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Real-time monitoring system for the detection of saline wedge in the Magdalena River- Colombia

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Abstract

This article aims to socialize the results of the development and implementation of a system based on IOT for aquifers, with its application in the estuary of the Rio Magdalena in Colombia. The SISME software supports the identification processes of different factors that can influence the appearance of the saline wedge in the navigable channel of the river. These aspects bring about the improvement of maritime safety and, in turn, allow us to know different aspects related to behavior through continuous sensing of the river. This article shows both the characterization of this river as well as studies related to it and the location of the sensors and description of the software developed.

Keywords: Magdalena River, IOT in Acuifers, Saline Wedge, Monitoring System.

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1. Introduction

In Colombia, the direct discharge of sediments from the Sierra Nevada de Santa Marta to the Ciénaga Grande comes from three main basins of the Sevilla, Aracataca and Fundación rivers. Together, the area of the basins is 2,700 km2; about 6 times larger than the area of the lagoon. The Aracataca River rises at an altitude of 5,000 m in the glacial lagoons of the Sierra and runs for about 45 km to its mouth. The Seville River rises at 4,000 m above sea level, traveling 36 km. The Fundación River rises at 3,000 m and travels 60 km. It should be considered that according to [1], the water that enters the lagoon system from the Magdalena River carries sediments at an average concentration of 0.636 kg / m3, contributing about 100 tons per year, of which 67% are sediments. clay, 32% silt size and only 1% sand size. The mixture of fresh river waters and salty seawater causes the formation of horizontal and vertical salinity gradients, the characteristics of which depend on the river flow and its seasonal variations, the amplitude of the tides, and the energy of the waves. and the morphology of the estuary. It may happen that as the tidal and wave energy increases, the exchanges between the salt wedge and the freshwater layer lead first to the establishment of a vertical salinity gradient (partially mixed estuary), and then to a mixing intense between salty and fresh waters (vertically homogeneous estuary, while there remains a horizontal gradient of increasing salinity downstream and a lateral gradient due to the Coriolis force. In the first state, the particles are transported by tidal currents and by the river current. In the second case, the particles come mainly from the sea, and are transported mainly by tidal currents. Note that the stratified, partially mixed, or vertically homogeneous structures can alternate in the same mouth according to the seasons or as a function of climatic accidents, as occurs with the interaction of the Magdalena River current when it meets the littoral current and the Caribbean tides.

In this article, section 2 shows general information on the Magdalena River, section 3 details different previous studies that have been related to the aquifer. In section 4 it is explained where the sensors are in the navigable channel and in section 5 the details of the software developed are shown and finally the conclusions are shown.

2. Generalities of the Magdalena River

As it is a fluvial area exposed to oceanic meteorological conditions, it was decided not to use the information available from Barranquilla, replacing it with the studies carried out in a project led by the ARC “Barranquilla” Naval School of NCOs called “Consolidation of the environmental baseline (description, diagnosis and prospecting) of the coastal marine zone of the Atlantic department, which contributes to the design of strategies and delimitation of environmental management units ”that characterized the coastal wind conditions by areas or sectors of the department. In the case that concerns us, the characterization of the north zone will be used.

Dry season (North zone): Winds with speeds of 11.9 and 13.9 m / s occur with probabilities of occurrence of 55% and 95%, respectively. In the case of the winds, it was observed that the NNE direction is significant, with a probability of occurrence of 38%. The wind speed exceeded 12 hours a year in medium regime is 15.5 m.

Transition time (North zone): During this period, the atmospheric conditions are influenced by the decrease in the northeast trade winds considerably, oscillating between 0.1 and 13.7 m / s in intensity and on few occasions exceeding 12 m / s. The direction is highly variable, prevailing winds from the NE and NW quadrants. The predominant wind direction is NE with a probability of occurrence of 41%, with speeds 7.3 and 11.8 m/s for probabilities of non-exceedance of 50% and 99%, respectively.

Humidity Season (North Zone): The winds present a variable direction, coming from the NE and NW quadrants, the predominant direction is NE and the NNE, ENE and N components intensify with magnitudes of 11.2, 9.7 and 7.9 m / s respectively, for probability of non-exceedance of 99%.

