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Design of Scada System for Zeolite Purified Water using Labview

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Introduction

Water is an essential resource for life, however, due to the constant worldwide population growth, this consumption also increases every time (García-Loor *et al*., 2020). Previously, civilizations used water from natural sources, such as rivers or lakes, but the pollution generated by globalization has caused the presence of physical, chemical, and microbiological agents in these sources. Water is used in agriculture, industry, and consumption by 70, 19, and 11 %, respectively (Bernabé-Crespo *et al*., 2021). An alternative to this problem was to provide drinking water, organizing storage and distribution systems for this resource. Guarantee the quality of water for human intake has become a challenge, because it is exposed to harmful substances and microorganisms that affect the health of people if they consume it directly (Simbaña *et al*., 2022). There are several scenarios related to this problem, such as the discontinuity of the service, and the conditions of the domestic distribution lines, among others.

South American countries have abundant water resources, but more than 30 % of the population does not have drinking water, particularly in rural sectors (Cuenca *et al*., 2021). In Ecuador, there is a consumption of 249 liters of water for each inhabitant per day and the National Institute of Statistics and Censuses (INEC) affirms that 79.3 % of the water is not contaminated and the remaining percentage is exposed to polluting agents (Castro-Vázquez and Tenesaca-Quishpe, 2022). Cadme-Arévalo *et al*. (2021) indicate that 36.5 and 16.7 % of households in the urban sector have received drinking water with a bad taste and odor, respectively. Also, more than 55 % of people who have directly consumed water have had gastric diseases, mainly diarrhea. Arellano and Lindao (2019) affirm that there is distrust in the population to drink drinking water, due to the related possible diseases, therefore, more than 87 % of people prefer to consume bottled water.

According to the World Health Organization (WHO), in the Water Quality Guidelines, drinking water must be protected to avoid microbiological contamination, especially from fecal agents. Due to economic activities in rural sectors, such as agriculture and livestock, this resource has a greater probability of containing harmful microorganisms and being exposed to environmental contamination. More than 90 % of the analyzed samples contained bacteria, *Escherichia coli* being the most present, which affects the gastrointestinal system and can cause stomach upset, nausea, vomiting, and diarrhea. This problem is caused by the lack of water treatment and filtration systems, besides to the fact that rivers have been treated as wastewater receptacles. *Cryptosporidium* is another microorganism of fecal origin that causes diseases, either by direct consumption of water or indirectly, by ingesting food irrigated with contaminated water (Hernández-Gallo *et al.*, 2019).

A constant technological advance is necessary to satisfy the population's requirements, however, it generates pollution that has caused climatic changes and effects on the atmosphere. This contamination has changed the natural distribution of water and the natural filtration systems towards the sources utilized (Ruiz-Martínez *et al.,* 2021). However, there are still several elements that contribute to water filtration, the capture of contaminants, and moisture absorption, such as zeolite. Zeolite is a type of microporous mineral 70 % used worldwide for water treatment systems and which works through an ion exchange (Gallo-González & Vásquez-Rodríguez, 2021). Water that comes from underground sources contain certain heavy metals and alkalis that can be harmful to the health. Something similar occurs with water distribution pipes, that due to wear and tear can contaminate the water. The granulated zeolite reaches to contain up to 66 % of the Arsenic that is present in water (Rubio-Arias *et al*., 2021). This water quality management process in Ecuador is controlled by the National Water Secretariat (SENAGUA), for the analysis of organic matter and metal content that may cause an unpleasant taste or odor in water for human intake (Ramírez-Palma *et al.,* 2019).

The purpose of a SCADA system is based in remote terminals for input of operational information, that is recorded and sent to a control station. Hence, labor in operation and maintenance is reduced by requiring only an operator to supervise and generate command actions remotely. The way to operate the control station must be simple, therefore, it is necessary to present a visual interface that is easy to understand. Babu *et al*. (2021) define the importance of a human-computer interface (HMI), which consists of displaying the information collected by the sensors through a screen. Then, the operator knows the instantaneous values of water flow from the pump, the water level that is contained in the tank, and other parameters. Even though a filling process is already supervised and controlled, it continues to have productive effects due to human interaction. For this reason, technological advance is related to the development of more efficient microprocessors and programming methods that allow working at a higher pace. A constantly advancing software is Laboratory Virtual Instrument Engineering Workbench (LabVIEW), an instrumentation tool that works in multi-node processes with numerical analysis of measurement devices for a friendly visual interface presentation. The mechatronic intelligence in the measurement, identification, and control of water level control systems was analyzed by Olejnik & Awrejcewicz (2022). Literature about intelligent machines and mathematical methods for industrial water control systems with SCADA was reviewed. The validity of an analytical and predictive result using LabVIEW considered the analysis of obtained results experimentally, emphasizing that a hybrid system is an appropriate alternative if economic resources are available.

