JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

A Study on Improving the Efficiency of Water Supply System Through Smart and Sustainable Technologies: A Review

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Abstract: Water shortage is the lack of fresh water resources to meet the standard water demand. Water is unequally distributed over time and space. A lot of it is wasted, polluted and unsustainably managed. Improving water infrastructure must be a priority, as water conservation and efficiency are key components of smart and sustainable water management. 50% of world population is going to be under high water shortage according to World Water Development (UN) report.[3] Countries of Africa and Asia like Bangladesh, China, and India who is still developing are likely to face water scarcity more. In developing countries like India, the gap in supply and demand of water is increasing and predominant. Although India has 16 per cent of the world's population, the country possesses only four percent of the world's freshwater resources. By 2050, at least 30 Indian cities will face a grave water risk, according to the WWF (World Wide Fund).[17] The problems range from poor management of water sources, contaminated supplies, leaky distribution networks and vast volumes of untreated wastewater being poured into India's rivers. The scarcity can be reduced or water supply system is being efficient by different governing systems under the smart city project by using Supervisory Control and Data Acquisition (SCADA), Internet of Things (IoT), Artificial Intelligence (AI) and Water Quality Monitoring (WQM). Hence the present study dealt with effective, efficient and smart water supply system, occurrence of water losses and its control.

Keywords **- Water scarcity, Water supply system, Supervisory Control and Data Acquisition, Internet of Things, Artificial Intelligence, Water Quality Monitoring**

I. INTRODUCTION

Water losses are known to be the indicator in India's water management system. Reducing these water losses is ultra-critical to efficient resource utilization, efficient utility management, and enhanced consumer satisfaction. It is frequently found that the reasons for loss of revenue occurs when pipe network is inadequate, through unofficial connections poor information system and bad billing practices and a low level of technical skills and technology. Tax systems and revenue collection often do not reflect the real value of water supplied, which limits the cost recovery of utilities and encourages customers to undervalue the service. One of the major challenges facing water utilities is the high level of water loss in distribution networks. If a considerable proportion of water that is supplied is lost, meeting consumer demands is much more difficult. Since this water yields no revenue, heavy losses also make it harder to keep water tariffs at a reasonable and affordable level. This situation is common in many Indian cities and also a reason for intermittent water supply.

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1.1. Non-Revenue Water:

"Non-Revenue Water" (NRW) – defined as the difference between the amount of water put into the distribution system and the amount of water billed to consumers—averages 50% in the region's cities and can reach much higher levels Non-Revenue Water (NRW) is a good indicator for water utility performance; high levels of Non-Revenue Water (NRW) typically indicate a poorly managed water utility. In addition, published Non-Revenue Water (NRW)data are often problematic, suspicious, inaccurate, or provide only partial information.

1.2. Water Leakages:

Water leakages are being one of the major issues which every county is facing. It comes under cater category of physical loss in NRW type. Water leakages occur due to aging of pipeline which corrodes. Excavation across the road also causes pipe damage. High pressure across the pipe line also causes bursting of pipeline. Leakages are hard to detect as they can be in the pipes which was underground. In underdeveloped countries or major countries there is no automatic detection method present. Leaks are detected by the local people if it is visible. Leakages will also reduce the pressure present in the pipeline. This problem may reduce the efficiency of water supply infrastructure during the peak hours.

1.3. Quality of Water:

There are almost one billion people around the world who don't have pure water supply. Due to pollution and leakages, there is high chance of contamination. Providing pure water from source to tap is a real challenge for African and Asian countries. It is seen that children under 5 years affected most by water contaminated diseases. Diseases like cholera, Diarrhea are the most common diseases of contaminated water.

Water, due to its numerous benefits and the problems created by its excesses, shortages and quality deterioration, water as a resource requires special attention. As on today, the population of India is in excess of thousand million. The urban population would be around 40% and rest will be semi urban and rural. This means a exceedingly large demand on the public amenities including water supply for domestic purposes and additionally more water would be needed for purposes such as irrigation, industry, etc., which have to keep step with the increasing demands of rising population. Therefore, identification of sources of water supply, their conservation and optimal utilization is of greatest importance. Even the present scale of water supply to urban and rural population is grossly insufficient and not all communities are provided with safe water supply, let alone piped water system; barely any metropolitan city has a continuous water supply; and very few cities could boast of providing adequate water supply to meet their growing demands at adequate pressure.

Many facts are involved in tackling the problem of providing protected water supply to all communities at the minimum cost and in the shortest possible time. The planning and design of water supply network requires close attention these days because unproductive water distribution leads to various losses due to which the ultimate goals of water supply such as quality, quantity and pressure are not being achieved.

