After tests in communities of the West Coast US and the inland China, a community survey method was taken in Shenzhen early 2006 with GIS application. We conducted a questionnaire survey on the residents living in a certain distance within the air monitoring station. By spatial interpolation, we could compare the 'official' pollution data with what the residents actually feel. Then we can figure out the relationship between residents feel and pollution data from monitoring station, which turned out to be an inexpensive way to effectively complement the monitoring station records at the community level. It determines the air risk type of each individual community investigated, including those far off communities that the conventional monitoring service has difficulty to cover, and hence provide more precise and up-to-date ambient air risk information for the air policy makers.

Key words: air monitoring, community survey, GIS, Shenzhen

1. Introduction

Air pollution has significant effects on public health. It is believed to be responsible for many respiratory and cardiovascular diseases (Fanou, L. A. et al, 2006; Langkulsen, U. et al, 2006; Coils, J. J. et al, 1997). So it is necessary to implement legislations to protect public health from adverse effects of pollution (Vandenberg, J. J., 2005). However, proper policies can be set only when the pollution change trends are correctly monitored and adequately understood.

In Shenzhen, The station records are detailed and the environmental reports are precise, however, they work better at the macro-level (e.g. district level) rather than the grass-root level (e.g. community level). First, limited types of pollutant are included in the environmental report; second, air quality data collected by environmental stations represent only a small area around it. Plus, to evaluate the ambient air risk, more than the air pollutant data should be taken into consideration. Our hypothesis is that community survey can be an inexpensive way to effectively complement the monitoring station records at the community level.

After two pioneer projects in communities of the West Coast US (Greenwood Community, 2004) and the inland China (Hechuan Community, 2005), the research group tried out the new survey method with GIS application in Shenzhen early 2006 (from May 1st to May 7th) and got the monitoring station records later on, mainly for correlation analysis.

2. Study area

Shenzhen is located between 113.46 and 114.37 east longitude, and between 22.27and 22.52 north latitude. Demarcated from Hong Kong in the south by Shenzhen River, Shenzhen thus has a good economic location (Fig. 1). Since 1980, Shenzhen has a rapid growth speed in urbanization, accompanying with some environmental problems.

Fig.1. Location of Shenzhen Special Economic Zone (SZSEZ) and the sampling sites. The red circles are 7-km buffer zones of environmental monitoring stations. The Shenzhen Environmental Protection Monitoring Center (SZEPMC) initiated in 1992 produces pollution level and environmental change trends year-report based on the monitor station (big dots in the figure) records. (SZEMC, 2000)

3. Methods

3.1. Attaining Environmental monitoring station records

The monitor station records of air pollutant level are available on the Shenzhen Environmental Quality Year Report since the year 1996. Before that year, monitoring station data can be attained directly from the Environmental Protection Bureau of Shenzhen Municipality. From 1989 to 2003, the integrated index comprised of TSP, SO2, and NOx did not show significant overall change trend of the ambient air quality (Liu, X. et al, 2006). We also check this as listed in Tab1.

Table 1

Air quality yearly changing value according to monitoring station data 2005 and 2006

ID	E	N	Station Name	Integrated Index of May, 2005	Integrated Index of May 1-7, 2006	Changing value
1	114.1167	22.5417	Nanhu	0.898	0.877	-0.021
2	114.1167	22.5625	Honghu	1.372	1.223	-0.149
3	114.0958	22.5500	Liyuan	1.042	1.116	0.074
4	113.9219	22.5111	Nanyou	1.068	0.859	-0.209
5	113.9164	22.5344	Lixiang	1.152	1.429	0.277
6	113.9819	22.5400	Huaqiaocheng	0.975	1.589	0.614
7	114.2614	22.5908	Yantian	0.875	1.679	0.804
8	114.2400	22.7267	Longgang	1.355	1.428	0.073

* Positive Changing value score indicates that the pollutant level is turning higher, and negative Changing value score indicates that pollutant level is turning lower, 0 (if any) indicates no change .