Nanda *et al.* (2021) presented the design and real-time implementation of smart water management using LabVIEW and the Internet of Things (IoT). With IoT, people interact with machines, devices, sensors, and other ones, through network communications to transmit and receive information. Electronic sensors connected to a 34-pin processor linked to a computer that also works with Wi-Fi were used. All operation data is sent directly to LabVIEW to be pre-processed and display results in the interface of an IoT center. A system for level supervision and control was proposed using a web application, where management activities can be carried out. Another monitoring system for bottled water using IoT and LabVIEW was presented by Devan *et al.* (2019). The wireless connectivity from the sensors to applications for the control of a SCADA system was proposed. The conservation of natural resources and the reduction of water waste were mentioned as important, identifying those various daily used devices that contribute to automated processes, making it possible to present alternatives towards sustainable development with modern technologies.

Water supply systems for human intake will necessarily adhere to the regulation of good manufacturing practices of the Ministry of Public Health. There are requirements to consider the water consumable, based on the INEN 1108:2014 standard (2014). In addition, the Constitution of Ecuador in article 60 indicates that the human right to water implies free access and use of surface or groundwater for human consumption. This is as long as this consumption does not divert from their channel or discharge discharges or produce an alteration in their quality or a significant decrease in their quantity, nor affect the rights of third parties and under the established limits and parameters (Asamblea Constitucional del Ecuador, 2008). The objective of this work is to present a data acquisition and control system using LabVIEW during the filling process in a tank that contains water for human intake that has been purified with zeolite filtration. The document is distributed as follows: the methodology presents the characteristics of the elements used and the configuration in the software. The results describe the obtained information during the simulation, which is discussed in Conclusions, indicating whether the investigation is correctly planned.

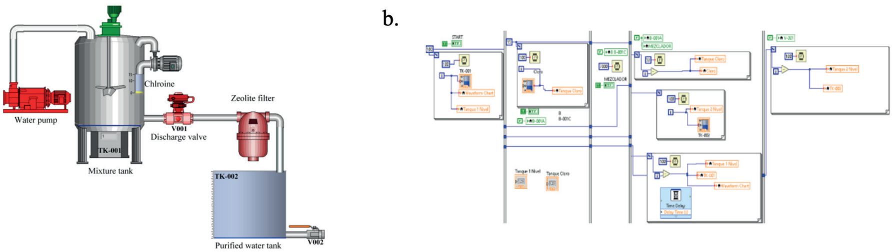
Methodology

System description

Zeolite has a better solids retention capacity, besides this type of filter can retain particles of up to 5 µm (Burgos & Agudo, 2015). Figure 1a presents the disposition of the required components for the water distribution and filtration system. There is a water pump that leads the water to the tank, where chlorine is added in the first stage of purification and it is mixed with paddles. At this stage, there is a sensor for water control and chlorine level. Previously treated water is conducted through an outlet line to a discharge valve, that regulates the required pressure. In the final stage, the water flows through the zeolite filter where impurities are retained, guaranteeing the human intake. Block diagram constitutes the source code, it allows the implementation of the program to control the water flow. It also executes any processing of the inputs and outputs that were created in the panel *front*. Figure 1b presents the diagram with a wide variety of blocks for the water filtration and distribution system for human intake. It is important to mention that these elements perform an important role within the block diagram.

