RESEARCH ARTICLE OPEN ACCESS

Quality Risk Analysis for Sustainable Smart Water Supply Using Data Perception

Mrs. J. Sarada [1], U Pravallika [2]

[1] Asst. Professor, Department of Master of Computer Applications
[2] Student, Department of Master of Computer Applications
[1], [2] Chadalawada Ramanamma Engineering College (Autonomous)

ABSTRACT

Over the past decade, many tools have been developed for risk analysis of water systems. Many advances have been made, both in the theoretical platform and in practical models and procedures. Various risk analysis approaches have been used to identify potential hazards, calculate the probability of accidents and assess the severity of consequences. The objective of this paper is to review these developments, focusing on the fundamental ideas and thinking behind them, considering their application at strategic, programmatic and operational levels of decision-making, in order to improve the understanding of stakeholders (researchers, regulators, etc.). To achieve this objective, scientific papers on risk analysis associated with water treatment systems were identified and reviewed, with particular focus on risk assessment methods (qualitative, semi-qualitative or quantitative, deterministic or probabilistic, etc.), tools (ETA, FTA, FMEA/FMECA, QMRA, HRA, Markov, etc.), applicability of these tools and results of case studies. We recommend employing an adaptive frequency analysis (AdpFA) technique to resolve the data using the indicators' frequency domain for their internal linkages and forecasts. We also investigate how well this strategy scales across indicator, geographic, and temporal domains. For the application, we selected data sets of industrial quality from four different Norwegian urban water supply systems: Oslo, Bergen, Strommen, and Aalesund. We examine the spectrogram, rate the timeliness and precision of the predictions, and compare it to traditional ANN and Random Forest methods. The results show that our method works better in most instances. It is possible to support early alerts for concerns to industrial water quality.

Keywords: - ETA, FTA, FMEA/FMECA, QMRA, HRA, Markov, etc.

I. INTRODUCTION

There are numerous risk analysis techniques, ranging from simple qualitative analysis for dynamic systems. At present, promising advances have also been made on important issues in this field. Due to their multi-functionality and ability to affect a wide range of applications, they have attracted particular attention, especially in the field of water, where drinking water supply quality monitoring is a major concern for public health policymakers (Tixier et al. 2002).

Water supply systems have been found to be the most critical because of their considerable impact on public health (Maier, J., & Allende 1999; Swamee, P. K., & Tyagi 2000). In reality, water supply systems are made up of infrastructure and devices that are susceptible to sabotage and are characterised by the presence of the main components of each water supply system: raw water sources (usually a reservoir, river intake or aquifer), water treatment plants (including various treatment processes) and the networks that distribute drinking water to consumers. Seepage of some contaminants into the water distribution system can occur through storage tanks and pipes. Seepage through distribution systems can occur during or after maintenance and renovation work (Kirmeyer, G. J., & Martel 2001). If the pressure in the pipe is very low or insufficient, this greatly increases the likelihood of backflow contamination or leakage in the pipe. This can occur when the pipe pressure is reduced for repair or during transient pressures (e.g. when the hydrant is used for fire suppression or during water hammer). In addition, internal degradation of metal pipes and plumbing equipment can lead to increased concentrations of metal compounds in water. Not all metals experience the same corrosion mechanism, but overall, water with low pH, high dissolved oxygen, very high temperature and high levels of dissolved solids will result in a higher corrosion rate (Kleiner, Adams, and Rogers 1998). The chemical substances that manage to seep into the water system are frequently those originating from the internal lining material and the lining of the pipes, which cause a physico-chemical deterioration of the water quality, accompanied by health risks.

