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A Groundwater Quality Monitoring Frame work, using citizen science approach, in Sudan

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Abstract

Monitoring the level and the quality of the groundwater provides important information about the coverage of the water, the condition of the aquifers, types of water sectors (public or private), the quality of drinking water, and climatic change. To manage water resources needs long term monitoring plans aided by community participation networks.

The main aim of this study is to conceptualize a low-cost frame for ground-water quality monitoring draws on community contribution and participation and on young scientists in Sudan, and addressing citizen science approach, and establish large scale network, in addition, this frame model finding possible trends in the change in water quality.

Meanwhile, a collaborative community participation approach involving local community has been applied to assess the quality of groundwater in Alkalakla South Khartoum, Sudan.

In this case the frame suggested that network participants inter training programs to measure and analysis physio-chemical and biological parameters in their wells by a low-cost instrument such as sensors and smartphones, however, data and surveys can be sent through smart-phones or datasheet on a web-based portal. Quality control and assurances can be applied to manage the data.

The frame model designed to provide stakeholders and can be an extension of government planning information about groundwater quality regularly. Beside shapes the motivation of participants and raised contextual knowledge to close the water quality data gaps, this frame model can be scaled and extended for monitoring of groundwater quality in Sudan. Moreover, it can be a serious alternative of the classical water monitoring program and can be helped stakeholders to solve inevitable change in groundwater quality.

Keywords:* *Groundwater quality; Monitoring; A citizen in science; Participation

Introduction

UNICEF has declared that more than 32% and 22% of the total population don't have access to water in rural and urban areas respectively in Sudan, reports that more than quarter of the population are still using unsafe drinking water [1]. The main water resources in Sudan are surface water such as the river Nile, hafier and wadis, while groundwater is considered to be the most used source of drinking water especially in rural areas. Groundwater provides about 45% of the drinking water from all sources in Sudan [2]. The number of people in need of humanitarian services increased from 4.8 million in 2018 to 8.5 million 2019, whereas, the number of people needing water and sanitation increased from 3.5 million to 5.6 million from 2017 to 2019. [3,4].

Citizen science

The term citizen science appeared early in the twentieth century. The general meaning of citizen science is the engagement of community members in science projects like observing, collecting, processing, responding to data as part of scientific inquiry. One finds good examples in the many fields of ecology and environmental science etc. Since 1900 and every year since then, the national Audubon Society in the USA sustained a project to count certain species of bird at Christmas time; this is done community members in each count area [5]. In the last two decades, this term has been applied to many scientific processes, it has been represented in the monitoring of marine and coastal area [6]. Non-professionals also have been engaged in the field of ecology and climate change; Dickinson et al. describe how they used geospatial technique to understand the distribution, abundance, and life cycles of organisms over time. In addition, ecologists show the contribution of citizen science to building a

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multi-disciplinary database to respond in change in the environment [7].

Citizen science has been used in a wide range of studies in the water sector of in studies in the engagement of community members in collecting data, analysis and quality monitoring in groundwater. [6]. A citizen science approach has been used in hydrology to monitor water levels, and to study the condition of rivers. Mobile phones have been used as a tool for transferring data, with photos of rivers showing water levels (dry, medium and full), flow rate (still, slow and fast) and collections of trash being some of that data [8].

Eight water projects based on community participation in four different states in Sudan have been assessed and monitored; the assessment framework used systematic Secondary Information Collection, And Analysis (SSICA), while weighted sub-indicator analyses have been checked to calculate the sustainability scores, this study showed that almost half of the water projects (40%) are only moderately sustainable, due to weak organizational and financial support, as well as poor implementation performance [9].

Jollymore and his colleagues designed a program to investigate how human activity affects water quality in rivers and streams, and created a web site for this purpose. They applied a split sampling method to evaluate the data collected by participants and researchers [7]. A low-cost water quality monitoring system has been introduced for the Ayeyarwady River in Myanmar, based on the participation of community members. Results from their observations are compared with the measurements collected by lab technicians [10].

There are fewer studies of the contribution of citizens in monitoring the quality and level of ground-water. Baalbaki and his team analyzed 12 physical, chemical and biological markers for ground-water quality in Lebanon; the data is collected by citizen science participants, and the results demonstrate that the data collected by volunteers is comparable with data generated by expertise [11]. Community participation is used to monitor the quality of groundwater in Alberta, Canada this project was studied by little and his colleague. Large water level monitoring network of private wells has been created; volunteers are trained to measure the water level in their wells, and enter the data through a web-based data portal. Their monitoring activity is aided by an educational program [12].

