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Water Supply Chain Resource Management in Cities Using Data Mining Techniques

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ABSTRACT

This paper presents a comparative research study between a number of data mining techniques, knowledge discovery tools, data analysis and software packages to be used in a Decision Support System (DSS) for Smart water supply chain resources management. The case study deals with the evaluation and comparative research of water quality of city water supply within New Delhi city area. In the case of New-Delhi water supply alternative actions for improving of water supply and quality are defined for efficient supply in distributed area. The real time water quality monitor uses given standards by Water Quality Index (WQI) and Statistical analysis done on it suggests the shortest path between supply station and local area distribution Centre by used WEKA mining tool (decision tree) and OLAP. The results show that the city water isn't supplied efficiently in the city and not within the standard quality criteria of (WHO) standards and Indian standards. Leanings and research challenges observed during this comparative study have also been enumerated.

KEYWORDS

Data Mining, Smart Water Supply Chain Automation, Statistical Analysis, Water resources management, WEKA, WQI (Water Quality Index)

INTRODUCTION

Data mining is a process to structured data, finding interconnections among large amount historical-data, or discovering new information in terms of patterns or rules from huge amount of raw and unstructured data. It is involving various disciplines of fields such as: Statistics, ML, AI, IT, DT, High-Performance Computing, and Visualization methods. Data mining techniques are used to implement different structure, operation, rules and patterns in form of association rules, decision tree, sequential patterns, classification trees, etc. It is gone before by information planning before it can be yield valuable data. The principal objective of information mining comprises in separating concealed data from an informational index. The extricated data is valuable for dynamic. Right now,

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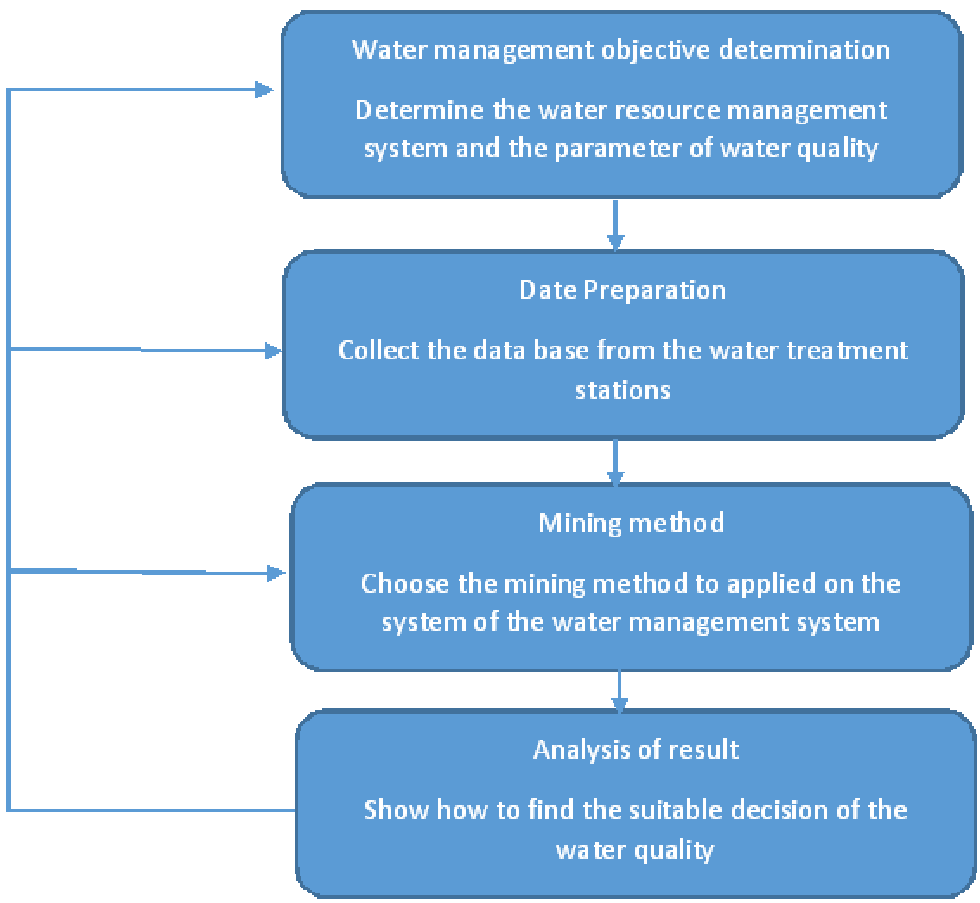
a few famous information mining devices are effectively applied to discover prescient data for various applications. The result of data mining may be reported in a variety of formats, such as listing, graphic outputs, summary tables and visualizations.