3. Related Studies

Study carried out by the Caracolante mission, in the Colombian continental shelf of the Caribbean, allow to suppose the existence of "cyclonic cells" of current. The origin of these cells may be the result of the joint effect of the Caribbean current and the coastal counter current, (hypothesis that must be verified on subsequent cruise, with current measurements and drift buoys). A preliminary survey at the mouth of the Magdalena delta also indicates its counter-current effect on the diffusion of fluvial waters and for the dispersion of suspended effluents into the sea. The dispersion of suspensions on the surface is carried out essentially in the axis of the river. On the surface, the turbidity spot is uniformly established around the mouth and under a slight thickness of water, further out, the concentrations remain below 2mg / l except in the east of the mouth where turbidity remains important. The predominant circulation of the waters is related on the one hand to the strong flows of the river that throw most of the particles in suspension in front of the mouth and on the other hand the influence of the counter-current, strong and of great magnitude in this time of year. The importance of this counter current can also be evidenced in favor of the observations obtained by satellite photographs that allow an instantaneous glance on the marine surfaces influenced by these effluents and on the variations in the concentration of these suspended matters.

In the multi-temporal analysis carried out by IDEAM from 1980 to 2000, the channel of the Magdalena River was identified. For the lower Magdalena area, which is the one of our interest, the following map was made, see figure No 1. The exchange of water with the sea takes place in the large swamp through the mouth of the bar, which is the passage for tidal currents and other currents generated by wind [2],

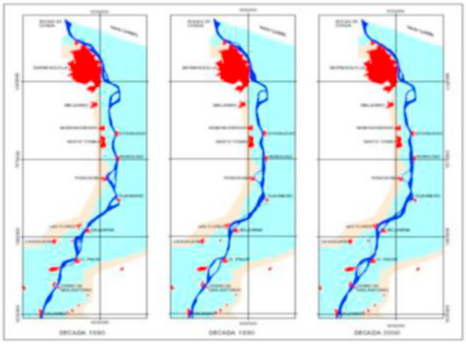

Fig. 1. River dynamics from 1980 to 2000 Source IDEAM.

The ebb and flow currents in the mouth are responsible for keeping the channel open, however, the imbalance generated by the shortage of fresh water in the lagoon system has affected them. Another mechanism of water exchange with the sea occurs throughout the island of Salamanca as subsurface deposits conditioned by the permeability of the substrate and underground flows [1]. The precipitations: they are considered scarce. In the coastal zone they vary between 760 mm per year in the west and 400 mm per year in the east. There is little information on the variability of rainfall from north to south, see figure No 2.

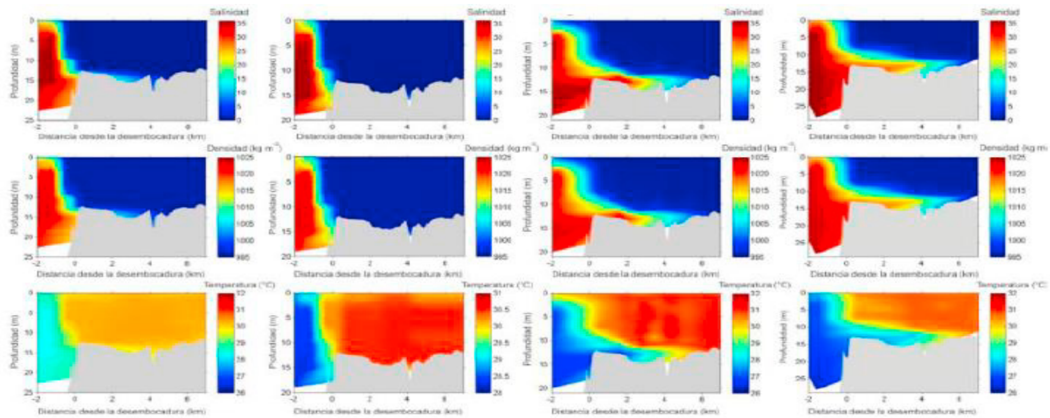

Fig. 2. Axial spatial distribution (along the deep channel) of salinity, dendensity,d temperature, measured at the mouth of the Magdalena River: (a) November 29/2012, (b) November 30/2012, (c) April 20 / 2013, and (d) April 21/2013[3]