The main goal of this article is to describe a frame work for groundwater quality monitoring based on a participatory approach in Sudan. The community participation encompasses a wide range of activities, meeting a diversity of needs, and it could be part of the democratization of science by engaging marginalized communities.

The frame work has four aspects to it. First, it fills the data gap in water quality by creating a long term, credible data set. Second, it raises people`s awareness about the water quality issue. Third, it educates people about how and why monitoring is done, and explain the result to them. Finally, help the government to take the decisions about water sectors, and to monitor the changes in water quality.

The methods

The model starts with describing a study area in terms of its location, population, sewer of wastewater network, economic activities (factories and mining), the annual rainfall, number of wells in every village, the type of well (public or private), and its geological structure. It also considers whether septic tanks pose a serious problem to the quality of groundwater, the government and universities are involved in reviewing the proposal, the data collection forms, and the surveys related to the project.

In this regards a batch study has been applied to test the framework.

Alkalaka Goba selected to be study area. It located in south Khartoum approximately 18 km from downtown between15.4678° and 32.4856°, at an elevation of 384 m height above sea level. This region characterized by a hot and semi-arid, however, the rainy season in the north between July and September.

There is no official sewer network for wastewater sanitation, most of people using septic tank. As a result wastewater may pose problems in the quality of ground water. Beside water Nile, groundwater considered to be the main source of domestic uses, and it regulated by Sudanese National Corporation of water.

30 samples have been selected from Alkalkla Goba blocks 5 to 11. Volunteers were participated by selecting samples from their houses and working places FIG. 1. An international guideline for selecting samples for physio-chemical analysis has been followed, to determine conductivity, pH, temperature, and calcium concentration. Announcement has been sent to enhance participation in social media through local groups of Alkalkla in facebook.

The need to enhance community participation

Community members can participate in a water quality monitoring program successfully if the management of the project puts in the effort, time and skills. To keep volunteer monitors active inspired and motivated, you can work by the five Rs for volunteer monitoring: Rights, Responsibilities, Recruitment, Recognition and Retention. One of the most common questions asked about this framework is how to engage people that may be unfamiliar and lack skills and training about water quality, especially in a marginalized community. The first step is to understand their cultural values, traditions and language. However, it is also possible that volunteers have the interest to learn new skills, perhaps to help them in school or other professional development. For others, the attraction to the project may be their interest in meeting others with similar interests in outdoor activities [13,14].

These are some tips to encourage participants to provide this important service to their community, but they must understand that a monitoring program stands or falls by their ability to collect and send the data to meet our data quality objectives.

The tips start with the agreement of each participant to be part of the work and understand the importance of their services, to cooperate with staff, be able to ask for help, and beyond asking; they should be open-minded and be flexible in recognizing the needs of the monitoring program.

Our study focused on the baseline of water quality condition in Alklakla south Khartoum to measure, analysis, and monitor the quality of the groundwater. TABLE.1 summaries the main activities, objectives tools, methods of training, types of monitoring, and data quality, assurance which descried by [11].

FIG.1. **Google earth map for selected samples.**

TABLE 1. **Participation matrix.**

Activity	Objective	Tools & equipment	Method of training	Monitoring	Quality control & assurance
Ground water analysis	Select samples from wells	Poly ethylene container	Using standard method of collecting water sample	Depend upon data needs Depend upon data needs	Check monitoring plan and methods regularly.
	Analyse physio chemical parameters	Sensors	Use kits for analysis		Repeat tests randomly.
	Sending data analysis regularly	Smart phone	How to use field data sheet		Establish quality assurance
		light emitting diode LED	Calibration and maintenance of sensors		
			Training Of Trainers TOT)		

Results and Discussion

Volunteers were responded randomly to collect groundwater samples in dry poly ethylene containers after a week. Which 70% were young school students, while the others were adult; teachers, doctors, and accouters. Announcement attached by instructions for collecting the samples. TABLE 2. summarizes physio-chemical parameters.