There have been several cases where water treatment plants have experienced catastrophic situations leading to epidemics. One such catastrophic event was the outbreak in Milwaukee, Wisconsin, USA, in April 1993, which resulted in more than 400,000 affected population, nearly 100 deaths, and a city completely paralysed. Other examples include the 1994 norovirus gastroenteritis outbreak, probably due to the consumption of faecally contaminated water in a nursing home in Albacete (Spain), which resulted in 341 deaths; the 1991 hepatitis E outbreaks in Kanpur (India), which affected 79,000 people, and the norovirus gastroenteritis outbreak in 1999, again probably associated with the consumption of faecally contaminated water in a nursing home in Albacete (Spain). Risk analysis methods are important for the controllable management of risks and hazardous events in drinking water production. These may include: biological or chemical watershed pollution, treatment process failures and water distribution system failures such as leakage or water pollution. The field of risk analysis is composed of three main parts: the first part corresponds to risk management. The focus is on measuring both the intensity of the possible hazard or harm but also their quantity in the medium assessed which could lead to the population being afflicted by noxious substances and conditions (NRC 1983). Risk evaluation assesses different policy options depending on the data obtained in the assessment carried out. It selects and implements particular control features, regulations to follow and implement when required. Risk communication is the capability to communicate vital information about the hazard which is an essential component in the process. It comprises sending and receiving data and assessment of the hazard and the strategies to be put in place by the technical crew (managers and assessors), but also feedback from users, and other stakeholders (Terje Aven and Zio 2014; Reddi et al. 2015). In this review article, the methods and tools are illustrated with examples providing the information necessary to make informed decisions about the risks associated with a treatment and distribution process. We truly believe our research will not only be relevant for researchers in the area of water production, treatment and consumption but also for officials, legislators and those in charge of operating the system since the assessment models can be adapted to meet their specific needs.

II. LITERATURE SURVEY

1. Urbanization and climate change impacts on surface water quality Enhancing the resilience by reducing impervious surfaces

Climate change and urbanization are key factors affecting the future of water quality in urbanized catchments. The work reported in this paper is an evaluation of the combined and relative impact of climate change and urbanization on the water quality of receiving water bodies in the context of a highly urbanized watershed served by a combined sewer system (CSS) in northern Italy. The impact is determined by an integrated modelling study involving two years of field campaigns. The results obtained from the case study show that impervious urban surfaces and rainfall intensity are significant predictors of combined sewer overflows (CSOs) and consequently of the water quality of the receiving water body. Scenarios for the year 2100 demonstrate that climate change combined with increasing urbanization is likely to lead to severe worsening of river water quality due to a doubling of the total phosphorus load from CSOs compared to the current load. Reduction in imperviousness was found to be a suitable strategy to adapt to these scenarios by limiting the construction of new impervious areas and decreasing the existing areas by only 15%. This information can be further utilized to develop future designs, which in turn should make these systems more resilient to future changes in climate and urbanization.

2. Sustainable development ´ goals: A need for relevant indicators

At the UN in New York the Open Working Group created by the UN General Assembly proposed a set of global Sustainable Development Goals (SDGs) which comprises 17 goals and 169 targets. Further to that, a preliminary set of 330 indicators was introduced in March 2015. Some SDGs build on preceding Millennium Development Goals while others incorporate new ideas. A critical review has revealed that indicators of varied quality (in terms of the fulfilment certain criteria) have been proposed to assess sustainable development. Despite the fact that there is plenty of theoretical work on quality standards for indicators, in practice users cannot often be sure how adequately the indicators measure the monitored phenomena. Therefore we stress the need to operationalise the Sustainable Development Goals' targets and evaluate the indicators' relevance, the characteristic of utmost importance among the indicators' quality traits. The current format of the proposed SDGs and their targets has laid a policy framework; however, without thorough expert and scientific follow up on their operationalisation the indicators may be ambiguous. Therefore we argue for the foundation of a conceptual framework for selecting appropriate indicators for targets from existing sets or formulating new ones. Experts should focus on the "indicator-indicated fact" relation to ensure the indicators' relevance in order for clear, unambiguous messages to be conveyed to users (decision- and policy-makers and also the lay public). Finally we offer some recommendations for indicators providers in order to contribute to the tremendous amount of conceptual work needed to lay a strong foundation for the development of the final indicators framework.