Water is a fundamental human need sufficient for the wellbeing and prosperity of people. The accessibility and arrangement of a particular measure of consumable water is a fundamental requirement for all people who are living in various territories of arranged and impromptu settlements. In the research region so as to fill this hole in the interest and gracefully of water, individuals look towards the elective hotspots for meeting out their water request like burrowing their own tube-wells and bore wells inside their premises. The investigation zone has confronting troubles in dealing with its water assets and because of persevering deficits underway of consumable water gracefully to the families which makes them subject to groundwater for drinking reason. Such water corrupted circumstance requires the current examination to assess groundwater quality for turning out to be appropriate water the executives plan in focal and southeast regions.

Data mining is an interactive, semi-automated process which is begins with unstructured and raw data. Results of the data mining process may be insights, rules, or predictive models. Figure 1 illustrates the process as a multi-step, iterative process. First step is presenting the parameters of water quality, second step is responsible to receive and collect the data from the stations, third step is choices the suitable mining tool and forth step is shows the suitable decision of water quality.

Figure 1. Phases of data mining process



This paper presents a near research concentrate between various data mining methods, information revelation devices, information investigation and programming bundles to be utilized in a Decision Support System (DSS) for water supply chain resources management. Moreover, a case study is presented that deals with the evaluation and comparative research of water quality of city water supply within New Delhi city area.

LITERATURE REVIEW

There is a significant exploration course towards the advancement of observing frameworks, which utilize remote sensor systems for water boundaries obtaining. Ryberg (2006) elapse investigation of water-quality information gathered in 2003-05 was utilized to assess fixations and burdens for alkalinity, disintegrated solids, sulfate, chloride, all out nitrite in addition to nitrate, absolute nitrogen, all out phosphorus, and suspended residue. Burden evaluations can be utilized by water-quality administrators for correlation of flow water-quality conditions to water-quality guidelines communicated as all out most extreme day by day stacks (TMDLs). Further, Martinez et al. (2007) proposed an approach that takes into account extensive stretch and little inclusion qualities for ocean water file monitoring, an on-line location framework utilizing remote sensor systems to screen ocean water record. A few sensors with same or diverse capacity are coordinated to set up the wise sensor arrange which can improve the framework ability of checking and mechanization. Further, Wang et al. (2010) proposed a model that uses conventional water quality discovery technique, a novel arrangement of remote water quality estimating and observing dependent on remote sensor organize (WSN) and Code Division Multiple Access (CDMA) innovation. The elements of remote discovery and constant observing of characteristic water are executed through the CDMA remote information transmission. Schnoor et al. (2011) suggested a model that reasonable water the executives must be accomplished by a typical learning process including industrialized, recently industrialized, and creating nations, following general manageability rules. Hangan et al. (2013) proposed a model in which ceaseless continuous water boundaries checking are a need with regards to contemporary water assets the board. Kadhem (2013) proposed a model in which 96 water tests were gathered from the Tigris River inside Baghdad city. These examples were utilized for considering the physical and substance boundaries by utilizing a land data framework GIS (spatial examination). Further, Muste et al. (2013) proposed a framework that delineates an execution of a start to finish CI framework for comprehension of the natural dangers, shifts in soil protection practices, and open view of ecological wellbeing with safeguarding of the monetary advantages of agrarian creation at the watershed scale. The frameworks were executed in a 270 km^2 Clear Creek catchment in eastern Iowa. Salah et al. (2014) proposed a model in which various data mining, information revelation devices and programming bundles to be utilized in a Decision Support System (DSS) for water assets the board. The contextual analysis manages the assessment of water nature of Tigris River inside Baghdad city territory. The water quality strategy utilizes a lot of thirteen water-quality boundaries as per water quality file (WQI) investigation by utilized WEAK mining tool (decision tree). Further, Noiva et al. (2016) proposed a model in which the manageability of urban water frameworks is frequently looked at in little quantities of cases chose as much for their recognition with respect to their likenesses and contrasts. This exploration broke down a dataset of 142 urban areas that incorporates yearly per capita water use and populace. It included a 0.5° matrix yearly water spending esteem (P-PET/yr) as a record of hydro climatic water gracefully. To turn out to be increasingly practical they should build water use productivity, request the board, reuse, and reusing. The essential data about enormous information, uses of huge information in water assets building related examinations, focal points and weaknesses of huge information was surveyed in Adamala (2017). A model for monitoring tank water level and water pollution was proposed by Kiruthiga et al. (2018). Further, Zidan et al. (2018) proposed a model for remote real-time monitoring and controlling systems for water treatment. The proposed framework screens the convergence of chlorine and controls the dosing pump to keep chlorine focus as wanted with little as conceivable human mediation. Parameswari & Moses (2018) proposed a model for checking of drinking water quality, the board of water quality and water system water, lakes, treatment, and lakes by utilizing the remote sensors organize. The significant commitment of this model was to build up a safe procedure of a modern observing arrangement of water quality dependent on remote sensor organize. Progressively, the inserted framework relies upon secure IoT is arranged utilizing WSN, which can asset completely understand those necessities. Further, Kamienski et al. (2019) proposed a model for IoT-based smart water management for accuracy water system in agriculture. The significant disadvantage of this model is that it requires exceptionally structured arrangements and the re-building of certain segments to give higher versatility. Hadipour et al. (2019) proposed a framework in which an imaginative method of multi-intelligent control framework (MICS) of a water pump and a pump station, which is essentially planned, set up, and utilized in a rural area. Results dependent on this model shows that 60% of water can be spared by utilizing MICS by means of IOT. Hareef & Reddy (2020) designed a framework for real time water quality monitoring framework for aquaculture ponds. Results suggests that the physio-chemical parameters of water are within range and the pond water is found suitable for the growth of shrimp and fish, but there are still certain challenges that have to fulfilled like low cost, accurate design of water quality sensors, solar panel cleaning and cleaning of sensor electrodes. Table 1 below provides a comparison of the proposed method with other state-of-art methods in this field.

