The Use of 4IR Technology Advancements for the Detection and Monitoring of Contaminants of Emerging Concern in South African Water Resources

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Supplementary information

Basic System Design and Software Selection

A web GIS (spatial data viewer) system that consists of a geodatabase, a map server, and a web viewer was the basis of the entire design (Figure S1). The other considerations were that the whole system should be built using only open-source software. No propriety software or licences would be required making it cheaper to maintain. Other considerations were that the web viewer should be easy to develop by any party who has coding capabilities and user-friendly for anyone with basic computer skills.
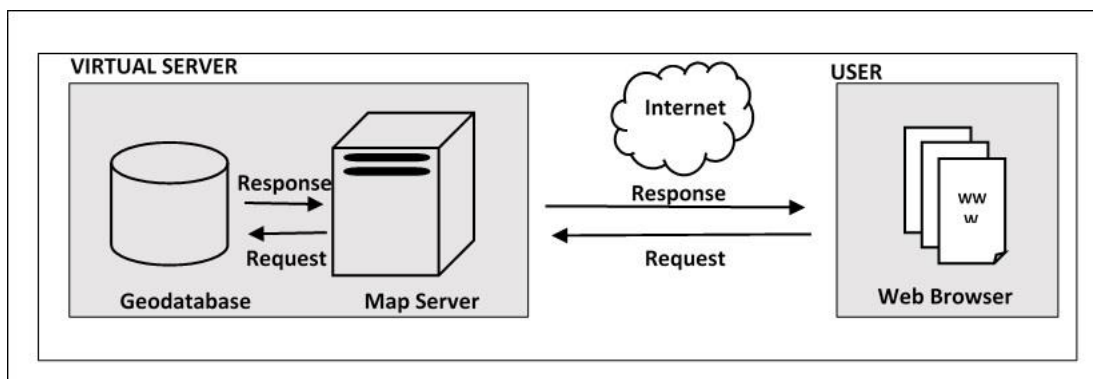

Figure S1: A basic web GIS is comprised of three parts; a geodatabase, mapserver and web browser.
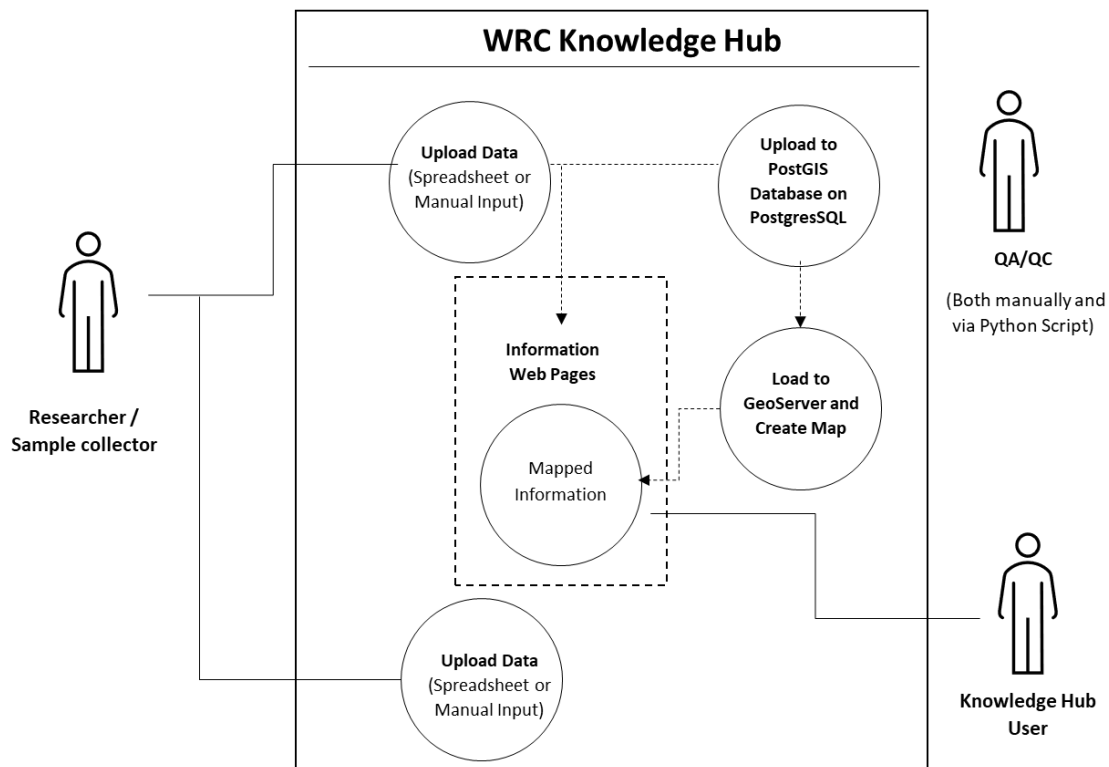
Figure S2: The basic use case in the CEC Knowledge Hub is that researcher enters sample data, that data is processed to be viewed in web pages or the web GIS viewer (QA- Quality Assurance and QC- Quality Control.