3. A miniature porous aluminum oxide-based flow cell for online water quality monitoring using bacterial sensor cells

The use of live bacterial reporters as sensing entities in whole-cell biosensors allows the investigation of the biological effects of a tested sample, as well as the bioavailability of its components. Here we present a proof of concept for a new design for online continuous water monitoring flow-cell biosensor, incorporating recombinant reporter bacteria, engineered to generate an optical signal (fluorescent or bioluminescent) in the presence of the target compound(s). At the heart of the flow-cell is a disposable chip made of porous aluminum oxide (PAO), which retains the sensor microorganisms on its rigid planar surface, while its high porosity allows an undisturbed access both to the sample and to essential nutrients. The ability of the bacterial reporters to detect model toxic chemicals was first demonstrated using a "naked" PAO chip placed on solid agar, and later in a chip encased in a specially designed flow-through configuration which enables continuous on-line monitoring. The applicability of the PAO chip to simultaneous online detection of diverse groups of chemicals was demonstrated by the incorporation of a 6-member sensor array into the flow-through chip. The selective response of the array was also confirmed in spiked municipal wastewater effluents. Sensing activity was retained by the bacteria after 12-weeks storage of freeze-dried biochips, demonstrating the biochip potential as a simple minimal maintenance "plug-in" cartridge. This low-cost and easy to handle PAO-based flow-cell biosensor may serve as a basis for a future platform for water quality monitoring.

4. The use of a Neural Network technique for the prediction of water quality parameter

This paper is concerned with the use of Neural Network models for the prediction of water quality parameters in rivers. The procedure that should be followed in the development of such models is outlined. Artificial Neural Networks (ANNs) were developed for the prediction of the monthly values of three water quality parameters of the Strymon river at a station located in Sidirokastro Bridge near the Greek — Bulgarian borders by using the monthly values of the other existing water quality parameters as input variables. The monthly data of thirteen parameters and the discharge, at the Sidirokastro station, for the time period 1980–1990 were selected for this analysis. The results demonstrate the ability of the appropriate ANN models for the prediction of water quality parameters. This provides a very useful tool for filling the missing values that is a very serious problem in most of the Greek monitoring stations.

III. BACKGROUND STUDY

Existing ANN and random forests don't have the same dataset processing steps as the suggested adaptive frequency analysis approach does, hence their error rates are larger than those of the proposed approach. Because the author of the planned research did not post the Norwegian country water supply dataset online, we do not have it. However, we did find the Indian state water supply quality dataset. There are various obstacles we must overcome in order to assess the risk posed by changes in water quality and to examine the mechanism behind data sources.

- Data Sparsity: There is frequently a huge amount of data available. In reality, overlaps between two conditions (such the same time and place) for water quality indicator samples are frequently very tiny or nonexistent. This is supported by two key factors. First off, the sample takers do not adhere to the proper protocol (incomplete indicator collections, and data loss). Second, the data standard has altered from previous years (indicators have been added or removed). The data set is sparse as a result.
- Data Synchronization: Most physical and chemical indicators of water quality may be collected in real-time using current sensing technologies. However, the tests typically take significantly longer, anything from several hours to several days, for biological indicators, which are the primary determinants of health. This makes synchronising the data set challenging.
- Risk modelling: Improving health is the ultimate goal of drinking water quality regulation. Significant disease epidemics can be brought on by some particular biological markers, including bacteria like Ecoli. The effects may be permanent if they spread throughout the system that distributes drinking water. A new model is required to explain the connection between those biological indicators and drinking water risk.

IV. PROPOSED SYSTEM

Because commercial water quality is a major concern for almost all countries due to the growing population and governments want to provide their citizens with quality and adequate water, the author of this paper describes an algorithm called Adp-FA (Adaptive Frequency Analysis) to predict commercial water quality and its risk. In this study, the author uses scalable features like INDICATOR, Geography (locations), and Time to analyse water quality sensor data collected from 4 different states (OSLO, Bergen, Strommen, and Alesund) of Norway. The author of this paper uses water supply data to build a machine learning model. The proposed Adp-FA algorithm's RMSE (root mean square error) is then compared to those of ANN and Random Forest. Give an example of a technique that has lower RMSE error rates than ANN and Random Forest.