Effective water distribution system with the study of water supply, occurrence of water losses and its control by improving the efficiency of water supply system through smart and sustainable technologies. One of the technologies through which the effective water distribution can be attained is SCADA which mainly aims at providing drinking water as per the Indian standards and reducing the water wastage during distribution, and thereby attaining controlled supervision on both quality and quantity of water.

1.4. Objective

The main objective of this research is to find out various problems and issues pertaining to water supply system and factors affecting to it.

II. CRITICAL LITERATURE REVIEW

Asian Development Bank (2020) suggested that water utilities worldwide are undergoing a digital transformation, driven by the internet, big data, and AI algorithms. To remain competitive and improve customer service delivery, water utilities need to shift from an "old school" operation, as a result of operating a monopoly with little external pressure, or Hydraulic Modelling 1.0, to a new era of efficiency and accountability, or Hydraulic Modelling 2.0. Application of advanced technologies and techniques, especially AI algorithms, in water supply in general and for the prognosis of UFW in particular. Even though there are many AI tools for many different applications, the most promising ones for water distribution network analysis and UFW estimation are those based on a combination of physically based and data-driven models. Physically based methods are the way forward for water utilities to start their digital transformation into smart water.

Asian Development Bank (2019) study on Smart technology can change conventional water and wastewater systems into instrumented, interconnected, and intelligent systems. By building accurate water balances of each area, losses can be calculated and problem areas targeted for rehabilitation or leakage reduction initiatives. A next step would be to improve asset management. Building a digital spatial database of assets in GIS is important for developing strategic plans for network upgrades and rehabilitation. If assets and networks can be monitored remotely in real time (flow, pressure, etc.) through smart systems, leakage detection, for example, can be undertaken in real time. Water network simulations can also allow real-time decision making to optimize performance as shown in Figure 1.

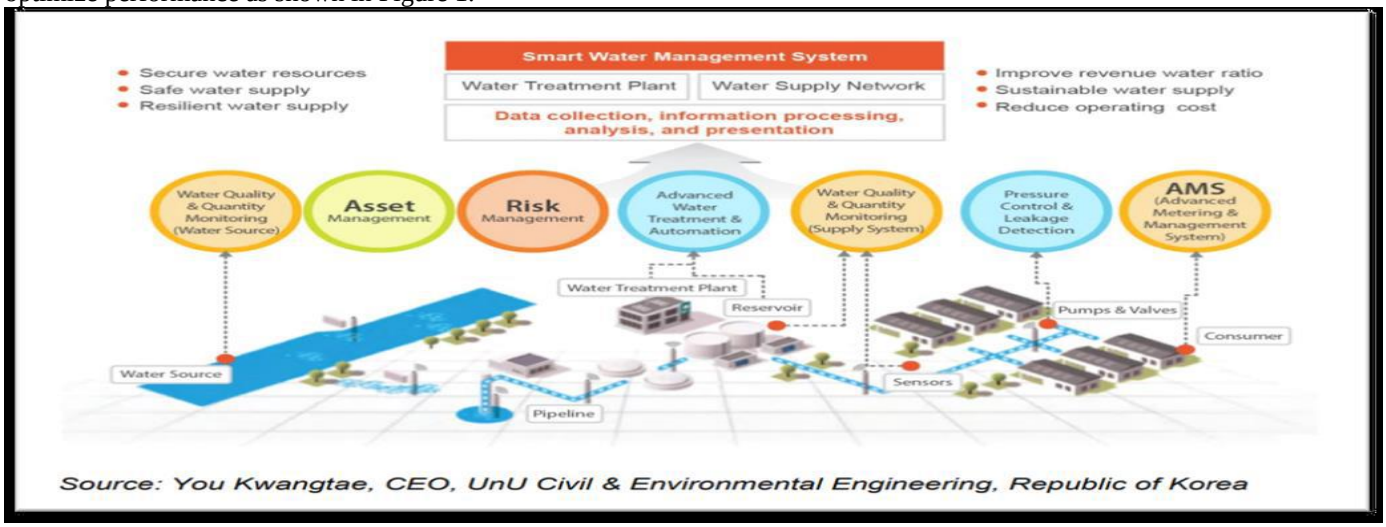

Figure 1: Smart Water Management

Dipali Babubhai Paneria, Bhasker Vijaykumar Bhatt (2017) are explained on A water distribution system is a hydraulic infrastructure that consists of different elements like pipes, valves, pumps, tanks and reservoirs. This infrastructure helps to convey water from the source to the consumers. Designing and operation a water distribution system is the most important consideration for a lifetime of expected loading conditions. Furthermore, a water distribution system must be able to assist the abnormal conditions such as pipe breakage, mechanical failure of pipes, valves, and control systems, power outages and inaccurate demand projections. For modernizing the existing water distribution system as per Smart Cities Mission Statement & Guidelines prepared by MoUD, Smart water management should consist smart meters & management, leak detection, and preventive maintenance, water quality monitoring.