TABLE 2. **Summarize physio-chemical parameters Alkalakla Goba.**

Parameters	Max	Min	Mean	Stander value	Stdv
Calcium as (CaCO3)	410	117	251.66	75ppm	108.664
Conductivity	1390	110	869.938	500 µs	303.098
TDS	973	77	622.183	500 ppm	212.168
pH	9.5	7	8.2	6.5-8.5	0.66392
Temperature	40	31	34	44 °C	2.62923
Odor					
Color					

Table 2 represents physio-chemical parameters from calcium to conductivity to temperature (n=30). 29 samples showed high conductivity at sampling location 1390 to 590µs which far from WHO standers, on other hand, it showed high correlation with total dissolve salt TDS abut (90.92), due to solubility of minerals in this region, which not meet the accepted stander level of WHO standard. As a result concentration of calcium, TDS and conductivity results analogous with geological structure of the location which dominated alkali rocks. Geologist argued that Khartoum basin is a part of the Blue Nile rift basin system, which located in the north between the White Nile and the Blue Nile and stretches to the southeast across the Blue Nile. The study area formation is an outcrop of Nubian basin sandstone, which contains younger granite from Precambrian-Mesozoic age [15]

There is no high turbidity concentration recorded in all analyzed samples, while seven samples recorded strange odor taste.

Data management

The challenge is to introduce a system that will give reliable data on groundwater from volunteer participants, and will do over time. Data from water samples, surveys and questionnaires from each water source must be summarised in electronic supplementary material, and captured on a smartphone or website. The table below illustrates the survey form. This is on an app which can be downloaded free from an app store.

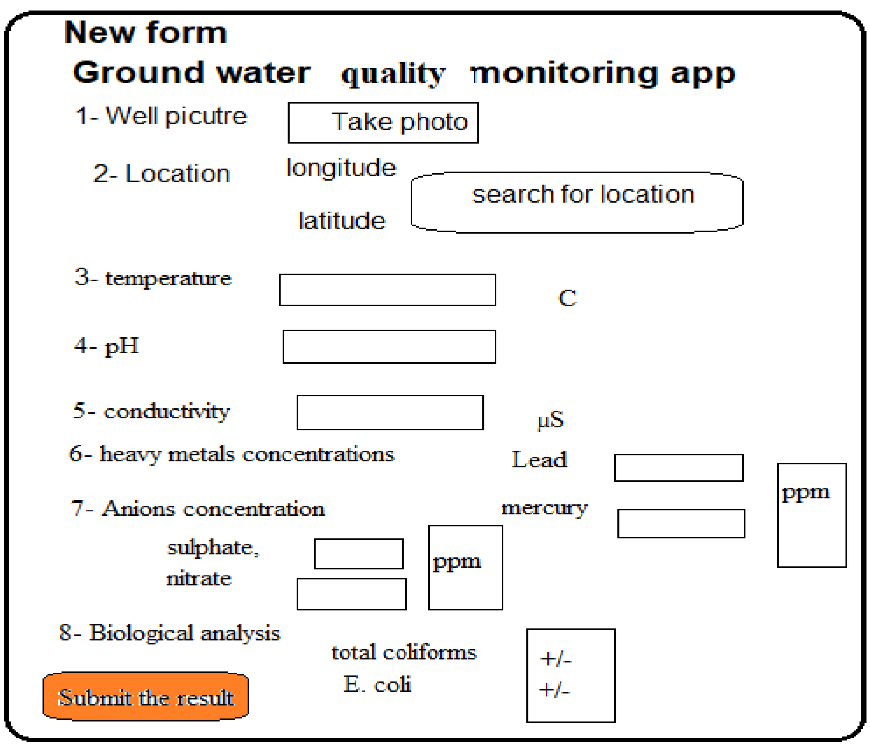

FIG.2. **Flow application and survey form.**

The most critical aspect of citizen science is quality assurance and quality control. The process of achieving this quality differs from project to project due to the nature of each one. Five definitions of data quality for monitoring have been established by the United States Environmental Protection Agency (USEPA) as a road map to data management: accuracy, precision, completeness, representativeness, and comparability [10].

In our project, we have selected accuracy, consistency and completeness as criteria.

- Accuracy: data selected from participants.
- Consistency: Participant's data from two different times is compared with two different researchers' analyses to prove that the participant uses the same procedure every time.
- Completeness: All monitoring network data meet. [16].