Advantages:
The timeliness and precision of the predictions are better than the existing and traditional ANN and Random Forest methods

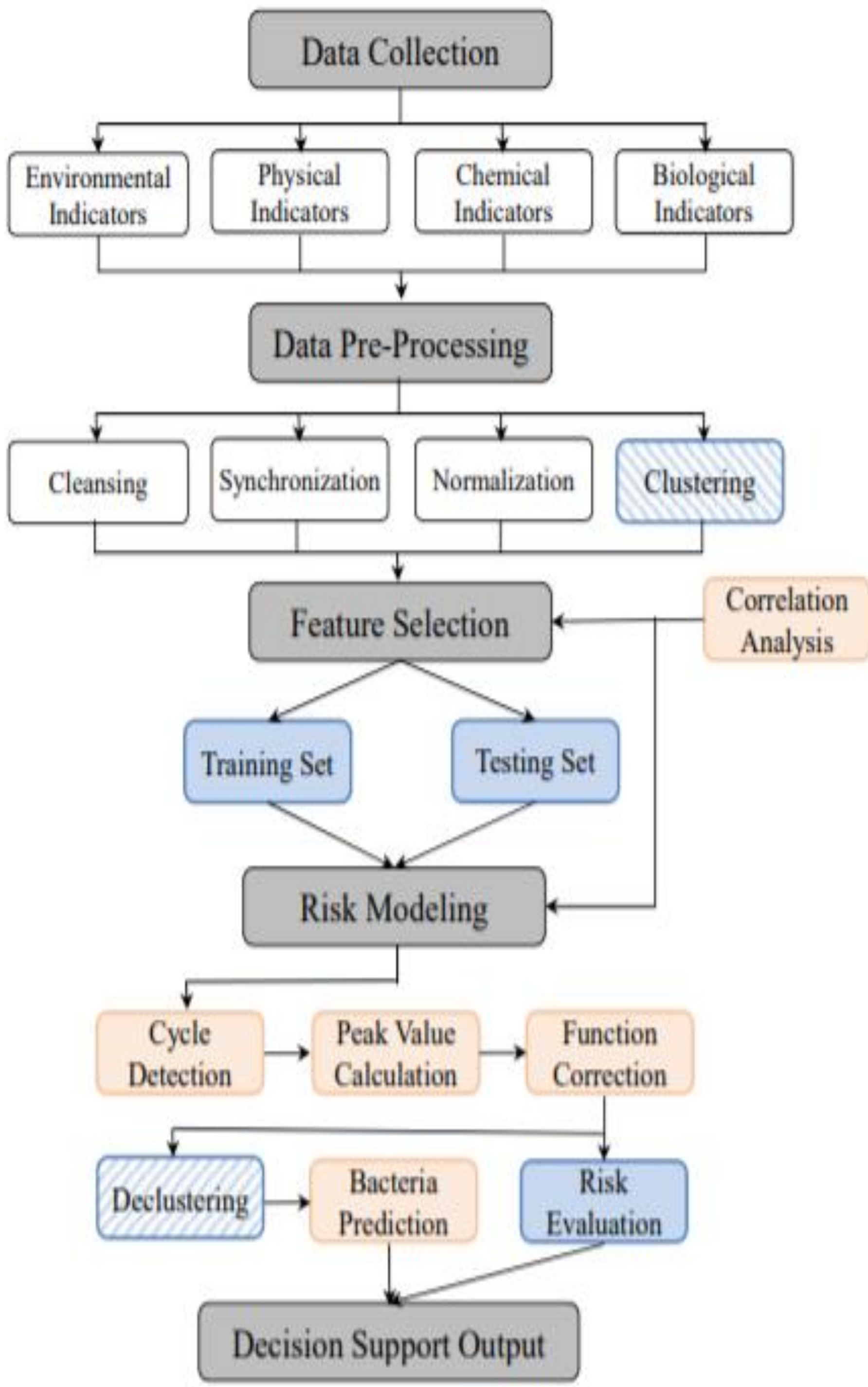

Fig: Architecture Diagram

V. RESULTS

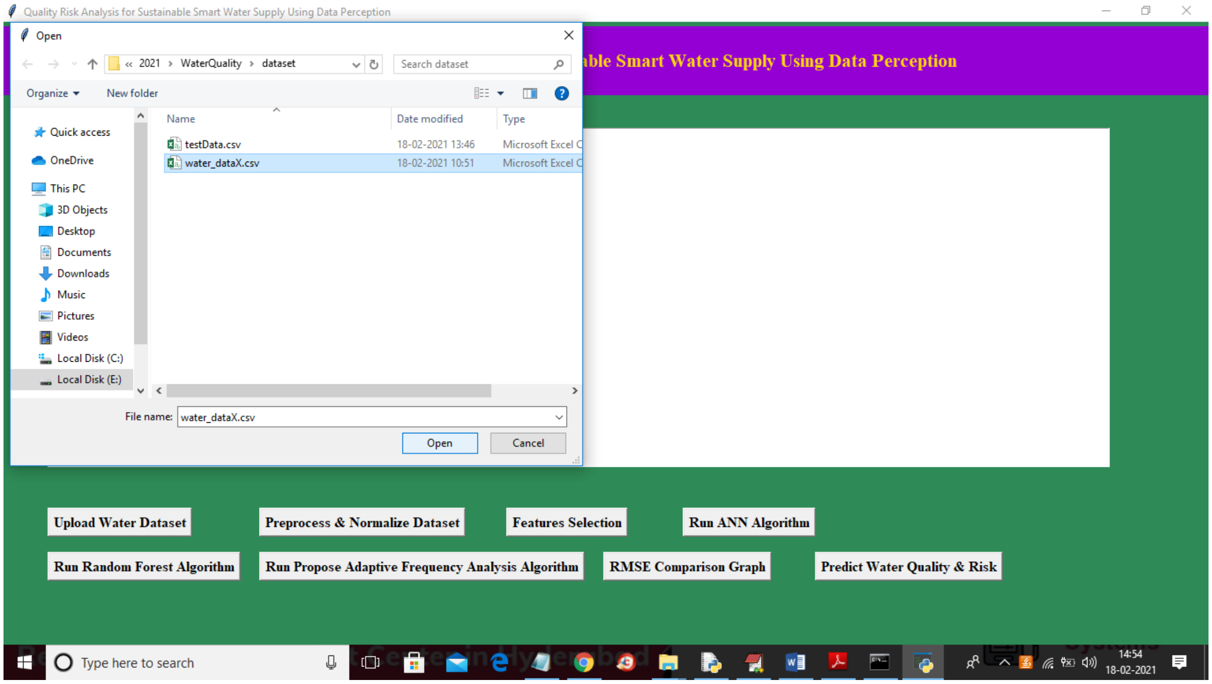