In it, it is shown that for the dry and transitional season the saline wedge can have different effects reaching up to 4.54 km upstream from the mouth in the month of November, while for April the intrusion reached up to 6.94 km [3]. The Coastal Observing System for the North and Arctic Seas (COSYNA) was established to better understand the complex interdisciplinary processes of the North Seas and Arctic shores in a changing environment. Observations are carried out by combining remote satellite and radar sensors with various on-site platforms. They have developed new sensors, instruments, and algorithms to further improve understanding of the interdisciplinary interactions between the physics, biogeochemistry, and ecology of coastal seas, using new modeling and data assimilation techniques to integrate observations and models into a quasi-system. operational that provides descriptions and forecasts of key hydrographic variables [4]. Unlike them, in this project remote sensors will be developed by GSM, or cellular band, which make the efficiency of the system better and require less power to use, reducing costs in power supply amperage.

The United States Coast Guard (USCG), the United States Navy and other and port security units routinely conduct underwater inspections for a variety of mission requirements, including self-propelled semi-submersible (SPSS) detection and small submarines, indoor safety inspections (i.e. detection of contraband, foreign objects, explosives, weapons of mass destruction (WMD). Low-cost, multiparametric, expandable and wired Coastal Seabed Observatory (OBSEA), located 4 km from Vilanova i la Gertru, Barcelona, at a depth of 20 m, it is directly connected to a land station through a telecommunications cable . The land station is connected to a submarine telecommunications cable that extends 1,000 m from land to the main node of the sea. The cable, which is made up of six single-mode optics. fibers for data transmission, a central copper conductor tube and an aluminum shielding foil, allow continuous transmission of data and power [5].Submarine channel estimation study based on placement of different nodes in shallow water. This article examines channel estimation parameters such as channel impulse response, coherence bandwidth, BER due to delay for MSK receiver Differentially detected and transmission loss impact of underwater node placement in three scenarios (land-based, buoy-based, and horizontal point-to-point sensor node) [6].The work carried out by the City University has been the development and introduction of the monitoring of the water column with a system called DataBuoy. This multiplexed unit of data from up to 5 sensor packages suspended at different depths in the water column below a floating buoy. Each package of sensors measured temperature, salinity, and light intensity, and fed the result back to a multiplexer. The data was sent through a MODEM to a PC. The DataBuoy I system consisted of a single buoy with a single string of sensors under it [7].

4. Sensor's location

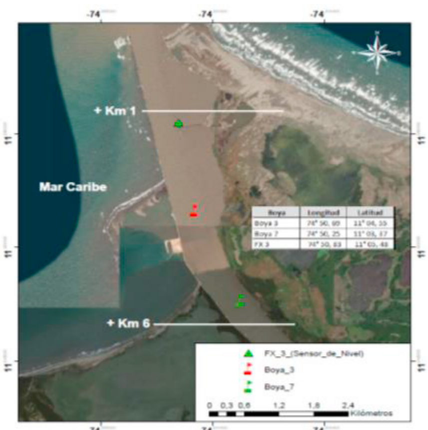

Fig. 3. (a) Sensor's locations (b) Bouys's Description.

For the proper functioning of the system, a set of buoys were located, which are equipped with conductivity, temperature, and pressure sensors, see figure 3 b. These sensors emit signals every 15 minutes from two buoys located at kilometers 3 and 5 of the navigable channel of the Magdalena River as shown in figure No. 3a.

