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Using GIS for Pollution Control

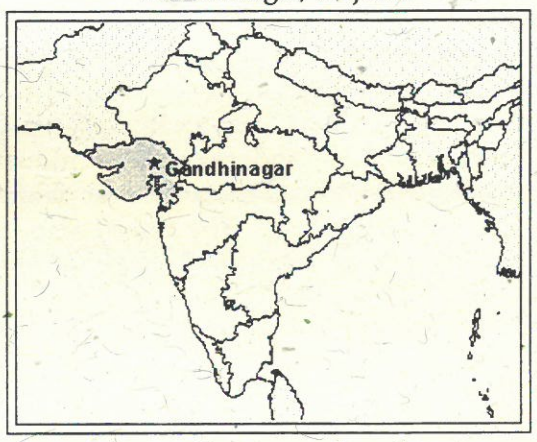
How can geographic information systems (GIS) assist in pollution control and prevention? What role can GIS play in environmental monitoring and impact assessment? Can GIS offer information management solutions to pollution control agencies enabling more efficient and effective administration and use of resources for meeting agency mandates? This paper provides some answers to these questions by describing the use of GIS in the hazardous waste tracking system adopted by the Gujarat Pollution Control Board in India.

Geographic information systems (GIS) are being utilized around the world to assist industrial pollution prevention and control. Agencies carrying out environmental assessment commonly employ GIS to assess the potential impact of industrial discharges on the surrounding natural and social landscape, including assigning costs to alternative sites and design. GIS also may be employed to maintain, monitor, and disseminate information on pollutant release. For example, the North-East Estonian Department of the Institute of Ecology in Jõhvi, Estonia, has set up a regional GIS on the state of the atmosphere in Eastern Virumaa. Questions about pollution sources and polluting substances, existing air quality, and trends are being handled by this system. In the U.S., the Federal Environmental Protection Agency's toxic release inventory (TRI) program publishes GIS-based toxic release data on the nation's industries as part of the Emergency Planning and Community Right-to-Know Act.

GIS may be used *post facto* for assessing the extent of damage caused by a polluting incident, such as an oil spill or gas leak, and for determining the best course of action for cleanup. A number of countries also employ GIS and three dimensional modeling tools to determine the most cost-effective method of cleaning up abandoned industrial sites.

In India, the Gujarat Pollution Control Board (GPCB), the state-level pollution control agency in the western industrial State of Gujarat (see figure 1), is building a GIS-based hazardous waste tracking system as part of a Bank-funded Industrial Pollution Prevention project. This system will network the agency's 10 regional and sub-regional offices with its head office in Gandhinagar, the Gujarat State capital, and allow the Board to maintain a common and integrated database to monitor compliance of industries by tracking their sources and levels of pollutants. Software tools are employed to carry out modeling by integrating pollution information with environmental, physical, and social information. In addition, the network serves as a basis for integrating information on agency staff, thus enabling efficient mobilization of available resources.

Figure 1
Gandhinagar, Gujarat



Agency Mandates

As one of the most industrialized Indian states, Gujarat has almost 34,000 industries producing waste categorized as hazardous according to

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government criteria. A 1994 survey of the seven largest of the more than 100 industrial development estates estimated annual hazardous waste production to be 220,381 tons per year and projected growth to be more than 3.5 million tons per year over the next 15 years. The total generated in the State has recently been estimated at 0.35 million tons.

The GPCB is the agency responsible for enforcement of environmental regulations at the state level and as such is involved in monitoring industrial pollutants by point sources as well as monitoring environmental quality in industrial areas. The Board reviews applications from industries on the amount and type of pollutants likely to be discharged and, after vetting the data against specified quality criteria and standards, may grant a no objection certificate (NOC) to the industries. The NOC is valid for a given time period, at the end of which it must be renewed via another application.

After the NOC has been granted, the Board's field offices conduct random checks of industries and, through the judiciary, initiate actions against those in noncompliance. The Board also has a monitoring role in implementing programs for collecting continuous data on air and water quality. The data are collected by monitoring stations and transmitted to Board headquarters. The Board in turn reports on the overall situation to the Ministry of Environment and Forests and the Central Pollution Control Board in New Delhi.