Telecommunication standardization sector of ITU (2014) discussed on water management is closely associated with water resource development and environmental protection, and it also entails proper management of the demand for public services and cost effectiveness. Recognizing the challenges faced by the water sector, stakeholders from academia, corporations and the ICT sector have developed water intelligence tools that use ICTs to alleviate global water issues. The role played by smart water systems in optimizing the efficiency, effectiveness and flexibility of water. ICTs offer valuable opportunities to improve the productivity and efficiency within the water sector, with the aim of contributing to the sustainability of the resource. These technologies allow the continuous monitoring of water resources, providing real-time monitoring and measuring, making improvements in modelling and problem diagnosis, thus enabling proper maintenance and optimization of all aspects of the water network.

Sulaiman Muhammad Gana (2016) described the increasing awareness of water management problems has resulted in a need for information in ground water flow and distribution. There have been various approaches to design water monitoring networks, some of these designs have not been effective and reliable. Optimization of a monitoring network requires that the system be organized and structured with respect to the number of locations of sampling points. Monitoring and control technologies are indispensable for the safe utilization of water. They allow for the surveillance of source water quality, quantity and the detection of threats, thus defining the boundary conditions for the subsequent prevention and providing earl y warning in case of unexpected contaminations or overflow. This paper therefore presents a design of a SCADA monitoring system with a with a radio telemetry technique to monitor the distribution and flow of water from the source to some points.

Shubhada S. Warke (2016) identified that Supervisory Control and Data Acquisition commonly known as SCADA is now days used for variety of application in various sectors around the world. This paper deals with a state of art review on applications of SCADA systems in various areas. The SCADA system can be used for monitoring variety of processes including wind turbine, refinery, water flow, dams, industrial processes, air pollution, and water pollution from remote areas. With the development in technology now SCADA systems are available with many applications and they can be used with variety of intelligent systems. SCADA system is gaining more and more importance now, as world is moving towards sustainable development and becoming more environment conscious, in these scenarios SCADA can be used to monitor many issues related to environment. This paper presents a detailed review on applications of SCADA in variety of sectors like water monitoring, air pollution monitoring, in smart buildings etc.

Shaikh Mudassir Nadeem, Memon Adil Imtiyaz, Prof. Vijayshri Losarwar (2016) focused on Smart cities are the heart of the country, Cities are called smart when they are integrated with smart systems i.e., Water Supply, Electricity Control System and smart communication technology. In our Paper we have developed a demo model of PLC (Programmable Logic Controller) and SCADA (Supervisory Control and Data Acquisition) for Smart city water supply control system in which the process is going to be controlled manually as well as remotely. In this system we have used different components like motor, switches, solenoid valve, sensors i.e., flow sensor, level sensors that can be controlled from system and different values generated through this component are calculated and saved in the SQL database. And by fetching the saved records from the database we are going to display these values on an online portal of our system. The connection made between the SCADA and SQL Database plays an important role in saving the real time data so that the records can be accessed from database itself. This system can be actually implemented in any developing smart city for better improvement of water supply, as the whole process can be controlled locally as well as manually from the panel or our personal SCADA system. Data which is stored in SQL database can be accessed through online portal of water supply system.

Cveta Martinovska Bande1; Gjorgi Bande2 (2016) this paper presents a case study of a SCADA system for monitoring and control of the parameters in water supply system. The system maintains functional parameters and performs continuous supervision of water distribution stations in order to allow any problem to be solved. The control system is organized in a hierarchical structure with three layers. The first layer consists of field instruments, remote terminal units and field control devices. The signals from instruments via transmitters are sent to dedicated PLC panels at the second layer. The SCADA central level contains high speed PC computers for the supervision or operative drive of remote processes. The proposed system allows optimal functioning of the pumping systems, safety of the equipment and installations and efficient water usage.

