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Research paper

Development Gross Pollutant Management Strategies Knowledge Database using ArcGIS

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Abstract

This study aims to suggest an efficient method for the management of gross pollutants. The local data collected will finally become input to Innovative Gross Pollutant Management Strategies Knowledge Database, which will help engineers or local authorities to manage the GPTs efficiently. Furthermore, the knowledge management portal ensures knowledge sharing and the establishment of knowledge bank for Gross Pollutant under Malaysian condition. The developed gross pollutant management strategies knowledge database is able to assist the client during inspection & maintenance data collection using ArcGIS Collector. The data will be uploaded into the web base ARC GIS Online System, enable better management of gross pollutant traps, in term of inspection & maintenance. The result obtained in this study provides information that can help future decision for GPTs installation and maintenance program. Ultimately, the data obtained will assist the engineers and local authorities to implement appropriate strategies for trapping gross pollutants in an urban area, expand the sources for managing gross pollutants in order to rehabilitate the river system and preparing budget allocation for GPTs operation & maintenance.

Keywords: *gross pollutants; Knowledge Database; ArcGIS, Stormwater management*

1. Introduction

In the last few decades, river management and restoration play an important role in the environment. Thus, improving water quality is one of the major areas of research as many researchers are conducted in this applied research field [1-7]. Pollutants carried by urban stormwater runoff are considered as a significant contributor to the degradation of receiving waters [8]. Gross pollutants are often targeted first for the removal and many structural measures have been applied with varying results [9, 10]. Urban stormwater pollutants include gross pollutants, trace metals and nutrients that are associated with sediments, and dissolved pollutants [11]. These accumulated pollutants are not only aesthetically unattractive, but also demonstrate an environmentally threatening and devastating effect on the natural equilibrium, and impede the hydraulic performance of the urban drainage system [12-14]. In particular, aquatic fauna is a risk of becoming entangled in or suffocating from, litter ingested in the course of their search for food; while pathogenic organisms or toxins, could interfere with the biota terrestrial ecosystems, resulting in food chains imbalance [15]. A study conducted in Melbourne, Australia has noted that urban areas contribute 20-40kg of gross pollutants per hectare to the stormwater, equivalent to approximately 60,000 tons or 230,000 cubic meters of gross pollutants, with the generation of two billions tons of litter annually [16]. Gross pollutant trap (GPTs) is a device that is purposely designed to remove litter, debris and sediment from stormwater [17]. It is fixed at the downstream end of a drainage system, which is before entering the waterway such as a river, pond or wetland. Some of them are designed to filter oil and to remove the chemical from the water flow. Literally, gross pollutant traps combined the mechanism of gross solids interception and retention [18]. This mechanism utilizes the energy coming from the inflow to separate floatable materials with non-floatable materials. For examples, sedimentation tank is used to settle the non-floatable material such sediments, trash rack applying the intercept mechanism by intercept gross solids from stormwater and CDS utilized both mechanisms of interception and retention. In this study, Gross Pollutant Management Strategies Knowledge Database developed for managing gross pollutants. This study targets to impart a management and planning tool for proactive and operative management of the gross pollutants in the urban areas. The system was developed based on previous and current research and collection of data, which will complement the system as a data storage hub.

2. Material and Methods

2.1. System Architecture

System Architecture is also based on a scalable and extensible platform that can be easily extended and configured to meet the progressive needs of supporting delivery of services across multiple platforms, including desktop, server, web and mobile. Figure 1 shows the system architecture for a gross pollutant management strategies database.

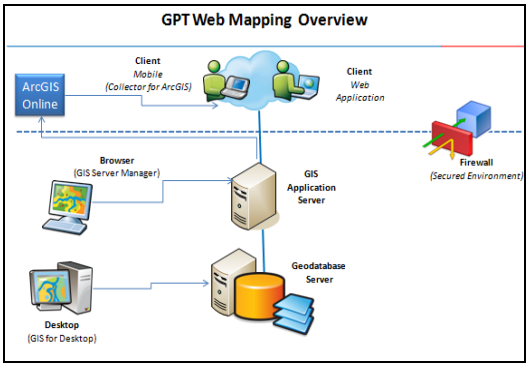


Fig. 1: System Architecture of Gross Pollutant Managmement Strategies Database

The phases involved in developing gross pollutant management strategies knowledge database are discussed in Fig 2.