Information for Management

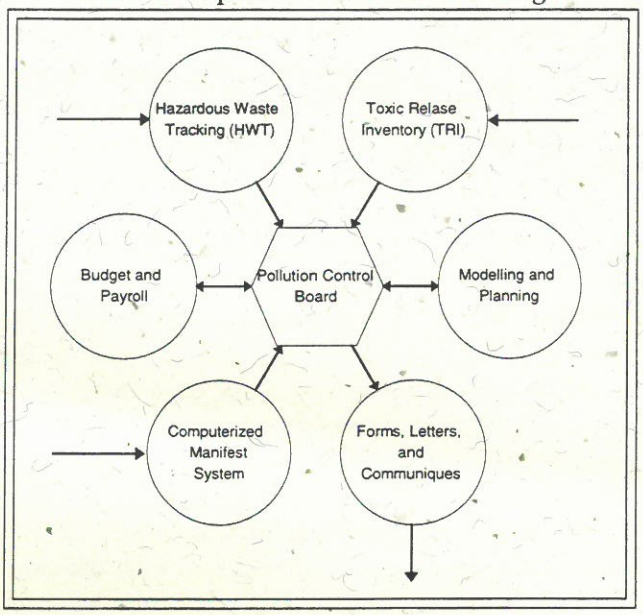
The GPCB, organized as a collection of interacting work-groups, requires timely information on every aspect of its work (see figure 2). Problems obtaining information or inaccurate or unreliable information can delay decisions affecting industries, and hence, affect sound decisionmaking.

Computerized information technology based on relational database management software and geographic information systems can enhance the delivery of quality information for managers at the pollution control boards. As much of the information handled by the Board is confidential, computerized technology can assure security and protect the privacy of the industries.

Hazardous Waste Tracking System

As part of the Bank-funded Industrial Pollution Control and Prevention Project, GPCB is setting up a GIS-based hazardous waste tracking system. Of the more than 400 hazardous and toxic chemicals listed by the Central Pollution Control Board, the 17 considered "most polluting" will be the focus of a GIS-based hazardous waste tracking system.

Figure 2
Work-Groups and Information Linkages

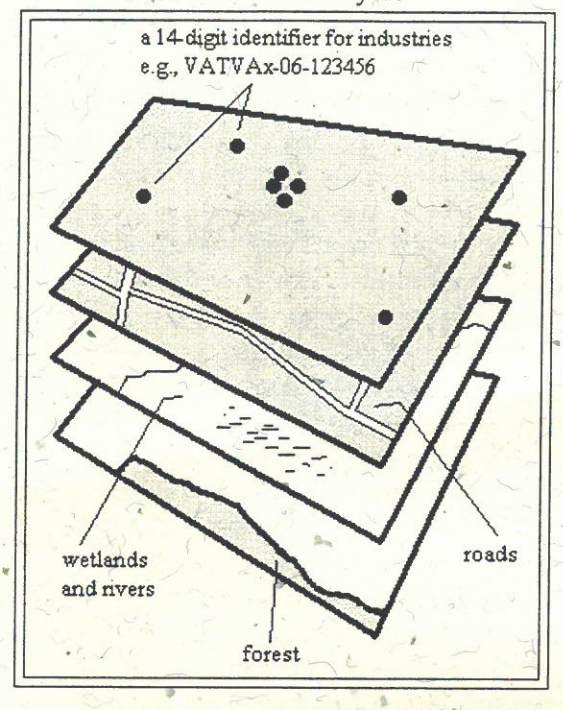


The first step in establishing the system has involved a statewide survey of industries and documentation of the type and amount of hazardous waste discharged. Once the survey data have been collected, they will be entered into a computerized geo-referenced database linked to a map of Gujarat showing locations of all industries. GPCB has developed a coding scheme for assigning unique identifiers to each industrial unit in the state. The identifiers will use 14-digit placeholders, where the first six digits will identify the industrial development estate, the next two the industry category code, and the last six the survey and plot number of the unit. Additional layers in this database will include physical information such as land use, land cover, soil type, hydrology, and socio-economic information obtained from demographic and other data (see figure 3).

Using the programming and macro language tools available in the GIS and relational database software, applications will be developed to enable GPCB staff to query and extract information from the database. The application interface will be similar to the paper forms used by the Board in its normal day-to-day operations.

An industry seeking a no objection certificate must submit the appropriate form with all the

Figure 3
Information Layers



requisite data entered into the system. GPCB officials will then examine the data in conjunction with other information in the GIS and can quickly and efficiently come to a decision about granting the certificate. As the applications are developed, the system will be expanded to include the field offices of the Board. Conversely, community representatives and the general public will be able to request information from the Board. Also, when the toxic release inventory is implemented the system will operate as a clearinghouse for information on the discharge of pollutants.

Eventually all the Board offices will be networked over the telephone system. Consequently, it will be possible for an industrialist to go to a field office, provide all the data for examination by the officers at headquarters, and have the certificate granted without having to travel to Gandhinagar.

Further Automation

As the hazardous waste tracking system is implemented around the state, other functions as depicted in figure 2 can be modernized and automated. Possible areas of focus would be the toxic release inventory (TRI) and a computerized manifest system.

A TRI typically combines hazard and exposure information on release of pollutants on a chemical-by-chemical and facility-by-facility basis. Industries make available pollutant data as well as information on source reduction, waste recycling and any other pollution prevention activities. TRI data can be made available to local governments, NGOs, and the public enabling them to identify potential environmental concerns.

A manifest is used for tracking hazardous waste shipments from the site of waste generation to the site of waste treatment and disposal. It can provide waste-related information during transportation emergencies, and also serve as a record-keeping and reporting tool.