Web map design

The number of CECs displayed can be switched on and off using the layers tab and allows for comparison within sites. While within the main map view area, upon clicking a point, context information shown in Figure S3 will come up in the form of a balloon on the point with an information view table to the top right of the map viewer. The balloon shows a snippet of the information available in the table, and the table shows some but not all the information in the system for a particular point. To view more information for that point one needs to click the link provided in the more info row of the table. If there happens to be multiple points in a single coordinate location, then those points will "spiderfy" to display all available data points.
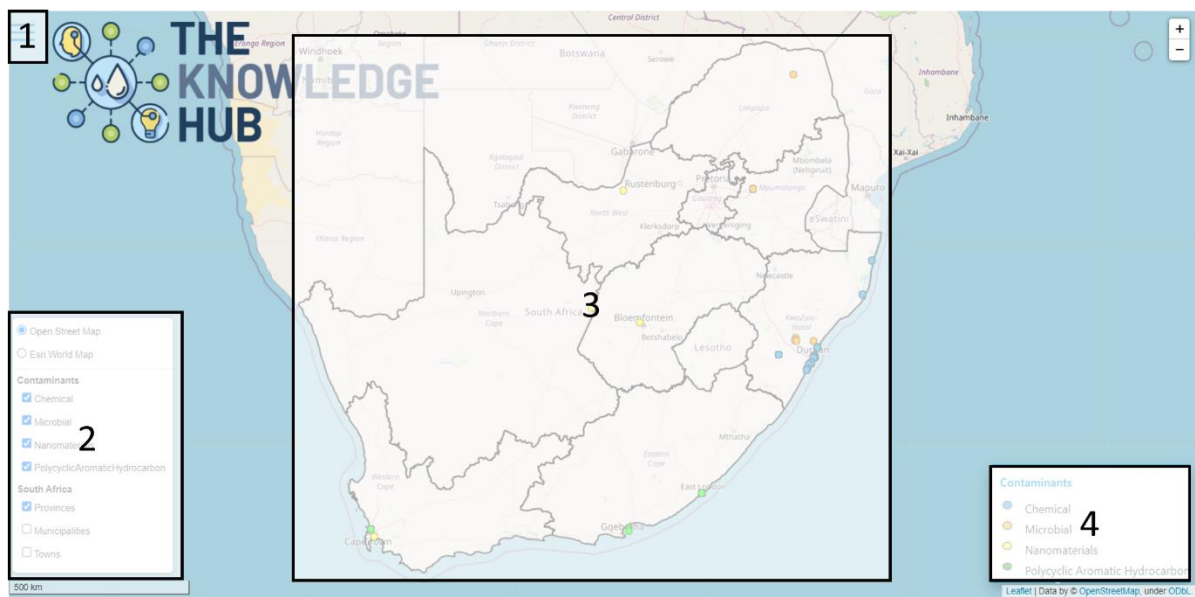
Figure S3: Final map viewer where (1) Links to other pages on the website, (2) Shows the layers in the interactive map and these can be toggled on and off, (3) Main map view area shows the contaminant layers as well as context layers and, (4) Legend of functional/contaminant layers.
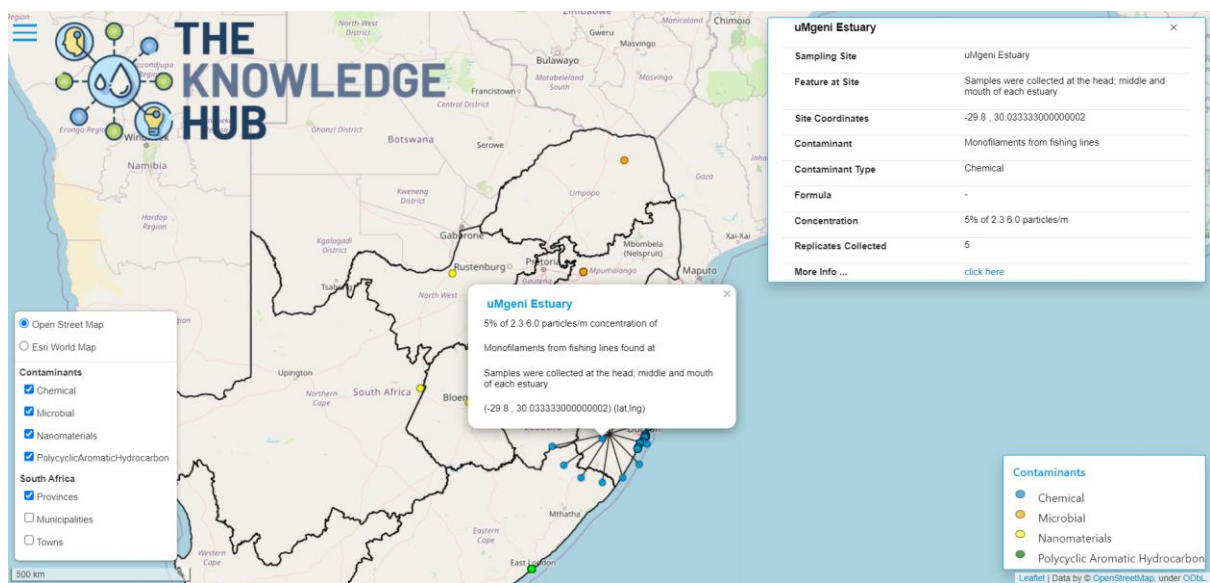