Errors can occur in collecting samples, analysing and entering the data. The first step to recover from errors is to enhance the electronic version of the survey form to match what is written in the field sheets. The web-based system should have the ability to correct information automatically, in the case of [no data/unexpected data] after any submitting new data [16].

In addition, one of the most effective ways of achieving success is to involve participants in monitoring the programme. The Xanadu programme has demonstrated a design for evaluating participants: it starts with understanding the connection between what we do on the land and how that affects water quality. The programme suggests that the coordinator should hold a meeting with key volunteers and other intended users to discuss the evaluation's findings [8]. Participants should know that their data will be linked to the database of the government, to serve as an online document for monitoring groundwater quality and activities that affect it. We believe that this database should be made open access to all researchers and stakeholders [17].

Conclusion

This study of the proposed framework aims to illustrate the reliability and usefulness of citizen science as a low-cost means of measuring the quality of groundwater in Sudan. Groundwater quality is dynamic due to its interaction with bedrock and the changing concentration of some chemical elements.

The framework is designed to provide stakeholders with information about the quality of groundwater regularly. The framework suggests building a monitoring network based on community participation and using low-cost tools such as sensors and smartphones for analysis of physico-chemical and biological parameters, linked to the dynamic website. We have proposed a training program for participants, starting from learning how to select samples for analysis, how to operate and use the instruments, and how to communicate with the coordinator by sending the data through a mobile application, SMS or website. To track the monitoring network, the framework explains how can we can manage the data through monitoring and establish quality assurance and quality control, to reach a high degree of accuracy, consistency, and completeness.

REFERENCES

1. UNICEF. World Water Day : 68 percent of Sudan's population with access to basic improved. 2017.
2. Yasin SI, Adam M. Mapping of Groundwater quality in Great Kordufan states with Geochemistry and Health Aspects
3. OCHA on behalf of the Humanitarian Country Team. Humanitarian Response Plan Somalia. In Humanitarian Response Plan. 2015.
4. UNOCHA. Humanitarian needs overview. 2016.
5. Silvertown, J. A new dawn for citizen science. Trends in Ecology and Evolution. 2009: 467–471.
6. Conrad CC, Hilchey KG. A review of citizen science and community-based environmental monitoring: issues and opportunities. Environ. Monit. Assess. 2011;176(1):273-91.
7. Dickinson JL, Shirk J, Bonter D, et al. The current state of citizen science as a tool for ecological research and public engagement. Front. Ecol. Environ. 2012;10(6):291-7.
8. Jollymore A, Haines MJ, Satterfield T, et al. Citizen science for water quality monitoring: Data implications of citizen perspectives. J Environ Manage. 2017;200:456-67.
9. Ibrahim SH. Community-Based Water Projects Sustainability: Lessons and Challenges-A Case study from Sudan. J Public Health Policy. 2016; 2(6):38-45.
10. Thatoe Nwe Win T, Bogaard T, van de Giesen N. A low-cost water quality monitoring system for the Ayeyarwady River in Myanmar using a participatory approach. Water. 2019;11(10):1984.
11. Baalbaki R, Ahmad SH, Kays W, et al. Citizen science in Lebanon-A case study for groundwater quality monitoring. R. Soc. Open Sci. 2019; 6(2):181871.
12. Little KE, Hayashi M, Liang S. Community-based groundwater monitoring network using a citizen-science approach. Groundwater. 2016;54(3):317-24.
13. Herron E, Green L, Stepenuck K. Volunteer management and support.2010.
14. Trani JF, Ballard E, Bakhshi P, et al. Community based system dynamic as an approach for understanding and acting on messy problems: a case study for global mental health intervention in Afghanistan. Conflict and health. 2016; 10(1):1-1.
15. El Tahir N, Nyblade A, Julià J, et al. Crustal structure of the Khartoum Basin, Sudan. Tectonophysics. 2013; 593:151-60.
16. Sheppard SA, Terveen L. Quality is a verb: The operationalization of data quality in a citizen science community. InProceedings of the 7th International Symposium on wikis and open Collaboration. 2011:29-38.

17. Kushner J, Klink J, Stepenuck K, et al. Evaluating Your Volunteer Water Quality Monitoring Program. National Water Resources Project Fact Sheet XVI. University of Rhode Island and University of Wisconsin. 2012.