Figure 1
Components for the water distribution and filtration system a) disposition, b) block diagram

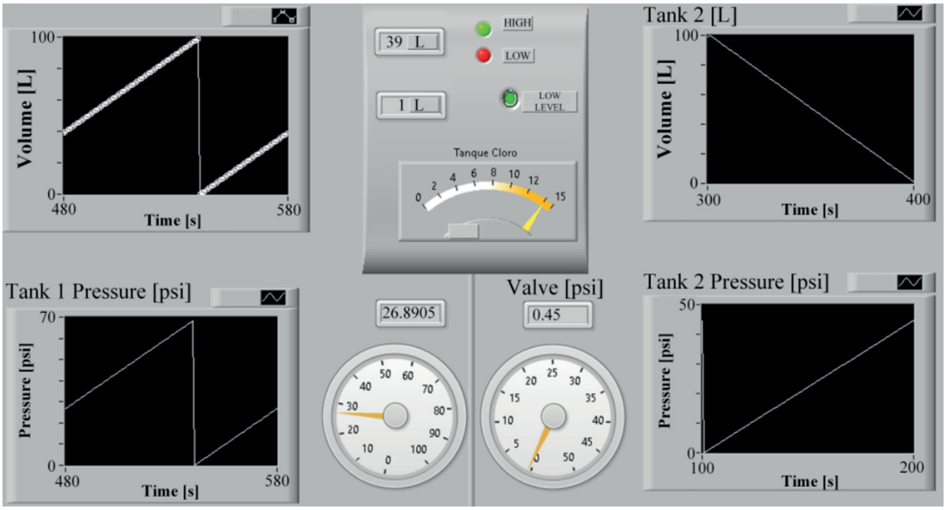
a. b.



Results

To start, a dynamic interface but at the same time simple was made, where the process and control to select data to be analyzed are observed with simulation options and flow charts. Configuration presents the Start Menu to access the simulation or the data graph. When accessing the first simulation option, an interface can be seen where the water SCADA system is simulated. The Data Graphic Option leads to the interface, visualizing if there are losses within the system, as well as the tanks filling. The analysis of results is developed according to the programming, linked to each tank. Figure 2 presents the general indicator since there are two graphs per tank and the process is monitored with a simple interface for reading the operating parameters to be considered. It shows the volume filling graph in the mixing tank, as a function of time and a graph with the fluid pressure variation inside the mixing tank, measured by a manometer. This analysis considered the programming that reflects whether the filling of the tank is correct or if there are leaks within it. In this way, it is verified that the filling process of this tank is carried out normally. It has also been verified that the system is operating correctly, without the presence of unexpected pressure drops due to leaks.

Figure 2
General Indicator for plot results



Conclusions

During this investigation, the information from different scientific databases was reviewed to know the operation and programming of SCADA systems. The different water filtration systems were also reviewed, determining that the zeolite filter is the one with the highest purification. This filter contains activated zeolite that guarantees filtering and disinfection of water for human consumption. LabVIEW software was used to execute the block diagram according to the main components of the system. From the results obtained when carrying out the simulation, it was defined that the volume of water belongs to the capacity of the tank, corresponding to the geometry of 510 × 510 × 830 mm, with a pressure of 10 bar. A pressurized system inside the tank was analyzed, therefore, the simulation allowed obtaining a maximum pressure value of 4.75 bar (68.96 psi), in an adequate working range for liquids.

The pressure change at the time of discharge has been considered to complete the filtering process, as well as other elements that provide characteristics, such as the valve that is implemented due to the greater mechanical resistance to hydraulic pressure. During the simulation, the measured pressure reached 3.10 bar (45 psi) as the maximum value. When analyzing the pressure difference in the distribution system, it was defined that, in operation, when the system unloads the first tank and empties, the pressure drops completely due to the absence of liquid. When a new load is started, the values return statically and behave in the same way before a new process. The presentation of this work has raised the design of the water distribution and filtration system for human consumption so that its future implementation is viable.

References

Arellano, A., & Lindao, V. (2019). Effects of water quality and management on bottled water consumption. *Novasinergia, 2*(1), 15-23. https://n9.cl/jp7ksq/

Asamblea Constitucional del Ecuador. (2008). Artículo 318. En *Constitución del Ecuador* (p. 95).

Babu, C., Jayakar, S., Rajesh, T., Saran, G., Thayaniti, C., & Kumar, A. (2021). An Investigation of HMI-based PLC-PID for Automatic Quality Water Distribution System. *Smart Technologies, Communication and Robotics, 1*, 1-7. https://n9.cl/k5ota/

Bernabé-Crespo, M., Tudela-Serrano, M., & Gómez-Espín, J. (2021). Water supply management in a semi-arid region: analysis of potable water consumption in Campo de Cartagena – Mar Menor, Southeastern Spain (2010-2019). *Boletín de la Asociación de Geógrafos, 88*, 1-34. https://n9.cl/ljd3v /

Burgos, E., & Agudo, D. (2015). *Análisis de la eficiencia de filtros a base de zeolita para la remoción de contaminantes en el agua proveniente de dos pozos de abastecimiento público en el recinto Tres postes, cantón Alfredo Baquerizo Moreno*. ESPOL-FICT.

