Implementations of Remote Sensing, GIS, and GPS for Water Resources and Water Quality Monitoring

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Abstract: Water quantity and quality monitoring at Taipei Watershed Management Bureau (WRATB) is not only a daily business but also a long term job. WRATB is responsible for providing high quality drinking water to about four millions population in Taipei. The quality of drinking water provided by WRATB is among one of the best in Taiwan. The total area is 717 square kilometers. The water resource pollution is usually divided into two categories, point source pollution and non-point source pollution. Garbage disposal is the most important component of the point source pollution, especially those by tourist during holidays and weekends. Pesticide pollution, fertilizer pollution, and natural pollution are the major contributions for nonpoint source pollution. The objective of this paper is to implement remote sensing, geographic information systems, and global positioning systems to monitor water quantity and water quality at WRATB. There are 12 water quality monitoring stations and four water gauge stations at WRATB. The coordinates of the 16 stations were determined by GPS devices and created into the base maps. MapObjects and visual BASIC were implemented to create application modules for water quality and quantity monitoring. Water quality of the two major watersheds at WRATB was put on Internet for public review monthly. The GIS software, ArcIMS, can put location maps and attributes of all 16 stations on Internet for general public review and technical implementations at WRATB. Inquiry and statistic charts automatic manipulations for the past 18 years are also available. Garbage disposal by community and tourist were also managed by GIS and GPS. The storage, collection, and transportation of garbage were reviewed by ArcMap file format. All garbage cart and garbage can at WRATB can be displayed on the base maps. Garbage disposal by tourist during holidays and weekends can be managed by a PDA with a GPS device and a digital camera. Man power allocation for tourist garbage disposal management can be done in an integration of GIS and GPS. Monitoring of water quality and quantity at WRATB can be done on Internet and by a PDA.

Keywords: remote sensing, GIS, GPS, water quality monitoring.

1. Introduction

Water quality and quantity is one of very important issues that should be pursued at Taipei Watershed Management Bureau. In order to supply high quality of drinking water on a sustainable basis, water resource protection has to look into all aspects of solutions. Water must be supplied in very high quality manner as well as quite sufficient for general publics. Monitoring water quantity and quality is a daily operation and a long-term job. General public has the right to know detail information about water quality and water quantity on Internet. Garbage disposal by tourist and community is one the main source of point pollution. The nonpoint source pollution is consisting of pesticide pollution, fertilizer pollution, and natural pollution. One of the major sources, hog farm pollution, has been wiped out at WRATB.

The objective of this paper was to implement remote sensing, geographic information systems, and global positioning systems to monitor water quantity and water quality at WRATB.

2. Material and Method

Water quantity monitoring has been performed since 1988. Monthly measurement and their changes every year have to summit to EPA and open for general public. Some of gauge stations have not measured due to natural disaster such as typhoon. There are 12 stations for water quality monitoring. What have to be sampled and measured are subjected to the guidelines and law set up by EPA. Temperature, pH values, BOD, COD, SS, and so on are items measured periodically.

Garbage disposal is the major components of water pollution at WRATB because so many tourists visit during holidays and weekends. This type of garbage has to be collected and treated efficiently. Monitoring of garbage dumped by tourists is then an important job.

1) Material

Table 1 shows water quality measurements at five sampling stations for a given month. Table 2 indicates water quantity measurements from 1988 to 1992 month by month. Those two types of data have been converted into relational databases and some of them were stored in HTML format for web browsing by general public.

Table 1. Water quality was measured at sampling stations with several elements.

Location	pH	DO (mg/l)	BOD5 (mg/l)	COD (mg/l)	SS (mg/l)
Kuolai	7.0	9.8	0.2	1.0	0.6
Pihu	6.9	9.9	0.5	1.3	0.4
Y.C.P.L Pinlin	6.8	9.4	0.7	1.6	7.2
Bridge Dalin	6.9	9.7	0.6	1.4	3.0
Bridge	6.8	9.9	0.6	1.7	1.2

Table 2. Water quantity was measured at one sampling station month by month.

year	JAN	FEB	March	Aprill	MAY
1988	5.113	4.813	4.500	4.465	3.862
1989	7.002	12.060	3.242	4.068	8.105
1990	6.982	4.629	7.952	1.438	4.746
1991	1.786	3.736	1.706	2.299	4.747
1992	5.180	12.200	5.010	5.260	5.520

Figure 1 shows location of all 16 sampling stations for water quality and water quantity monitoring in ArcPAD.
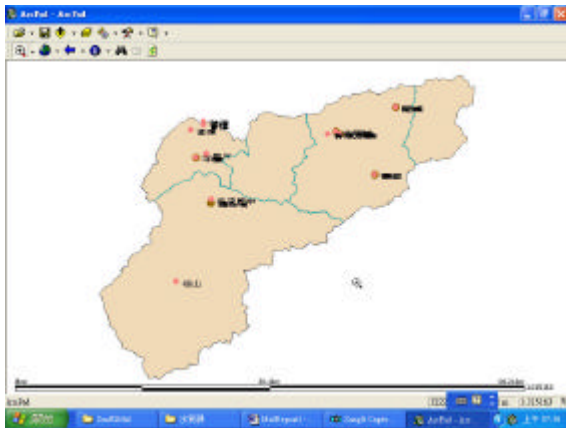

Fig. 1. Location of all 16 sampling stations for water quality and water quantity monitoring.