PROPOSED METHOD

A DSS to WQI foundation model for water quality administration framework in Delhi Jal Board is proposed. DSS of water quality index execution is portrayed underneath. This has been done to assess and identify the choice of water quality and further send an alarm notification by E-mail when register the water index quality data collected file. The DSS foundation utilizes distinct two stations to analyze condition and composition present in water for various stations. Afterwards, it acts as a guide to the clients that are concerned with the water quality index. The implementation is utilized WEKA mining device (AI (ML)) calculation which additionally utilized Decision Tree strategy calculation. These, empower the PC program to consequently examination tremendous information and choose what data is generally applicable. This solidified data would then be able to be utilized to consequently make expectations or to assist the individuals with making quicker choices and all the more precisely. Additionally, permit the entrance to applicable data and give criticism on the watched forms by methods for e-administrations and utilizing the email. The stage is relying upon the WEAP gateway that permits the administration of the substance of the stage to access to a lot of normal base maps.

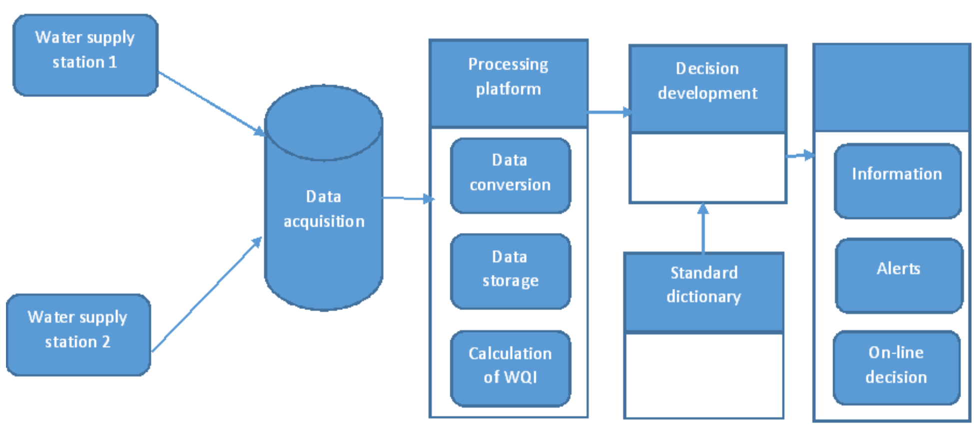
Delhi Jal Board is supplying the water for New-Delhi city which is divided it into two stations, each station sent the information of water to (data acquisition), where the information is situated in processing platform. In this process the information was transferred to database form in order to process it. In decision development procedure will be process the data and compare it with standard dictionary to gives appropriate information for water quality state to each station. Finally, DSS studied the information and decide on the water distribution functions. For instance, alerted the authorities about the water conditions to prevent supplying it to the people. Figure 2 shows the architecture of WQI in New Delhi.