Figure S4: Context information on a clicked point as displayed in the top right-hand corner.

Additional information on Front and Back end design

Main Web Site (Front End)

The Main Web Site or Front End of the system is the main starting point for interaction with the CEC Knowledge Hub. The system caters for both registered users (Stakeholders) and unregistered users.

Unregistered users can interact with all modules / parts of the Knowledge Hub, including the Web GIS / Spatial Map Viewer module. Unfortunately, unregistered users don't have access to the Stakeholder module of the Knowledge Hub.

Registered Users have access to all modules of the Knowledge Hub including the Stakeholder module. The Stakeholder module is used to input and export relevant data.

Registration on the CEC Knowledge Hub is dependent though on authorization from Admin members of the CEC Knowledge Hub.

Data inputting can be done per record or by bulk import of MS-Excel spreadsheets with multiple rows. A standard MS-Excel spreadsheet template will be available for download from the CEC Knowledge Hub, to be used with the bulk import option.

Both registered and unregistered users have access to the Citizen and Agriculture modules.

From the Citizen module, the user can access various profiles of contaminants of emerging concern. These profiles are one pager downloadable PDF documents, giving general information regarding the selected CEC.

From the Agricultural module, a variety of Standard Operating Procedures will be available for download, also as PDF documents.

Front End Technologies:

HTML - HTML is the abbreviation for Hypertext Mark-up Language. It is the standard mark-up language for documents designed to be displayed in a web browser. It can be assisted by technologies such as Cascading Style Sheets (CSS) and scripting languages such as PHP or JavaScript

CSS - CSS is the abbreviation for Cascading Style Sheets. It is a style sheet language used for describing the presentation of a document written in a mark-up language such as HTML. It is a cornerstone technology of the World Wide Web, alongside HTML and JavaScript.

PHP - PHP is the abbreviation for Hypertext Pre-Processor. It is downloadable freeware software (http://www.php.net). It is a general-purpose scripting language especially suited to web development

Leaflet 1.7.1 - Leaflet is the leading open-source JavaScript library for mobile-friendly interactive maps. [https://leafletjs.com/ accessed 2021/01/05]. The viewer itself uses HTML 5 and Leaflet, Ajax and plain old JavaScript.

Back End Technologies:

MySQL – MySQL 8 is the latest version of the open-source relational database management system and will be the primary DBMS used for the backend database. MySQL is especially suited for internet / cloud-based systems such as the knowledge hub. [https://www.mysql.com/ accessed 2021]

Python 3.8 - Python is a programming language that lets you work more quickly and integrate your systems more effectively. Its role in this project is mainly for systems integration.

Windows Server 2019 - Virtual server hosted on Microsoft Virtual Server

GeoServer 2.17 - GeoServer is an open-source server for sharing geospatial data. Designed for interoperability, it publishes data from any major spatial data source using open standards [http://geoserver.org/ accessed 2021/01/05]

Apache Tomcat 9 - is the open-source implementation of the Java Servlet, JavaServer Pages, Java Expression Language and Java WebSocket technologies. With Tomcat, you can power large-scale, mission-critical web applications [https://www.techrepublic.com/article/how-to-install-apache-tomcat-on-ubuntu-server-16-04/ accessed 2021/01/05]

Hosting

Currently, for the development phase, hosting of the system is done on a MS Windows Virtual Server only accessible from within the ARC network. This process has been approved to allow for public access after beta testing phases are complete.

Once the system goes live for the beta testing phase, it will be hosted on a MS Windows Virtual Server accessible from outside the ARC as well.

Content

It will consist mainly of data gathered and then used in the detection and monitoring of contaminants of emerging concern (CEC's) in South African water resources.