DOI: 10.7343/as-2019-372

An overview on the state of art on IAH coastal aquifer dynamics and coastal zone website

Una panoramica sullo stato dell'arte del sito web IAH sugli acquiferi costieri

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Riassunto: Il sito web del network IAH Coastal Aquifer Dynamics e Coastal Zone Management (CAD-CZM), consultabile all'indirizzo www.iah-cad-czm.net, si pone l'obiettivo di migliorare la condivisone delle conoscenze sullo stato degli acquiferi costieri per supportare, a scala mondiale, il monitoraggio e la gestione delle risorse idriche sotterranee a rischio di salinizzazione. L'obiettivo principale di questo progetto è promuovere la partecipazione di ricercatori, professionisti, parti interessate e gestori idrici all'implementazione del network CAD-CZM relativamente alla condivisione e diffusione di dati e informazioni relativi agli acquiferi costieri. Le attività del sito web del CAD-CZM network si allineano con l'interesse espresso, in diverse occasioni, dall'UNESCO e dalla IAEA sullo studio delle aree costiere nell'ambito di programmi congiunti in cooperazione con altre agenzie internazionali. La struttura del sito web CAD-CZM mira a raccogliere informazioni provenienti da qualsiasi tipo di fonte, sia tecnica che scientifica, con l'obiettivo di favorirne la diffusione al fine di monitorare lo sfruttamento e la gestione di queste vulnerabili risorse idriche sotterranee. Il sito web, articolato per aree geografiche, permette di selezionare l'area di studio e ottenere informazioni attraverso un link di Google Earth, presente all'interno della pagina web. Una volta identificata l'area di interesse, è possibile consultare e scaricare, se presente, un questionario contenente informazioni sulle principali caratteristiche dell'acquifero (litologia, caratteristiche idrogeologiche e geochimiche, fonti di salinità, metodi di monitoraggio applicati, strategie di gestione e tecnologie di desalinizzazione) e sullo stato di salinizzazione delle risorse idriche. Tali questionari, compilati da esperti sul tema, sono verificati e caricati sul sito dal comitato scientifico del sito web CAD-CZM. Il presente lavoro fornisce una panoramica aggiornata dello stato di salinizzazione degli acquiferi costieri, basato sull'analisi delle informazioni estratte dei questionari ad oggi inseriti sul sito web CAD-CZM, relativi a circa 70 acquiferi costieri distribuiti in tutto il mondo.

Keywords: *coastal aquifers, salinization, groundwater management, IAH.*

Parole chiave: acquiferi costieri, salinizzazione, gestione delle acque sotterranee, IAH.

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Ricevuto/*Received*: 14 January 2019-Accettato/*Accepted*: 14 March 2019
Pubblicato online/*Published online*: 29 March 2019

Abstract: *The website of the IAH Coastal Aquifer Dynamics and Coastal Zone Management (CAD-CZM) Network, linkable at the web address www.iah-cad-czm.net, aims at improving the knowledge about coastal aquifer for supporting worldwide the assessment, development and management of water resources endangered by saltwater intrusion. The overall target of this project is promoting the development of web-GIS that gathers coastal aquifer data from different sources to assist, by the support of researchers, professionals, stakeholders and water managers to make the correct choices for the sustainable use of these precious resources. The CAD-CZM network tries to satisfy the interest expressed in the recommendations issued on different occasions by UNESCO and IAEA for studying coastal areas in the frame of joint programs in cooperation with other international agencies. The CAD-CZM website structure aims to collect information coming from any kind of source, as technical as scientific, and its target is to make them available in the aim of taking under control the rate of exploitation and the management of these vulnerable groundwater resources. The website organization is like that anyone could find the specific coastal zone, he is interested in gaining information, only looking for it on the google earth link, present inside the website. Once identified the area of interest, it is possible to download, if present, the specific sheet including all the information collected, checked and uploaded, by the scientific committee of the website. Starting from the analysis of a database of more than 70 coastal aquifer, reporting information about lithology, hydrogeological and geochemical characteristics, salinity sources, applied monitoring methods, management strategies, and seawater and brackish groundwater desalination technologies adopted, an updated overview of the state of the knowledge about seawater intrusion all over the world is presented.*

Introduction

Groundwater is worldwide the major source for domestic, industrial and agricultural supplies. However, population growth, increasing urbanization, industrialization, tourism, and climatic changes have caused an intensive exploitation of groundwater resources leading coastal aquifers to become more vulnerable to seawater intrusion (Sappa et al. 2015; Sappa et al. 2017). In most cases, intensive groundwater abstraction in coastal aquifers has produced seawater intrusion and significant piezometric level lowering. The characterization of seawater intrusion is difficult and expensive, and there is therefore a need to develop methods for rapid assessment of salinization as part of large-scale screening studies in order to guide sustainable management (Morgan et al. 2015).