It is one of the best apparatuses to create data/information for water quality to move the data to the individuals to settle on a choice. It turns into a significant factor to gauge and the executives the water as a pastiche pointer for significance study of water treatment and control of water pollution. This represents a scientific methodology that helps in assessing enormous amounts of statics of water quality into a solitary number. This further help in giving a straight forward and justifiable tool for the management of WQI standards, treatment and quality. Water quality record helps in determining

Table 1. A Comparison of the State-of-Art Methods to Proposed Method

Reference	Objective	Contribution	Conclusion
Mandal et al. (2010)	To assess, compare and interdependency between the monthly/seasonal variation of selected parameters.	Designated best use classification of surface water.	Understanding the seasonal variation and interrelationship of the selected parameters may be helpful in routine analysis of river water quality.
Parmar & Keshari (2012)	Waste load allocation studies, environmental impact investigations, and for analyzing the cause and effect relationships in a water body using simulation model.	Sensitivity analysis to dependent parameter water quality change with respect to incremental changes in model parameters and performance of the model output is also assessed by incremental variation in the treatment level and flow augmentation	Sensitivity analysis is still an efficient method for uncertainty analysis of most versatile water quality simulation model QUAL2E.
Saravanan et al. (2018)	Supervisory Control and Data Acquisition (SCADA) system that integrates with the Internet of Things (IoT) technology for real-time water quality monitoring.	Physical parameter such as temperature, turbidity, and color were added to the system.	SCADA system and real-time mobile application that integrates with the IoT technology for real-time water quality monitoring.
Singh et al. (2019)	Entropy weighted WQIs are an enhancement over conventional WQIs based on Delphi method, analytical hierarchy process (AHP) and expert survey method.	The system is based on Entropy weighted irrigation water quality index (EIWQI) and parameters.	Evaluation water quality variability, entropy weighted irrigation water quality index (EIWQI) has been proposed, based on which RSC was observed as the most influencing parameter due to its highest entropy weight.
Bidhuri & Khan (2020)	Arithmetic weighted water quality index (WQI) method is applied for analyzing the quality of groundwater. Spatial interpolation model was applied to depict the groundwater quality of central and southeast districts of NCT of Delhi. In this study.	The assessment of groundwater quality was made by aggregating several number parameters and their dimensions into a single entity. It is observed on the basis of the WQI	The analysis of the water quality parameters of groundwater from twenty different sample locations in the study area shows that in terms of the selected parameters, expect arsenic were beyond the BIS prescribed desirable limits.
Proposed Method	Water supply alternative actions for improving of water supply and quality are defined for efficient supply in distributed area.	The water quality monitor uses given standards by Water Quality Index (WQI) and suggests the shortest path between supply station and local area distribution Centre by used WEKA mining tool (decision tree) and OLAP.	The consequences display that the Delhi Jal Board water deliver water isn't in the standard great criteria of (WHO) requirements. The water first-class on the east of New-Delhi (West-Delhi) is the most polluted and East-Delhi is also terrible water.

Figure 2. Architecture of WQI in New-Delhi



a solitary number that represents the quality of water for a specific area at a given time considering the various quality parameters. The usage depends on the qualities accessible for the water of Delhi Jal Board, in New-Delhi. Information procurement is made by 100 and the outcomes presented. The values were determined with the help of Weighted Arithmetic Index method. Determine the quality rating scale for various compounds (qi) with the help of given formula:

$$qi = \left(\frac{ci}{si} \right) * 100$$

Assign the quality rating scale (qi) for all the given parameters of water by separating the composition of concentration (ci) to various water sample collected at each station by its respective standard value (si). Now, multiply the resulting value by 100 for the detection of any drastic change in the output. Calculate the relative weight of the indexed components (wi) by taking the inverse value of standard value i.e. si for each of the specific parameters. Formula used to calculate the same is provided below:

$$wi = \frac{1}{si}$$

One can calculate the water quality index (WQI) with the help of taking sum of multiplications of unit weight (wi) and quality index scale (qi) for various components. Formula for calculating WQI can be represented as shown below:

$$WQI = \sum_{i=1}^{i=n} wixqi$$

In the above formula, n is the number of components, qi represents the quality index parameter, and wi represents the weight unit of (i) parameter. WQI is useful for determining specific usage as well as checking the water quality index. For the purpose of this study, WQI is considered for measuring the status of parameters is (n=100) outputs using formula:

$$WQI = \frac{\sum_{i=1}^{n} wixqi}{\sum_{i=1}^{n} wi}$$

Based on the measured WQI and components are given according as per the standards present in Table 2.