Fig: Selecting and uploading 'water_dataX.csv' file

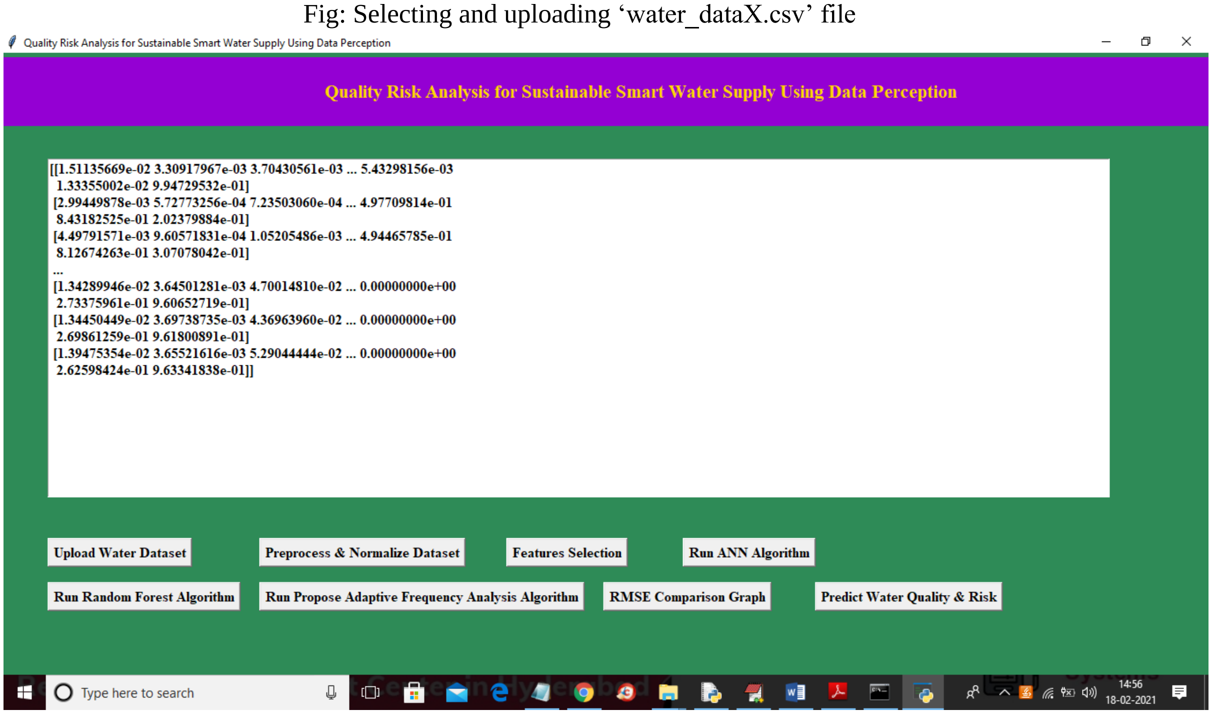

Fig: Preprocessing all values converted to numeric format

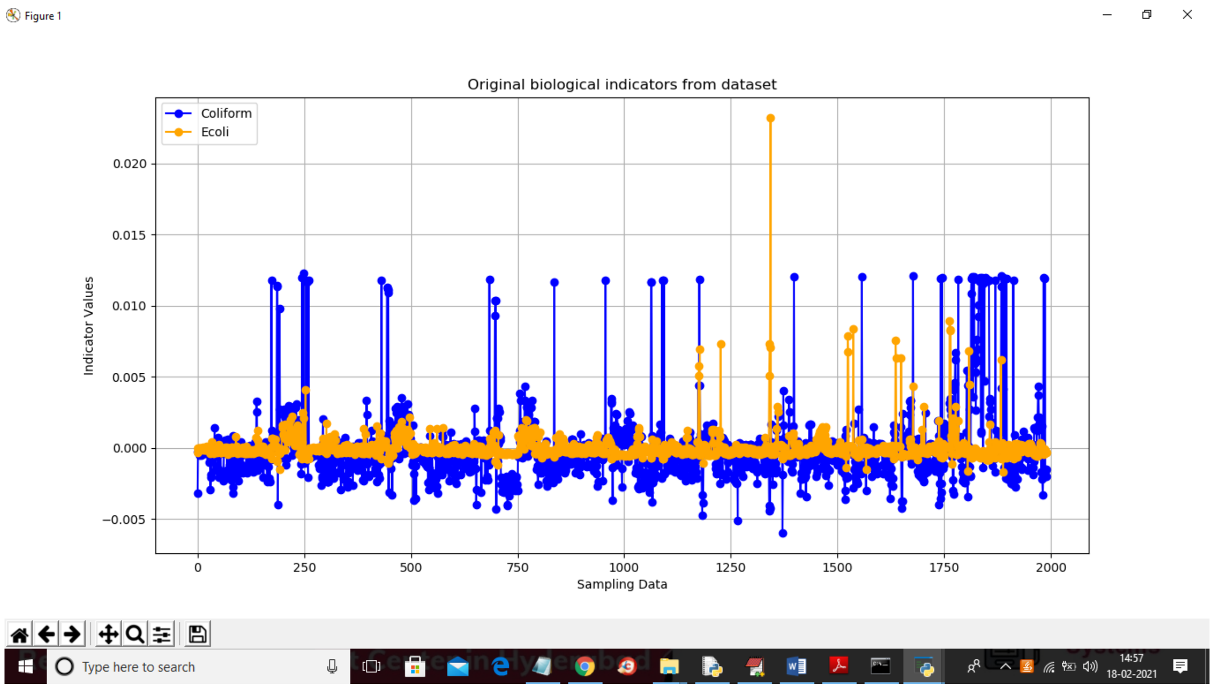

Fig: Where blue colour represents presence of COLIFORM and orange colour represents COLI bacteria present in dataset.