Ramraje D. Sonvane, Dr. P. B. Nagarnaik, Dr. V.P. Thergaonkar (2016) founded that water audit is an effective management tool for minimizing losses, optimizing various uses and thus enabling considerable conservation of water not in irrigation sector alone but in other sectors of water use such as domestic, power and industrial as well. A water audit determines the amount of water lost from a water supply system and the cost of this loss to the utility. It will quantify Unaccounted for Water (UFW) and Non-Revenue Water (NRW). Water audits balance the amount produced with the amount billed and account for the remaining water (loss). Comprehensive audits can give the utility a detailed profile of the water supply system and water users, allowing easier management of resources and improved reliability. It is an important step towards water conservation and, if linked with a leak detection plan, can save the utility a significant amount of money and time.

R.A. Ganorkar, P.I. Rode, S. A Deshmukh, Dr.R.M. Dhoble (2013) accomplish the world's water resources are finite but exist on a planet with a constantly growing population. The development of water resources to man's benefit has been a fundamental factor in the evolution of civilizations throughout history. But, as our populations continue to grow and shift, the availability of quality water resources is in decline. Pollution, climate change and construction of cities in dry regions are some of the factors exacerbating evolving supply/demand imbalances. Many innovative technologies have been developed in recent times to assist the efficient delivery and utilization of drinking water. Water audits provide a rational, scientific framework that categorizes all water use in your system. It is a tool to overcome drought related problem, shortage, leakage and losses. International Water Association (IWA) / American Water Work Association (AWWA) initiated a large-scale effort to asses reduced above related problem with the help of audit.

Mircea Dobriceanu, Alexandru Bitoleanu, Mihaela Popescu (2008) conducted study on water supply represents a vital problem for people, and this imposes the need to know the information regarding consumptions, resources and production. This implies a continuous supervision of the water supply process in order to allow any problem that could appear to be solved, and in the same time, to maintain normal functioning parameters. Proper solutions imply automation and monitoring architectures which contain: a supervision and control system for the real time installation, programmable logic controllers with basic functions (communication, adjusting, measuring, etc. libraries, communication systems, standard interfaces or dedicated ones with sensors, electrical drive elements, measuring devices, etc. The informatics systems present the possibility of preventing some phenomenon, by analyzing and processing the data, leading to an optimum functioning and to important financial economies. In this way, the paper presents a SCADA system for the monitoring and control of the technological parameters in the water distribution stations, which will allow the optimum functioning of the pumping system, safety and endurance growth in the equipment's and installations exploring, and so obtaining efficient energy usage and optimum administration of the drinkable water.

III. PROBLEMS AND ISSUES PERTAINING TO WATER SUPPLY SYSTEM

- Manually operated field devices
- Wide spread assets
- Multiple users and manual data entry
- Planning of water supply quantity
- Unbalanced water distribution
- Unavailability of accurate data for decision making
- Water leakages- waste of water
- Quality of water and effect on health of citizens
- Unavailability of water for effective distribution at desired time for water department

IV. MAJOR FINDINGS

- Efficient water distribution network is important for deliver water to consumer with appropriate quality, quantity and pressure.
- It is thus very necessary to modernize present installations with latest technology and automation so that the growth can be handled effectively.
- Electronic instruments, such as pressure and acoustic sensors, connected wirelessly in real time to centralized and cloud-based monitoring systems will allow to detect and pinpoint leaks much quicker.
- IoT Smart water sensor can be used to track the flow of water over the distribution channels, helping in leakage detection, to reduce water wastage.
- Artificial Intelligence can improve the efficiency of water supply systems by maximizing information and data available to make better operational and planning decisions.
- Water Quality Monitoring (WQM) is a cost-effective and efficient system designed to monitor drinking water quality which makes use of Internet of Things (IoT) technology.
- Improving the efficiency of water supply system is to provide continual water supply with the state of art automation technology including Instrumentation and SCADA systems for monitoring of water supply flow and pressure in main distribution line and automation of pumping systems at GSR and Booster pump house area.

V. CONCLUSION

The various technologies have been adopted by different countries for effective water management as water scarcity is the biggest problem in the world-wide current scenario. So, to just minimize the impact of the same on futuristic planning proposal a country like India where 100 smart cities are developing, they should take some steps, so their water system can be become more efficient, more effective and smarter. The government of India or the developing countries governments are focusing more to reduce the water scarcity, the various steps has been taken, the various schemes are implemented such as Atal Mission for Rejuvenation and Urban Transformation, Jal Jeevan Mission-Har Ghar Jal, Swajal scheme, Atal Bhujal Yojana and Smart City Mission. The Municipal Corporations are also taking steps by using SCADA, WaterGEMS, EPANET and leakages, losses everything but making it smarter and more sustainable by IoT and AI will be the unique ways or solutions so that the water losses can be reduce.

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