2) Method

Brand-name GIS software such as ArcIMS, ArcView, and ArcPAD are the major items to provide most GIS functions for water quality and water quantity monitoring at WRATB. Visual Basic was used to develop more application modules. It is very simple that commercial GIS software can not do all the jobs alone. Programming languages such as ASP.Net and ADO.Net are used for development of application modules, data manipulations, creation of hyperlinks among maps and their associated attributes.

Personal digital assistant (PDA) is used for field operations including water quality and water quantity sampling and garbage management. ArcPAD is designed for PDA operations but is also good for personal computer implementations. It is a very good combination that GPS works together with PDA. Embedded visual Basic is needed for development of more application modules with PDA. PDA is running with Windows Pocket PC operating system.

ArcIMS was purchased and used for both Internet operations and intranet operations. Databases were mainly created by Microsoft Excel and they have to convert into Microsoft SQL server and also stored as Internet HTML file format for web browsing. With ASP.Net and ADO.Net, traditional database manipulations can be done on web pages by general public or government authority. More functions can be added on web pages without making any compromise for security reasons.

MapObjects were published by ESRI with several different software languages say, Visual Basic, Visual C++, Delphi, and so on. MapObjects can provide GIS functions with personal flavor but requires more computer efforts. Some of application modules were created with MapObjects such that they can be more user-friendly and cheaper.

3. Results and Discussion

1) Water Quality Monitoring

Many items of water quality have to be measured at headquarters of WRATB. Their measurements were then manipulated with Microsoft Excel. Standard procedure has been set up for the whole process. GIS can provide functions for field data collection, database manipulation, hyperlinks between location and its associated attributes, and map overlay with other map layers. When water pollution was detected, it can be analyzed with the help of GIS to come up with some management prescriptions. Because landslide maps, sewage facilities maps, land use maps, and high resolution images can be overlaid with the water sampling station map for further inspection.

2) Water Quantity Monitoring

Water quantity monitoring is much like the water quality monitoring but it is much simple. Some of the sampling stations have been converted into automatic process. A little bit of programming has to read the data set and input into the existed databases. Statistic table generation and statistic charts generation were provided by application modules in Visual Basic.

Both water quantity and water quality monitoring require satellite images to cover a single watershed. SPOT satellite images with 20 meters resolution have been purchased and used as background information. Higher

resolution satellite images such as 2 to 3 meters are more useful. Chinese Sat-II will be launched in the near future that will be implemented for water quality and water quantity monitoring at WRATB.

3) Garbage Management

Garbage management can be divided into two types of job. Community garbage collection and transportation is more like a routine work can be managed without much surprise. Figure 2 shows locations of all garbage can and garbage cart at WRATB. Every single garbage can or garbage cart has its associated attributes in the databases ready for further inquiry and analysis. How many garbage can and garbage cart within a village or at a scenic attraction can be answered by GIS.
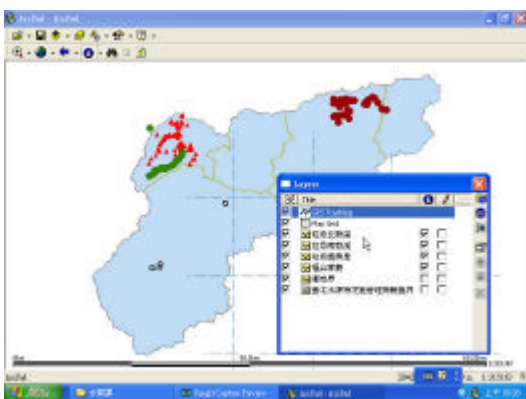

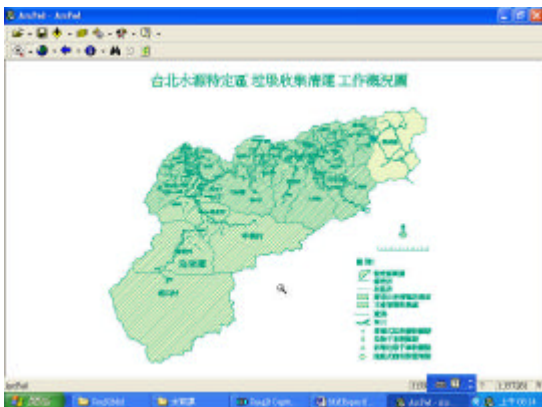**Fig. 2. Location map of garbage can and garbage cart at WRATB.**

Fig. 3. Garbage transportation route at WRA T B.

Figure 3 is a garbage transportation route map at WRATB. It was prepared with the help of GPS.

Garbage disposal by tourists during holidays and weekends is a challenge that requires close monitoring. Man power allocation at different sites has to prescribe according to this type of garbage monitoring. PDA and GPS work together in the open fields can provide very nice garbage information in real time. A compact flash type of digital camera can work with PDA providing color images on the right place. With the help of PHS and GPRS, PDA can be used for web browsing and provides real-time mobile GIS functions for garbage management.

4. Conclusions

Taipei Watershed Management Bureau is the only one government agency in Taiwan set up for water resource protection with full legal authority. It is more like a river valley authority in order to provide high quality of drinking water for about four millions populations in Taipei. Water quality and water quantity monitoring is a long-term process that require more sophisticate and effective approaches. GIS, remote sensing, GPS, and PDA can work together providing more cutting-edge approaches for water resource protection at WRATB.

References

[1]   Chang, K., 2002. Introduction to Geographic Information Systems, McGraw-Hill Companies Inc. 183-185.

[2]   **URL:** ECW Plug-ins & Tools CD-ROM. Available at: http://www.ermapper.com/downloads_new/.

[3]   Lin, H. C., 2002. *ASP.NET Programming.* Flag Publishing Inc. Taiwan. (Chinese Edition).