Table 3 shows the water quality index for untreated water, the samples were tested and measured under the conditions. This reflects the effect of pollution from sewage, industrial, urban wastes and Human activities etc.

WQI parameters were maintained and implemented in regards to their standards and suitability for daily-usage and human need of the water consumption. The ‘standards’ for the water to being in

Table 2. WQI Value and Classification

S. No.	WQI value	Water quality classification	Water quality
1	<50	Excellent	Excellent (water is clear and not in contact with domestic wastes. Ideal for all different purposes. No treatment required).
2	50-100	Good water	Good (initiation of serious changes in water quality due to environmental deterioration. Useful for domestic and industrial purposes. Suitable to secured wildlife and waterfowl).
3	100-200	Poor water	Poor (drastic changes in water quality begin to occur. The water can be used for domestic and industrial purposes after intensive treatment).
4	200-300	Very poor water	Very poor (dangerous changes may occur in the ecosystem. Constant disturbing smell. Conventional treatment costs are augmented).
5	>300	Water unsuitable for drinking	Unfit for drinking (highly dangerous pollution. Danger in any form of water consumption).

Table 3. Drinking water standards and unit weights

S. No.	Water quality parameters	Standards	Unit Weights(Wn)
1	pH value (pH unit)	6.5-8.5	0.007990
2	Alkalinity (mg/L)	100	0.000679
3	Turbidity(NTU)	5.0	0.013583
4	Dissolved Solids (mg/L)	500	0.000136
5	Hardness(mg/L)	100	0.000679
6	Calcium (mg/L)	100	0.000679
7	Magnesium (mg/L)	30	0.002264
8	Chloride(mg/L)	250	0.000272
9	Sulphate(mg/L)	250	0.000272
10	Ammonia(mg/L)	0.2	0.339574
11	Fluoride(mg/L)	1.0	0.067915
12	Iron(mg/L)	0.3	0.226383
13	Aluminum(mg/L)	0.2	0.229574

the quality which is considered as drinkable water, maintained by the World Health Organization (WHO) and unit weights of the nutrients present in the water are given in Table 2 and Table 3. The WHO made the standard for the better water standard monitoring and for adopting new techniques to provide best health service, standard for all living beings. The main reason for making standard is to conserve environment and wild life of the earth.

As discussed previously, Water Quality Index, i.e. WQI helps in determining the impact of various parameters on the water quality of an area. Some of these parameters includes testing it for arsenics like heavy metal, sulphates, dissolved solids, alkalinity etc. It is similar to the air quality index that is used for determining the quality of air. WQI measure is helpful to collect, summarize as well as report the quality of water to the general public in specific time intervals. It is a very crucial index for determining whether water is suitable for the consumption of human beings or not. This index is equally efficient in determining the quality of surface water as well as the groundwater of a specific area or location. World health organization is committed to ensure the availability of drinking water for the public. Even one of its primary goal is to ensure the right of people for safe drinking water irrespective of their economic or social conditions. WHO is continuously conducting researches regarding drinking water and sharing the knowledge with public through its website and other sources.