The major challenge is the lack of awareness of society regarding coastal aquifers common problems, and underfunding for scientific investigation. Sustainable groundwater use must rely on adequate evaluation of aquifer characteristics. In this respect, international integration could improve promotion of sustainable management in endangered coastal ecosystems. The most relevant subjects concerning saltwater intrusion in coastal aquifers, such as geochemistry, applied geophysics, case studies, aquifer management, submarine groundwater discharge, impacts of increased water demand on coastal water resources and ecosystems, effects of sea level rise and climate change, variable density flow and transport modeling, and new developing methods to characterize coastal groundwater systems were analyzed.

Methods

The CAD-CZM network is a web-based portal to coastal aquifer-related information and knowledge, which aims to collect geo-referenced data on the hydrogeological characteristics of coastal aquifers from all over the world. The structure of the website is hierarchically organized into six pages, containing the lists of the coastal aquifers identified in 6 macro-geographical regions across 32 countries (Tab. 1).

Data referred to more than seventy coastal aquifer studies have been collected, involving five continents: North and South America (15%), Africa (17%), Asia (11%), Europe (56%) and Oceania (1%) (Figure 1). The implementation of the CAD-CZM website was carried out from data extracted from about sixty questionnaires completed at now, partly directly by study authors, partly by the website manager and his collaborators. Data were uploaded after having them validated by the researchers responsible for the investigations. Thus, the development of the website is in progress.

The questionnaire is organized in 10 main categories:

1. General information (aquifer location, population, name of the drafter);
2. Hydrogeological properties (medium, type, lithology, special features, hydraulic characteristics; water level and bottom, storage, annual water pumping);
3. Geochemical properties (hydrochemistry, major chemistry, major salinity sources);
4. Investigation methods adopted;
5. Numerical hydrological modeling;
6. Monitoring methods applied;
7. Management methods;
8. Aquifer management actions;
9. Existing of potential problems;
10. Annexes and observations.

To increase the availability and facilitate continuous update of coastal aquifer management, a web-based portal was developed to contain the available data. There is a map viewer to visualize the selected data on a geographic location, and a features panel providing a file containing data referred to people living in any continent and the questionnaires download.

Tab. 1 - Countries included until now in the CAD-CZM network website database.
Tab. 1 - Paesi compresi nel database del sito web del CAD-CZM network.

Macro-Geographical Region	Country
North America	Canada
	USA
South America	Argentina
	Brazil
Asia	Bangladesh
	Lebanon
	Palestine
	Israel
	Vietnam
	Iran
	Pakistan
	Korea
Europe	Albania
	Belgium
	Corse
	Germany
	Greece
	Ireland
	Italy
	Malta
	Poland
	Portugal
	Spain
Africa	Tunisia
	Cape Verde
	Tanzania
	Comore
	France
	Libya
	Kenya
	Morocco
Oceania	New Caledonia

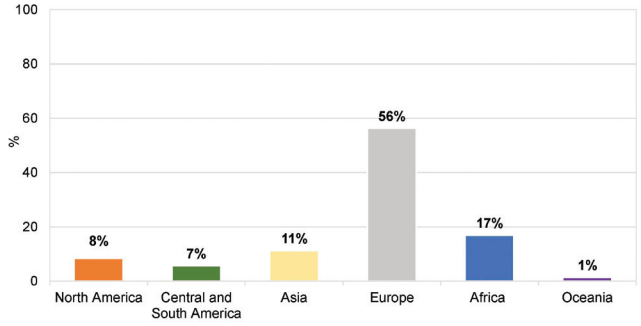

Fig. 1 - Geographical distribution of coastal aquifer involved in the CAD-CZM network website.

Fig. 1 - Distribuzione geografica degli acquiferi costieri compresi nel database del CAD-CZM network.

Results and discussion

Based on the information gathered up during a recognition of collected data, a state of the art about the coastal aquifers was defined, in order to compile a set of databases and specific information that will be useful to evaluate the seawater intrusion assessment all over the world.

Seawater intrusion, both natural and man induced, from lateral seawater penetration to upconing from below, are the main salinity sources of the case studies (63%), following by surface contamination (19%) and mineral dissolution (11%) (Fig. 2).

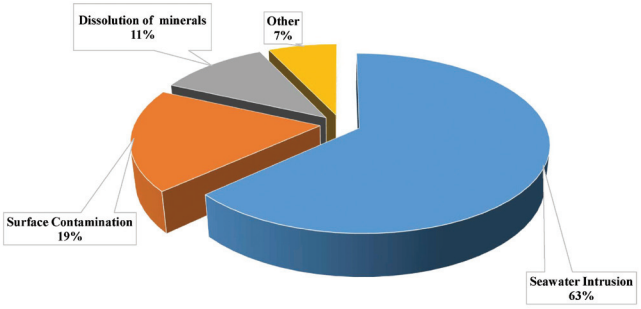

Fig. 2 - Main salinity sources of coastal aquifers.