3.2. Survey Design and Sampling method

The survey took 281 questionnaires at 36 sampling sites in a period of 7 days from May 1 to May 7, 2006, most of which were within the communities and dense population area. The coordinate data of each sampling site was logged with handhold GPS device. At each sampling site objects are randomly picked. We interview objects instead of letting objects write to reply to ensure that those less educated could be included in our sample. The survey figured out residents' judgment of the environmental changing trend. The responses are quantified to a 5 point scale, with 1 be deteriorating badly, 2 be turning bad, 3 be no obvious change, 4 be turning good, 5 be turning much better and 6 be N/A. The average score at each sampling site is assumed to be the consensus of that site. Therefore we have a table showing the average score of each site.

3.3. Spatial & Statistical analysis

To figure out the residents (or sampling sites) within some certain distance of the monitoring points, we implemented a computer program with the help of Interactive Data Language (IDL, Research System, Inc. http://www.rsinc.com/idl). With IDL, we extract sampling points within a specific distance of monitoring stations for further analysis.

The environmental risk with regard to ambient air quality reflected by the comparison could be too complicated for understanding. To simplify, after calculating the paired value at each individual community, we categorize the average changing trend (Score-3) rated by residents and average pollutant changing value recorded by monitoring stations into three ways: Turning Bad (Low) / Turning Good (High)/Stay the same (or N/A). Thus there would be 9 possible combinations with different risk types as shown in the table. (Table 3) Each type of risk reflects different environmental issues and calls for different treatment in air quality management policies.

4. Results and Discussions

The calculation assigns each individual community with a risk type, and the general description of the community is also listed in the table above (Table 2). The most frequently-appear type is F. Type H is the only type that has no community belonged to.

Table 2

Risk types defined by the residents rating and monitoring station record (+, －in the second column means turning higher or lower)

Risk Type	Residents Rating	Station Record	Environmental Issues Might Reflected*	Priority	Risk type account
A	－	+	① Deteriorating environment; ② Residents call for improvement.	Urgent	3
B	－	－	① Improper location of observation point ② Lurking variables lead to complaint.	Urgent	2
C	+	+	① Lurking variables lead to satisfaction; ② People have not realized exposure to risks.	Urgent	7
D	+	－	① Living environment has been improving; ② Potential risk has not affected life quality.	Median	1
E	－	0 or N/A	① The monitoring station do not cover the community; ② People call for improvement.	Urgent	4
F	+	0 or N/A	① The monitoring station do not cover the community; ② Living environment has been improving.	Median	13
G	0 or N/A	+	① People have not realized exposure to risks. ② People's different response to change.	Urgent	4
H	0 or N/A	－	① Lurking variables make people feel there is no improvement. ② People's different response to change.	Median	0
I	0 or N/A	0 or N/A	① The environment has no significant change. ② The monitoring station do not cover the community; ③ People's different response to change.	Median	2

* All the four include probability of error: 1. sampling error in community survey, which can be measured and controlled through well designed sampling method and enlarged sample size; 2. operation error of the recording device at the environmental monitoring station.

Among the 17 communities, there are more than half of the communities feeling the environment is turning better. This is not always good news though, for type C ranks the second of all the types. As said above, Type C indicates that the monitoring station records a deteriorating trend while people feel good about the air quality. People may have not yet realized their exposure to hazardous pollutants.

In response to the great adverse effects the air pollution brought about, our new community survey method with GIS application makes it possible to involve the community into the environmental management process, and complement the monitoring station data with regard to those locations and pollutants the station can not cover. The importance of the research also lies in that it is an inexpensive way to attain public health data in the developing country when fine air pollution related disease incidence data are not available. It is still challenge to take more proper sampling sites and determine better spatial analysis tools as well as statistics tools. However, one thing is pretty much clear that we shall place more work at the community level to improve ambient air risk monitoring service, and GIS application has already made it more feasible.

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