RESULTS AND DISCUSSION

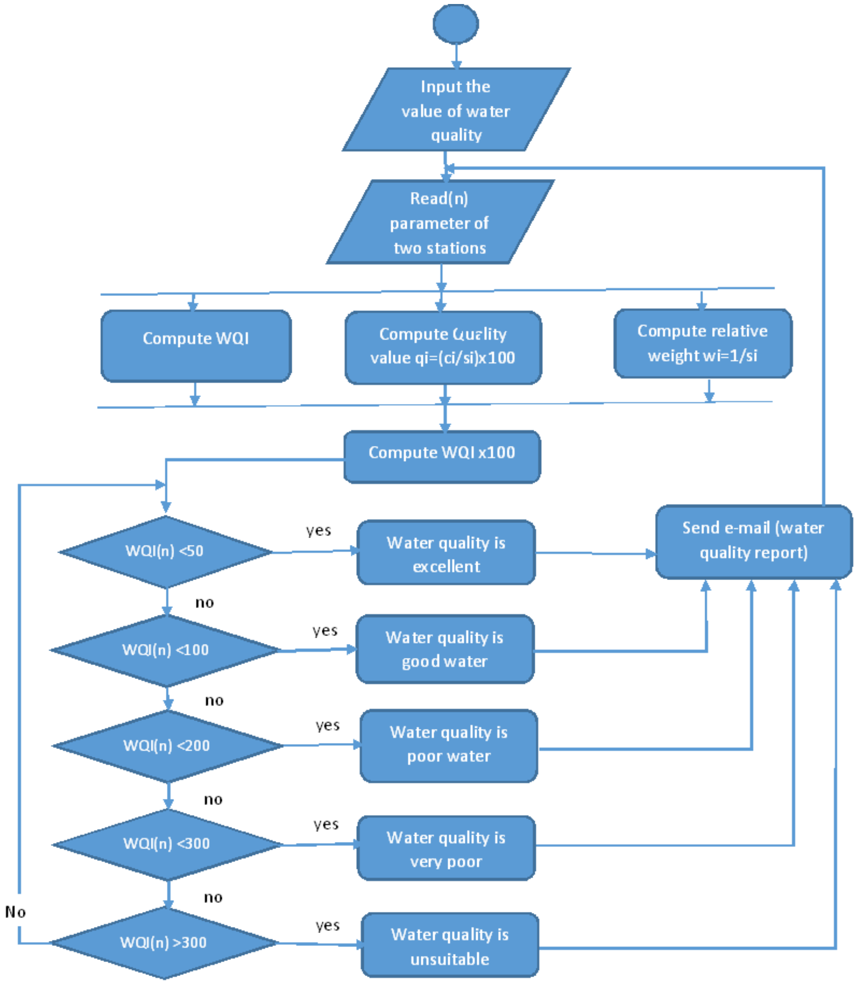
For this case study, a set of thirteen water-quality Standards/parameters (n) were used to calculate WQI. These are: pH value (pH unit), Hardness (milligram/ Liter), Calcium (milligram/ Liter), Iron (milligram/ Liter), Alkalinity (milligram/ Liter), Magnesium (milligram/ Liter), Chloride (milligram/ Liter), Sulphate (milligram/ Liter), Ammonia (milligram/ Liter), Fluoride (milligram/ Liter), Iron (milligram/ Liter), Alkalinity (milligram/ Liter), Turbidity (NTU), Dissolved Solids (milligram/ Liter), Aluminum (milligram/ Liter), and they are the essential nutrients for the water quality. Workflow for processing WQI, Water quality control and generates an automated alert as an email notification or message about the Real-time status of water quality.

There are five conditions to know the state of water quality. DSS should be send a messages as following, such as, (if wqi<50) (the water is excellent and best for all purpose), (if wqi>=50 and wqi<=100) (the water is good), (if wqi>100 and wqi<=200) (the water is poor and not suitable for drinking),(if wqi>200 and <=300) (the water is very poor and unstable for any usage) and (if wqi>300) the message is (the water unsuitable to drinking and environment).

Operational window (Main window) containing the parameters that lead to water quality administration shows the standard and the genuine required estimation of the parameters (Figure 3). In view, the condition of water quality is checked and resolved then a choice is taken, that contains a reasonable counsel to a particular condition of water. The application naturally sends an email to an approved individual/gathering of people, with data in regard to the water quality state event.

The results show the water fine in Delhi Jal Board (station one) is basic “very bad water”, diverse poor ingesting water and the impact of pollution and industrial effluents. One of the strong factors of application is the way that results could be introduced and combined in tables or maps. The first output is focus on case of water best for in addition use. The software outputs were covered a range of water quality parameters, Tables, txt file, and ought to been sent an electronic mail to the controller (the authority to monitoring in water station) to gazing the kingdom of water quality. The DSS was developed on a .Net framework platform, the use of Visual Basic for the mathematical computation and MySQL database for WQI great administration in New-Delhi city, result an aid to decision makers in setting up the excellent of water and the most suitable state of water to keep away from drinking the pollutant water. The results of water fantastic in station two is also “not suitable for drinking”, (poor water) various terrible consuming water and the effect of air pollution and industrial effluents too. There is a way to sending the alert by email which in the first must be calculated WQI as in Figure 3. The sitting contains writing the email address, sender password, receiver address, the subject, and the water state information. The email message gives detailed information about real-time the water quality state, the values of this quality and suggestions/advice. All information and statistics is stored in a meta database.