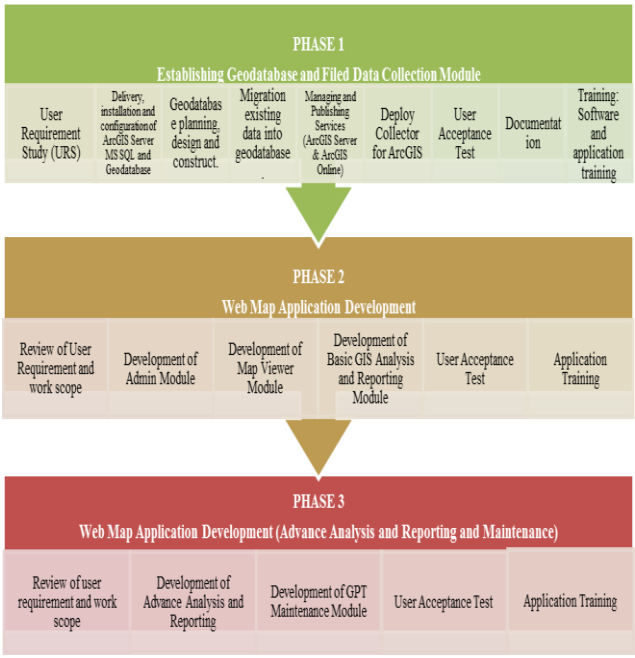


Fig. 2: Phases Developing Gross Pollutant Management Strategies Knowledge Database

Figure 2 shows the phase developing gross pollutant management strategies knowledge database. There are 3 phases which have phase 1 establishing geodatabase and filed data collection module. Next phase 2 describing web map application development and finally phase 3 which focus on web map application development.

2.2. Application Development

The application system is based on Web, Desktop GIS and Mobile GIS platform solution. The foundation of the architecture is designed based on N-tier architecture.

- Presentation layer
- Graphical user interface for information dissemination.
- Business Logic Layer
- Security layer
- Core application
- Integration
- Data Layer
- Database and Geodatabase

The solution architecture is envisioned to meet the following objectives:

- High degree of flexibility to cater to modifications that may be required
- Ascertain predictability of performance
- High-level security compliance including comprehensive and documented security policies, ease of implementing the policies and business rules.
- High degree of availability
- High degree of compliance with business process and business processes information requirements to establish the degree of usability

2.3. Geodatabase Development

Development of geodatabase is to establish a centralize geodatabase to supports one copy of the production geodatabase environment in order to minimize administrative management requirements and ensuring data integrity. Figure3 shows the sample of geodatabase layer. The process involves:

- Planning, design and construct of the operational geodatabase
- To migrate and integrate spatial data and non-spatial data into Geodatabase

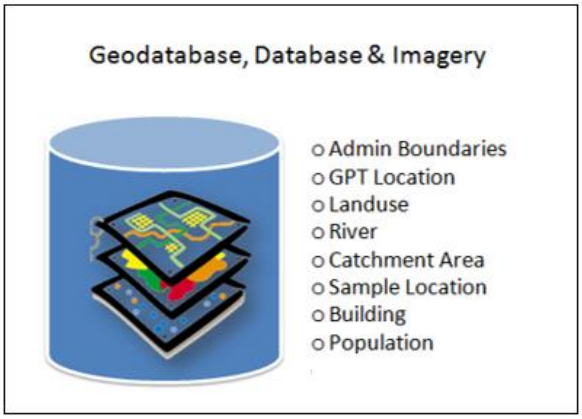


Fig. 3: Geodatabase Layer

2.4 Application Modules

Several modules have been developed in the system that forms an integrated application system that will be used in order to ensure transparent and consistent information flow throughout the entire organization. The interrelationships among the applications modules can be understood from a figure below, which illustrates the technical architecture integration, high-level business and data integration of the application system. Also shown is the high-level system interfacing.

i. **GIS Mobile Data Collection Module** - collector for ArcGIS is a mobile-based application solution for data collection, updating and site verification direct from the field into centralizing geodatabase. The user can update information in the field whether in the connected or disconnected environment. Figure 4 shows the collector for ArcGIS for field data collection.

ii. **Map Viewer Module** - an interface for map viewing and GIS functionalities such as buffering, query, identify, searching, display attribute and photo, producing a dynamic graph and map printing.

iii. **GPT's Maintenance Module** - this module will be used by the authority and the appointed contractor to update the status of their maintenance work of the GPTs. The sub-modules are routine maintenance Inspection and routine maintenance works.

iv. **Various analyses and reporting** - to be defined in the user requirement study and base on ongoing research and finding by UNITEN.

v. **Administrative and Security** - an important function because the system involves accessing and updating the central database and geodatabase.