Cadme-Arévalo, M., Rojas-Uribe, L., Arreaga-Cadme, T., Cedeño-Moreira, A., González-Osorio, B., & Saltos-Vásquez, L. (2021). Servicios de agua potable, saneamiento básico y problemas de salud asociados al consumo hídrico en el cantón Quevedo, Ecuador. *Ciencia Latina, 5*(5), 10301. https://n9.cl/go5wl/

Castro-Vázquez, R., & Tenesaca-Quishpe, P. (2022). Microbiological, physical and chemical quality impact the quality of drinking water. *Revista Electrónica Multidisciplinaria de Ciencias Básicas, Ingeniería y Arquitectura, 4*(1), 317-342.

Cuenca, J., Gallardo, K., & Domínguez-Gaibor, I. (2021). Ecuador Social perception of the quality and service of drinking water in El Coca City. *Green World Journal, 4*(1), 1-16.

Devan, P., Poovethan, K., Kumar, C., & Kumar, R. (2019). IoT Based Water Usage Monitoring System Using LabVIEW. *Smart Technologies and Innovation for a Sustainable Future*, 205-212. https://n9.cl/6cihg/

Gallo-González, A., & Vásquez-Rodríguez, G. (2021). Use of zeolites to controlling nonpoint sources of water pollution: a review. *Ingeniería del Agua, 25*(4), 241-246.

García-Loor, E., Chávez-Wilson, J., Loor-Zambrano, H., & Córdova-Mosquera, R. (2020). Purifying plants: Reality of bottled water in Ecuador. *Dominio de las Ciencias, 6*(2), 692-705. https://n9.cl/p6327/

Hernández-Gallo, N., Hernández-Flórez, L., & Crotés-Vecino, J. (2019). Application of the Driving Forces Methodology and the OMS model of Social Determinants of Health taking Cryptosporidiosis in Colombia as an example. *Salud Pública, 21*(6), 1-8. https://n9.cl/ggph0/

INEN. (2014). *Norma Técnica Ecuatoriana: INEN 1108*. Retrieved Agosto 23, 2022, https://acortar.link/YPpQpP/

Nanda, I., Shukla, V., Dhanekula, V., Gadipudi, M., Penugonda, V., & Maloji, S. (2021). Design and Real Time Implementation of SmartWater Management using LabVIEW and IoT. *International Conference on Computational Intelligence and Knowledge Economy, 1*, 524-528. https://n9.cl/4da1g/

Olejnik, P., & Awrejcewicz, J. (2022). Intelligent Mechatronics in the Measurement, Identification and Control of Water Level Systems: A Review and Experiment. *Machines, 10*(960), 1-31.

Ramírez-Palma, R., Véliz-Aguayo, A., Garcés-Vargas, J., Moreno-Alcívar, L., Herrera-Brunett, G., & Salvatierra-Barzola, M. (2019). Reducción de trazas de materia orgánica en agua potable mediante la adsorción con zeolita. *Ciencia UNEMI, 12*(29), 51-62. https://n9.cl/heioo3/

Rubio-Arias, H., Ochoa-Rivero, J., Villalba, M., Barrientos-Suárez, E., De la Mora, C., & Rocha-Gutiérrez, B. (2021). Eliminating heavy metals from water with filters packed with natural zeolite of varying sizes. *Tecnología y Ciencias del Agua, 4*, 1-47. https://n9.cl/73cj8x/

Ruiz-Martínez, J., Ovando-Chacón, G., Gómez-Rodríguez, J., Ovando-Chacón, S., & Rodríguez-León, A. (2021). Simulación de la separación de una mezcla bioetanol-agua con zeolita natural en lecho fijo. *Congreso Internacional Anual de la SOMIM, 27*, 1-9.

Simbaña, I., Quitiaquez, W., Ramírez, L., & Saquinga, D. (2022). Feasibility study of a rainwater harvesting system at Guamani – Quito. *Unanchay, 1*(1), 47-63.