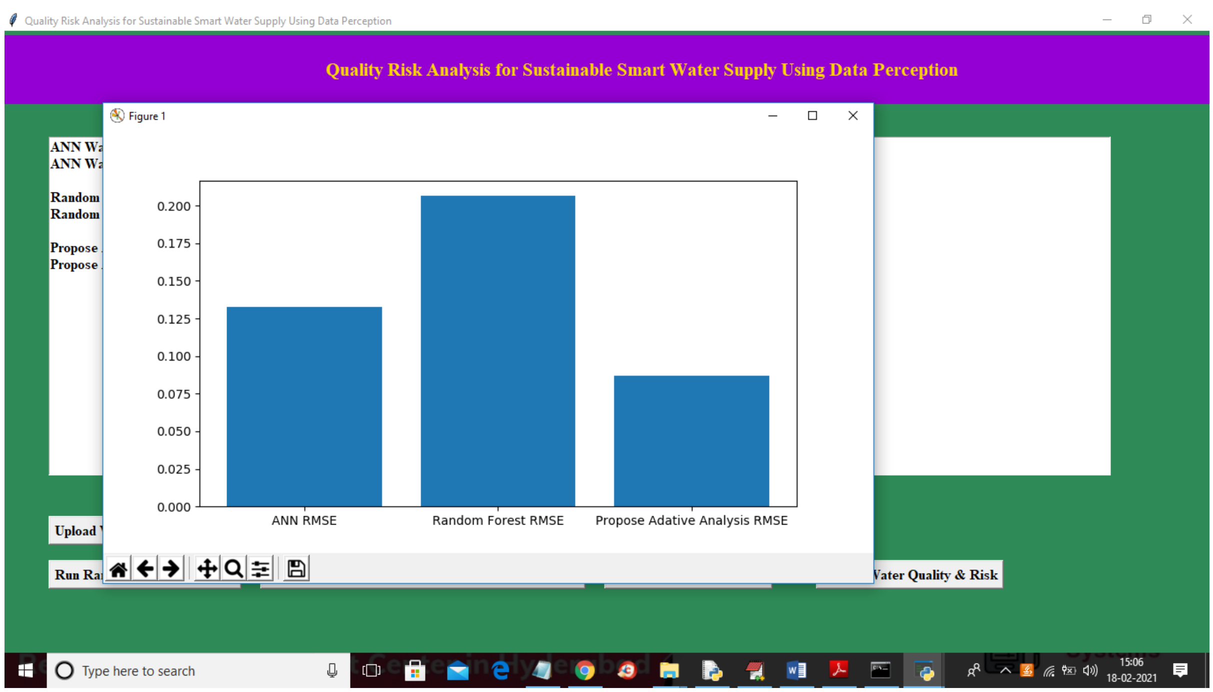

Fig: Accuracy in different algorithms

VI. CONCLUSION

For the creation of intelligent water supply systems and for contemporary urban living globally, water quality is a critical concern. Using conventional monitoring and risk control methodologies, it is difficult to identify bacterial broadcast in a timely manner and provide efficient decision assistance. We present a technique for data-driven early warning of water quality issues in this work.