Figure 3. Data-Flow diagram of WQI



The results of WQI were divided the stations on Delhi Jal Board at New-Delhi city into two separate stations: South-Delhi at the west and North-Delhi at east of Delhi Jal Board water supply. WQI values of untreated or raw water polluted "very poor water" to "poor water" in the whole supply system of the Delhi Jal Board water supply. Figure 4 shows the water quality samples of two stations and Figure 5 shows WQI monthly parameters.

It could be very crucial to set up an index to show the information of Delhi Jal Board water deliver water excellent and presenting the warning notification/alarm to take pollutants manipulate movements. This investigation of case seemed like a pioneer action for water best index in New-Delhi in addition to entire Iraq in well-known. This might also cause more extensive precise research on WQI in the location that allows you to satisfy the present gap of information about this challenge in India. The water exceptional at the east of New-Delhi (North-Delhi) is the most polluted (very poor) in Delhi Jal Board. From the result that received in this study, it may be said that authorities should video display units of tested reports of water to the industries that discharged their effluent or sewage without proper treatment to water bodies or Delhi Jal Board water. The water fine on the south of New-Delhi (South-Delhi) also it's far (impure water) to drink from the end result that acquired. Water nice application presents higher knowledge of the bodily and chemical tactics. Since, program is able to realistically constitute qualities waters; they may be used to support water fine control and selection-making.

Case Study on Water Quality Integrated in New-Delhi (WAQIND)

The case study is a part of DSS (decision support system) for integrated system of water quality index management in New-Delhi city (WAQIND).

Water of Delhi Jal Board is considered as the only source of portable water for New-Delhi city, the Delhi Jal Board water supply divides the city into two sides west (South-Delhi) and east (North-Delhi) with a flow direction from north to the south. The area is characterized by arid to semi-arid climate with dry hot summers, rainy and cold winters; the mean annual rainfall is about 190 mm. the catchment area reaches to 235,000 km^2. Delhi Jal Board sharing with NCR-region Delhi Jal Board water supply the main source for man uses, especially for drinking water since they pass the major cities in the country. In New-Delhi city, development and the demand for the freshwater consumption is increased due to the rapid growth in population due to immigration and rapid industrialization due to technology modification. Agriculture is widespread on both of the Delhi Jal Board water supply sides. Thus, Delhi Jal Board water supply water quality monitoring is necessary to evaluate the quality of different water uses.

Figure 4. Water Quality Test Samples of two stations

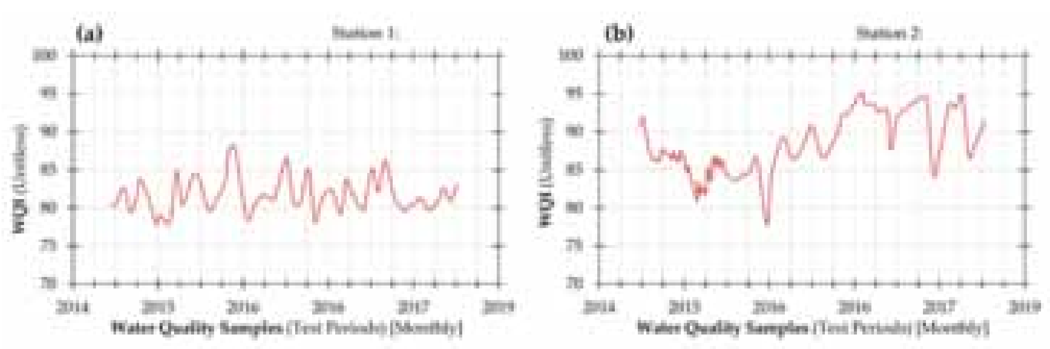
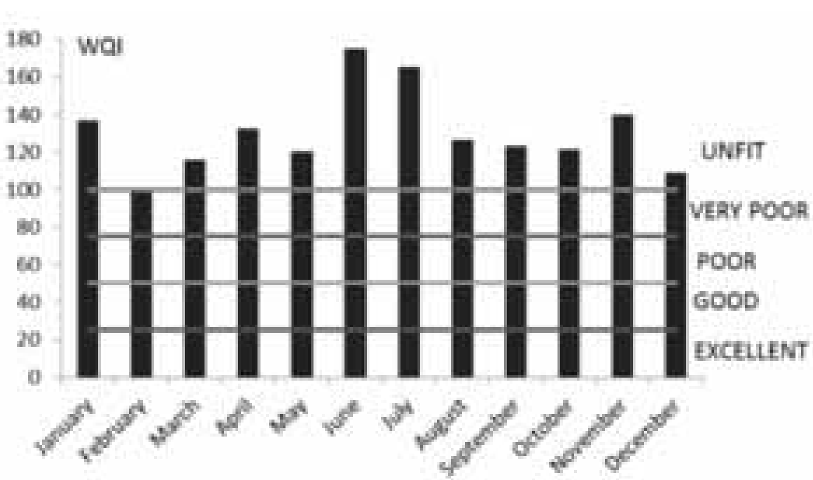