Fig. 2 - Principali fonti di salinizzazione degli acquiferi costieri.

The measurement of seawater intrusion, considering the strictest definition in terms of a moving interface, requires temporal investigation of salinity changes (Custodio 1976). For this reason, an accurate delineation of the extent of seawater intrusion in coastal aquifer is difficult due to the scarcity of water salinity measurements, even if various authors (Custodio 2010; Morgan et al. 2015) propose many summaries.

Coastal aquifer monitoring often requires a multi-disciplinary approach, as single techniques usually fail to provide unique answers.

The main investigation methods extracted from the filled questionnaires can be divided into two main categories: physical (73%) and chemical surveys (27%).

Water level measurements (28%) and electrical conductivity and temperature profiles (26%) are largely used to evaluate seawater intrusion because they are not very expensive and the instruments are easily available (Fig. 4). The large electrical resistivity contrast between seawater (0.2 Ωm) and freshwater (> 5 Ωm) makes the geophysical techniques a reliable investigation methods to map the subsurface groundwater salinity distribution in the aquifers. Direct current (DC)-resistivity and electromagnetic (EM) methods, in particular, have been applied successfully in coastal areas (26%) (Fig. 3).

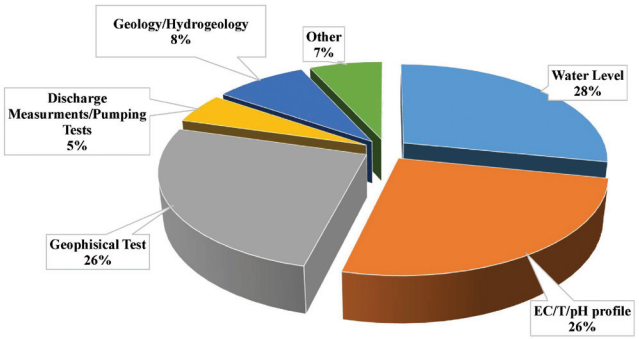

Fig. 3 - Main physical investigation methods distribution.

Fig. 3 - Distribuzione percentuale dei principali metodi fisici utilizzati.

Other seawater intrusion indicators include water chemistry characteristics (67%) that infer historical salt transport processes and applications of environmental tracers (33%) (Fig. 4).

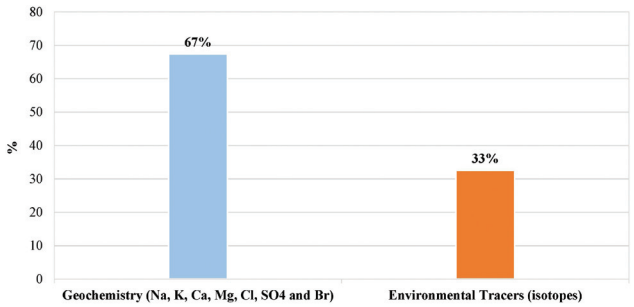

Fig. 4 - Chemical investigation methods distribution.

Fig. 4 - Distribuzione percentuale dei principali metodi chimici utilizzati.

Conclusions

The CAD-CZM network website has been successfully implemented to improve the continuous exchange of knowledge and information on hydrogeological process dynamics in coastal aquifers. The main objective is to allow water managers, groundwater users and researchers an easy access to the most current data about coastal aquifer that are available and to improve the most effective long-term management strategies for water resources endangered by saltwater intrusion.

To better understand the seawater intrusion assessment in sustainable water management, about seventy aquifers

from 31 countries were collected and analyzed with respect to lithology, hydrogeological and geochemical characteristics, salinity sources, special features, applied monitoring methods, numerical modelling, management strategies, and seawater and brackish groundwater desalination technologies adopted.

The data harvested has been used for the compilation of a coastal aquifer database, whose main goal is to provide information about major salinity sources and investigation methods adopted worldwide. The data collected so far on coastal aquifers from all over the world constitute the basis for a comparative analysis of the most adopted investigation and monitoring methods for seawater intrusion, vulnerability mapping, groundwater protection technologies, and institutional planning and management. The network is open to non-member specialists who might be encouraged to join IAH and contribute to development of knowledge on coastal water resources management.

The life and utility of this website depend on the capacity of all technical and scientific people involved in coastal aquifers studies and management to feed it by updated information on this important subject. Future activities of this project are related to the implementation and updating of the coastal aquifer website and the creation of a database in SQLite in order to store, update, change, and query data collected. SQLite is the most used database engine in the world because SQLite is a C-language library that implements a small, fast, self-contained, high-reliability, full-featured, SQL database engine.

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