VII. LITERATURE SURVEY

[1] S. Franco, V. Gaetano, and T. Gianni, "Urbanization and climate change impacts on surface water quality: Enhancing the resilience by reducing impervious surfaces," Water Research, vol. 144, pp. 491–502, 2018.

[2] T. Hak, S. Janou ´ skov ˇ a, and B. Moldan, "Sustainable development ´ goals: A need for relevant indicators," Ecological Indicators, vol. 60, pp. 565–573, 2016.

[3] World Health Organization (WHO), Guidelines for drinking-water quality: recommendations. World Health Organization, 2004.

[4] E. Weinthal, Y. Parag, A. Vengosh, A. Muti, and W. Kloppmann, "The eu drinking water directive: the boron standard and scientific uncertainty," European Environment, vol. 15, no. 1, pp. 1–12, 2005.

[5] R. W. Adler, J. C. Landman, and D. M. Cameron, The clean water act 20 years later. Island Press, 1993.

[6] D. Berge, "Overvaking av farrisvannet med tilløp fra 1958-2010," ˚ 2011.

[7] I. W. Andersen, "EUs rammedirektiv for vann–miljøkvalitetsnormer for vannmiljøet i møte med norsk rett," Kart og Plan, vol. 73, no. 5, pp. 355–366, 2013.

[8] V. Novotny, Water quality: prevention, identification and management of diffuse pollution. Van Nostrand-Reinhold Publishers, 1994.

[9] A. Hounslow, Water quality data: analysis and interpretation. CRC press, 2018.

[10] S. Yagur-Kroll, E. Schreuder, C. J. Ingham, R. Heideman, R. Rosen, and S. Belkin, "A miniature porous aluminum oxide-based flowcell for online water quality monitoring using bacterial sensor cells," Biosensors and Bioelectronics, vol. 64, pp. 625–632, 2015.

[11] H. R. Maier and G. C. Dandy, "The use of artificial neural networks for the prediction of water quality parameters," Water Resources Research, vol. 32, no. 4, pp. 1013–1022, 1996.

[12] H. Orouji, O. Bozorg Haddad, E. Fallah-Mehdipour, and M. Marino, "Modeling of water quality parameters using data- ˜ driven models," Journal of Environmental Engineering, vol. 139, no. 7, pp. 947–957, 2013.

[13] O. Bozorg-Haddad, S. Soleimani, and H. A. Loaiciga, "Modeling ´ water-quality parameters using genetic algorithm–least squares support vector regression and genetic programming," Journal of Environmental Engineering, vol. 143, no. 7, p. 04017021, 2017.

[14] N. Mahmoudi, H. Orouji, and E. Fallah-Mehdipour, "Integration of shuffled frog leaping algorithm and support vector regression for prediction of water quality parameters," Water Resources Management, vol. 30, no. 7, pp. 2195–2211, 2016.

[15] F.-J. Chang, Y.-H. Tsai, P.-A. Chen, A. Coynel, and G. Vachaud, "Modeling water quality in an urban river using hydrological factors–data driven approaches," Journal of Environmental Management, vol. 151, pp. 87–96, 2015.

[16] J. Gubbi, R. Buyya, S. Marusic, and M. Palaniswami, "Internet of things (iot): A vision, architectural elements, and future directions," Future generation computer systems, vol. 29, no. 7, pp. 1645– 1660, 2013.

[17] V. Mayer-Schonberger and K. Cukier, ¨ Big data: A revolution that will transform how we live, work, and think. Houghton Mifflin Harcourt, 2013.

[18] Y. Wu, F. Hu, G. Min, and A. Y. Zomaya, Big Data and Computational Intelligence in Networking. CRC Press, 2017.

[19] D. R. Hardoon, S. Szedmak, and J. Shawe-Taylor, "Canonical correlation analysis: An overview with application to learning methods," Neural computation, vol. 16, no. 12, pp. 2639–2664, 2004.

[20] I. T. Jolliffe and J. Cadima, "Principal component analysis: a review and recent developments," Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, vol. 374, no. 2065, p. 20150202, 2016.