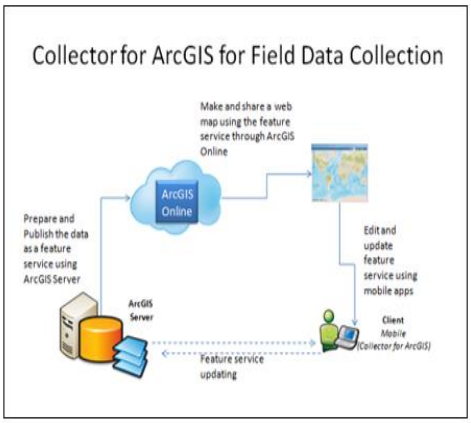


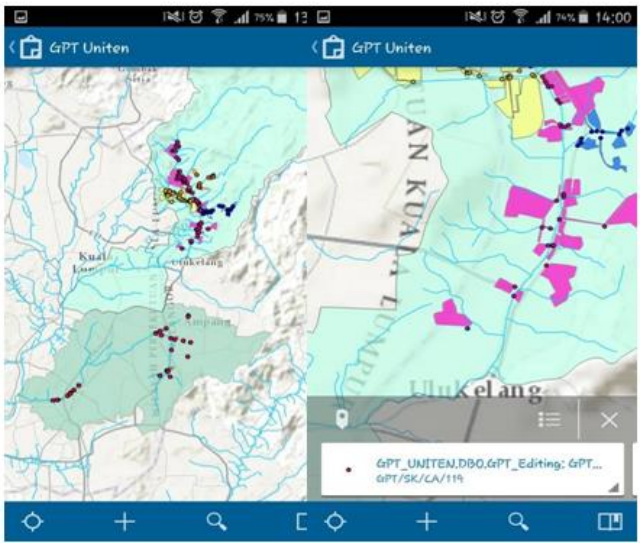
Fig 4: ArcGIS Collector for Field Data Collection

3. Result and discussion

GIS online plays an important role to monitor and analyze the performance of GPTs. The developed prototype aims to serve as an integrated medium between client, contractor and consultant and enable relevant parties to update any information related to GPTs such as location, maintenance schedule and wet load. It can improve measurement capabilities and increase practicality usage of the handheld device and mobile application.

3.1 ArcGIS Collector

ArcGIS Collector Mobile is a based application solution for data collection, updating & site verification direct from the field into a centralized geodatabase. It will help workers to the key in the data during GPTs maintenance and straight into the system.



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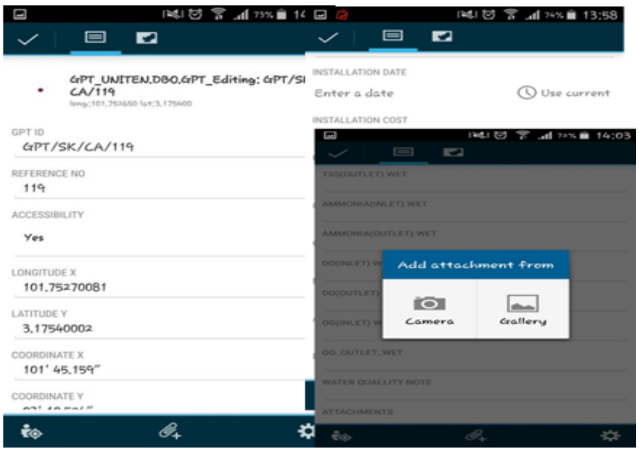
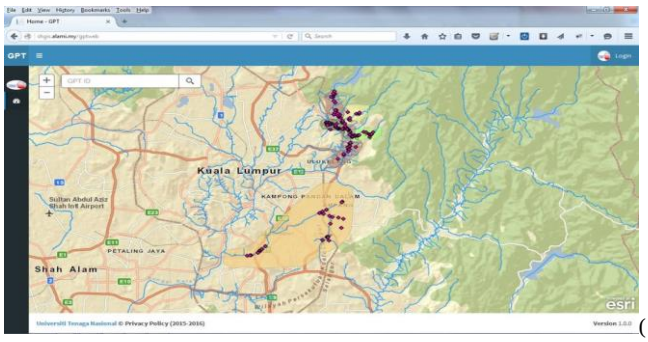


(b)

3.2 ArcGIS Online System

The web application of ArcGIS Online for data management, monitoring, analysis and reporting can be accessed through web address http://shgis.alami.my/gptweb. Figure 6 shows the main features of the ArcGIS Online Gross Pollutant Management Strategies Knowledge Database.