5. Software Description

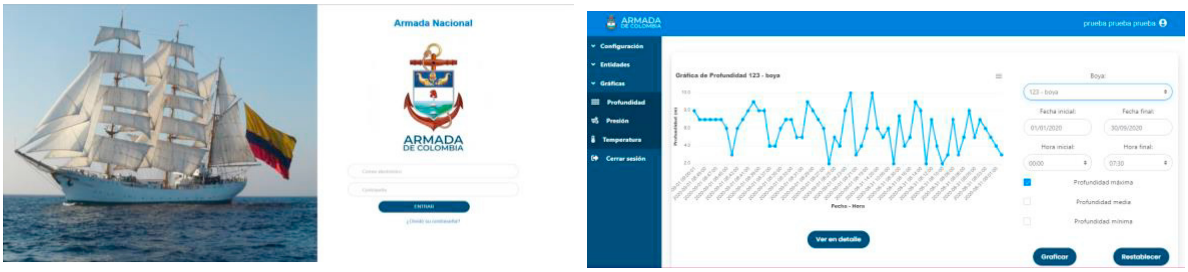

Fig. 4. (a) Initial screenshot of the software. (b) Visualization of graphs in real time

The application that analyzes in real time the saline wedge of the Magdalena-Colombia River, called SISME [8]. It is an application developed in the node language based on javascript, which has the components of the predictive models developed in phyton. For the data storage aspects, the mysql database was used, which uses a client-server architecture that allows the interaction between requests and responses. Through this interaction, the data from the buoys is taken in real time, which is processed through an interface and is displayed to contribute to the decision-making processes. Once the development of the management modules was completed, the next step was to install, configure and deploy the application on a server in the cloud. For this, AWS technology was used from Amazon, making the correct and detailed security restrictions. Amazon provides by default a temporary ip that once the server is turned off will change, which could generate a problem in the future given that the instability of the url it may cause packet loss. For this, an elastic IP has been configured, service available on Amazon that allows you to take a fixed IP with which you can always access packages with a fixed url. The default servers in Amazon come without being able to be accessed by any port, access to the server has been established via encrypted key under the SSH protocol, protocol of high security to be able to access to configure it, for it through the Firewall referred to by Amazon as Security Group, it has been established that it can only be accessed through the SSH port from a single computer ensuring that only one user can configure it and avoiding attacks by hackers who want to access the information. The database will be hosted in an independent server for security and under an Amazon service called Amazon RDS. High-capacity request service and a data backup system programmable, allowing to generate backup copies of the data in an automatic and periodic.

6. Conclusions

In the development of the project there were changes with respect to the materials to be used, this due to the fact that the cost-benefit ratio was sought, firstly, a practical and economical conductivity sensor was designed, the conditioning of this signal was carried out with a bridge of weanstone and AC / DC converter to amplify the output signal obtained and eliminate noise in it, but this sensor must be changed by the material that performs the sensing, it does not read for marine salinity; Therefore, an investigation is carried out in databases such as IEEE xplorer and scopus, obtaining the Atlas Scientific factory sensor with a long duration and a high cost-benefit percentage.

We proceed to carry out tests with this conductivity probe, in the different saline solutions that it brought as a factory sample, making an equation of the relationship between measured voltage, tested salinity level, to obtain the code in the Arduino program and in This algorithm will perform the salinity voltage conversions, and first send the sensed values through the Arduino serial monitor.

In an initial idea, the system had to be made with three buoys, which would transmit data to a reception point, for which the power supply for these three buoys was mathematically designed; but in the development of the work with the cabin boys, only the power supply for a single buoy with a single conductivity sensor was designed and implemented.

Then, the simulation was carried out in the proteus and Arduino software of an LM35 temperature sensor to convert degrees centigrade to voltages and display them on an LCD screen, for when the temperature sensors were available, the voltage temperature tests will be carried out and change the resolution for the input data.

Subsequently, the Arduino Uno board was changed to Arduino Mega to incorporate the three DS18B20 temperature sensors, making a change in the previous Arduino programming, since these send 6-bit binary words for read values, unlike the LM35 used in simulation.

Additionally, the GSM / GPRS SIM900 Shield module was used, which sends the data transmitted by the temperature and conductivity sensors through a cellular network to a PC through the Blink web application server. Taking as a limitation the cellular network coverage in the area where the system will be implemented.

Finally, the mathematical design of the power supply system was carried out for a single buoy that transmits data to a receiver.

Among the highly relevant aspects in the implementation process, the following can be highlighted: Count for the first time in history with a system that can monitor variables in real time in this estuary. Being able to analyze the behavior of these variables in real time will allow future work to contribute towards government decision-making. Among the future works is the expansion of the sensor network that may allow to have a greater range and to know the variability of the measurements in different stretches of the river.

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