Both TRI and manifest tracking may benefit greatly from computerization. A combination of relational database management tools, GIS, and networked computers make it easy and efficient to update such information and to make it available to all concerned parties. Reliable and timely data brings increased accountability and gives GPCB, as well as communities, the power to enforce environmental standards and regulations.

Automation of Office Information

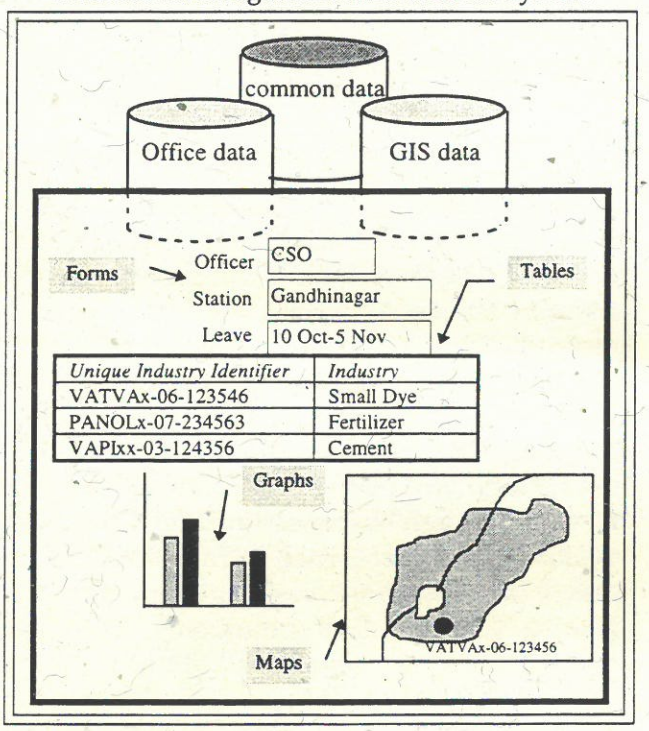
Besides modernizing the functional information capabilities of GPCB, computerization of administrative data—data on staff, leave, benefits, and payroll—enable the Board to improve agency administration and utilize available resources efficiently and effectively. For example, merging query capabilities across the administrative and functional databases allow GPCB managers to assign staff in the most effective manner. Such an integrated pollution management information system provides complete pollution management and administrative capabilities to the Board (see figure 4 on next page). The system draws upon office or management data, and geographic data, as well as cultural, and demographic data to meet routine GPCB information needs.

Typical office functions such as writing letters and communiqués, making presentations, newsletters, and brochures, communicating via electronic mail, and office calculations related to staff leave and benefits also benefit from automation.

Training

Staff familiarization and training with computers is essential to realize the advantages of automation and modernization. With this in mind, GPCB has decided to standardize its hazardous waste tracking system on Microsoft

Figure 4
Pollution Management Information System



Windows-based computers. Access to a hazardous waste tracking system as well as common office functions and information will be available to all officers through their desktop computers.

Standardization on Windows facilitates training by providing a common platform for performing most information-related functions. GPCB is planning to provide training to all its managers, scientists, and engineers on the basics of the Windows operating system, word processing, spreadsheet, simple database operations, and graphics and presentations.

Benefits

The following benefits are envisioned by improving information management at GPCB: improved efficiency as the information flow through the workplace becomes streamlined; integrated activities producing timely, comprehensive, and quality information; improved service delivery to the industrialists in the state, including shorter response and application turnaround times; ability to plan ahead and assign adequate resources to problems and activities; and, the ability to evaluate alternative scenarios for planning purposes and emergencies.

Eventually GPCB will be able to utilize information technology in all aspects of its work. Using the GIS-based hazardous waste tracking system as a base, the system could be expanded to include other functions such as TRI, computerized manifest tracking, modeling, resource allocation, and project planning. The same system could be employed to modernize office information management including staff, payroll, and benefits, and leave and attendance tracking. Thus, a fully integrated, agency-wide pollution management information system would help GPCB with its information needs for pollution prevention and control.

Although implementation of the GIS-based hazardous waste tracking system began in mid-1996, the following lessons have been learned from the experience thus far:

- System design should be preceded by adequate needs identification and capability assessment. This step is crucial as it identifies the problem context and lays down appropriate design parameters.
- Initial solution design should focus on the tasks required to solve the problem rather than on the tools themselves. This ensures flexibility in choosing the necessary tools in the rapidly changing information technology environment.
- It is common to find a low level of information technology awareness and competency in most public sector agencies of developing countries. It is crucial therefore that emphasis be placed on solving most information needs with simple to use, robust, and scalable technology rather than try and deliver very powerful but difficult to use tools.

Keeping these few caveats in mind, it is possible to develop a sophisticated, powerful, easy-to-use, modular, and scalable GIS-based system that meets present and future information needs in pollution prevention and control.