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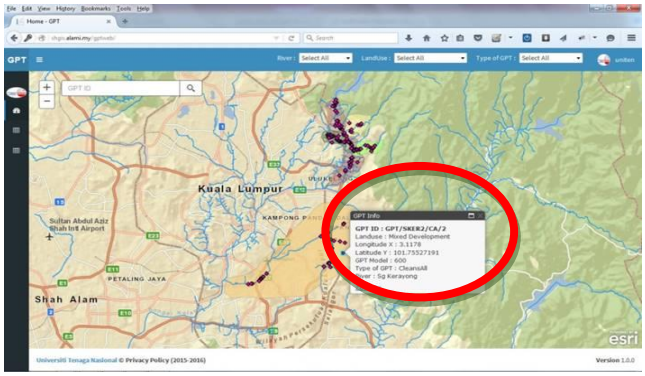

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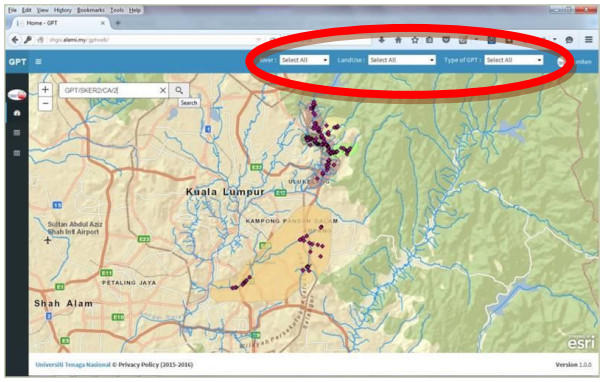

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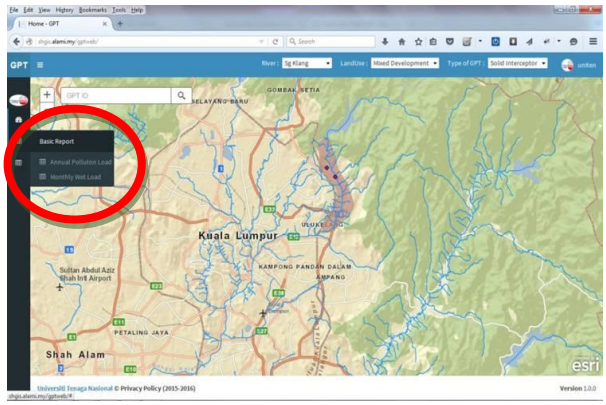

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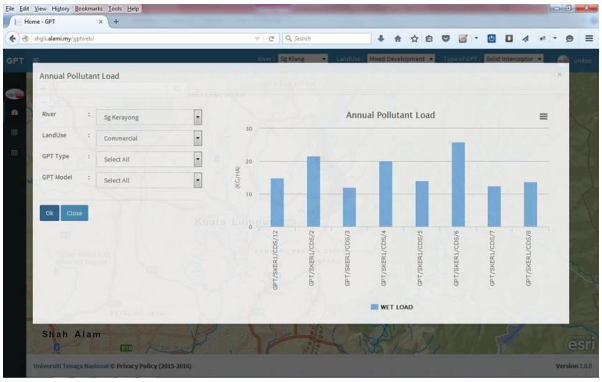

(e)

Fig. 5: (a) Front Page of ArcGIS Online Showing the location of GPTs for Data management, monitoring, analysis & reporting; (b) Display of Information of Selected GPT ID; (c) Multi-selection menu for GPT display - Catchment based, Land Use and Types of GPTs; (d) Reporting Menu; (e) Sample Analysis of Result from Reporting Menu

4. Conclusions

The database able to assist the client during data collection using ArcGIS Collector. The data will be uploaded into the web base ARC GIS Online System, enable better management of gross pollutant traps, in term of inspection & maintenance. It also enables simple analysis to help the user to see the trend of gross pollutant trapped by trapping devices. In addition, it helps to minimize administrative and management requirements and ensure data integrity. Furthermore, it facilitates the exchange and sharing of information throughout the relevant division and organization.

Acknowledgements

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