Figure 5. WQI monthly parameters



RESEARCH CHALLENGES

While designing and deploying the framework, some real-time challenges are observed which are enumerated below.

1) Regulation complexity and planning- The parameters of WQI changes from one station to other station because of unauthorized sewage and industrial waste
2) Climate change- uncertain change in climate causes immediate reaction towards the problem and requires analyses and management of techniques as per the climate.
3) Growing urban demand- As the population increases rapidly the demand of clean and fresh increases simultaneously in urban area, which increases the pressure on water supply system and quality of water.
4) Over-allocation of existing supplies- In some supply system or distribution center the allocation of water supply is not updated and being working on the basis of past availability.
5) Increasing vulnerability to severe weather events- Rapid increases in the severe weather conditions like- floods and draught, which causes the uncertainty in parameters of water for some intervals odd time due to this water treatment effected by the distinct data/information collect from the sensors.
6) Unrestricted extractions- In some of areas, unrestricted water extractions done due to lack in management plans or restrictions through unauthorized ground water extraction, direct pumping for river, mining of the resources and expansion of the farms in the river system area.
7) Land-use change- Expanding plantation, clear-felling and increasing agricultural area impacts on the water bodies such as- bushfires, over lodging of water and distribution of main streams.
8) Environment requirements- The climate of every environment is different on which water treatment is being carried-out without disturbing the ecosystem of main streams and water bodies.

CONCLUSION AND FUTURE SCOPE

This paper presents a comparative research study between a number of data mining techniques, knowledge discovery tools, data analysis and software packages to be used in a Decision Support System (DSS) for Smart water supply chain resources management. Certain research challenges saw in the execution of the activities have been featured in this paper for the researchers. These research challenges when tended to will improve the framework further to make it versatile and vigorous.

The version used for Delhi Jal Board is a trendy one with any Delhi Jal Board water supply that containing two fundamental stations within the metropolis. The proposed approach can be used in different Delhi Jal Board water elements, like Faridabad in Delhi in which a water specification is identical with Delhi Jal Board. Subsequently, a water fine checking application is carried out to simulate the WQI parameters profiles of the Delhi Jal Board water deliver in the course of low float duration. WQI (water satisfactory index) and software also are used to provide some enter data that relates to Delhi Jal Board water excellent management. The consequences display that the Delhi Jal Board water deliver water is not in the standard great criteria of (WHO) requirements and Iraqi requirements. The water first-class on the east of New-Delhi (West-Delhi) is the most polluted (Very poor water). The water great on the west of New-Delhi (East-Delhi) is also terrible water.

The results obtained from the comparative analysis show that the WQI method used in 2020 was used only for determining the quality of the groundwater, whereas the proposed method can be used for water obtained from various sources. Furthermore, the previous method considered the Indian Standard for determining the water quality, whereas the proposed method considers the WHO Standard, which is globally accepted. Additionally, the previous research was conducted on groundwater samples taken from twenty different locations, whereas the current research was conducted on river water and the Delhi Jal Board water supply sources. Unlike the previous method, the current method uses data mining tools that would help the administrative bodies to consider historical data and take necessary actions in case of any uncertain events like flood, drought, etc. The results obtained from the study shows that the proposed method would be better to determine the quality of water bodies from various sources and take would help the administrative bodies to take required actions accordingly. The proposed method would help in addressing the current issues of water crisis and deteriorating quality of supplied water. Besides, numerous health issues resulting due to poor quality of water can also be addressed using the proposed method. The current method is suggested for water quality improvement of drinking water and water used for daily household and industrial usage. Further, this work can be extended in future to provide the status of water level in tanks and notification of water supply in pipeline by using IoT.

COMPETING INTERESTS

The authors of this publication declare there are no competing interests.

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