

Mahdi Karkush
Deepankar Choudhury
Jie Han *Editors*

Current Trends in Geotechnical Engineering and Construction

Proceedings of 3ICGE-Iraq 2022

 Springer

Current Trends in Geotechnical Engineering and Construction

Mahdi Karkush · Deepankar Choudhury ·
Jie Han
Editors

Current Trends in Geotechnical Engineering and Construction

Proceedings of 3ICGE-Iraq 2022

 Springer

Editors

Mahdi Karkush
Civil Engineering
University of Baghdad
Baghdad, Iraq

Deepankar Choudhury
Civil Engineering
Indian Institute of Technology Bombay
Mumbai, Maharashtra, India

Jie Han
Civil, Environmental and Architectural
Engineering
University of Kansas
Kansas, KS, USA

ISBN 978-981-19-7357-4 ISBN 978-981-19-7358-1 (eBook)
<https://doi.org/10.1007/978-981-19-7358-1>

© The Editor(s) (if applicable) and The Author(s), under exclusive license
to Springer Nature Singapore Pte Ltd. 2023

This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors, and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

This book contains selected articles from the third International Conference on Geotechnical Engineering-Iraq (3ICGE-Iraq) held at University of Baghdad/Baghdad/Iraq on May 29–31, 2022, to discuss the challenges, opportunities, and problems of application of geotechnical engineering in projects. Also, the conference includes recent applications in structural engineering, materials of construction, construction management, engineering of water resources, and environmental engineering. The 3ICGE-Iraq was organized by the Iraqi Scientific Society of Soil Mechanics and Foundation Engineering (ISSSMFE) with the cooperation of the College of Engineering/University of Baghdad, College of Engineering/University of Kerbala, and Kerbala Center for Studies and Research/Imam Hussain Holy Shrine. The articles cover a wide spectrum of themes in civil engineering, including but not limited to sustainability and environmentally friendly applications. The contributing authors are researchers in their respective fields from several universities. This book will prove a valuable resource for practicing engineers and researchers in the field of geotechnical engineering, structural engineering, and construction and management of projects.

Mahdi Karkush
Deepankar Choudhury
Jie Han

Contents

Calculating the Real Need for Fire Brigade Stations in Al-Samawah City	1
Waleed A. Rzaij, Basim H. K. Al-Obaidi, and Mohammed R. Abbas	
Drinking Water Assessment Using Statistical Analyses of AL-Muthana Water Treatment Plant	13
Mohammed Abed Naser and Khalid Adel Abdulrazzaq	
Simulation Design and Performance of a Residential Complex Using Liquefied Petroleum Gas Network	21
Amna A. Farouq and Basim H. K. Al-Obaidi	
Disinfection Performance of Polyvinyl Chloride (PVC) Membrane Incorporating with AgNPs	31
Asmaa N. Al-Himeiri and Alaa H. Al-Fatlawi	
Optimal Bedding Selection with the Specific Soil Type According to the Thrust Forces Generated in the Water Distribution Networks Using the Restraining Joint System	38
Murtadha H. Dawood, Amer F. Izzet, and Basim H. Khudair	
Simulation of Residual Chlorine in Al-Yarmouk Drinking Water System Using WaterGEMS	52
Abdulrahman A. Abdulsamad and Khalid Adel Abdulrazzaq	
Optimization and Modelling of Electrochemical Removal of Nitrate from Solutions	62
Muhammed A. Shallal, Sarah A. Ali, Haneen H. Hamzaa, Salam M. Naser, Maliheh Arab, and Raad Hashim	
Determination of Potential Sites for Landfill Using Geographic Information Systems Technology in Shatra City	73
Mukhalad N. Mohammed and Faisal G. Mohammed	

Selection of Optimal Location for Wind Turbines in Diyala Governorate Using the Analytic Hierarchy Process (AHP) with GIS Technique	86
Qater AL- Nada Rasim Rejap and Yousif H. Khalaf	
Automatic Co-registration of UAV-Based Photogrammetry and Terrestrial Laser Scanning in Urban Areas	99
Mohammed G. Ahmed and Fanar M. Abed	
Identify the Critical Risk Factors at the Tendering Phase in Iraq	113
Marwa Makki Dishar and Meervat Razzaq Altaie	
Utilizing Delphi Technique and Bootstrap to Determine the Maximum Cost Reduction in Serial Tendering for School Construction Works . . .	124
Arshed A. Mohammed and Kadhim R. Erzaij	
Geotechnical Risk Management. A Case Study of Nablus City, Palestine	139
Fares Sami Hijjawi	
Analyzing the Quantity and Cost of the Waste Generated in Construction Projects in Iraq	151
Kadhum L. Atabi, L. Reig-Cerdá, and F. J. Colomer-Mendoza	
Proposing Risk Responses for Iraqi Petroleum Sector Using Analytic Network Process	164
Noor Abdulsattar Abduljabbar and Hatem Khaleefah Breesam	
Investigation of the Deformation of Sandy Soil Near a Laterally Loaded Single Pile Using the Particle Image Velocimetry Technique . . .	178
Balqees A. Ahmed and Dhergham A. R. Al-Hamdani	
Experimental and Numerical Evaluation for Bearing Capacity of a Square Footing on Geotextile Reinforced Sandy Soil	195
Hussein Shaia and Lubna Thamer	
Effect of Embedment Depth on the Load-Settlement Behavior of Precast Pile in Al-Gharraf Oil Field	211
Taha Y. Abdunabi, Mahdi O. Karkush, Yaser Safa, and Ali H. Mahdi	
Observations on the Behavior of Continuous Flight Auger Piles in Iraq	222
Mohammed Y. Fattah, Mahdi O. Karkush, Mohammed A. Al-Neami, Taha Y. Al-Kaabi, Mudhafar K. Hameedi, Maher M. Jebur, Shaimaa H. Fadhil, and Mohammed H. Al-Dahlaki	
Numerical Assessment of Ring Foundation Settlement Under Seismic Loading	230
Evan E. Al-Khalidi, Nabeel K. Lwti, Mahdi O. Karkush, and Wisam A. Aljuboori	

Experimental Assessment of Bearing Capacity on Pile Foundations of the New Monument in Nur-Sultan City 243
 Askar Zhussupbekov, Dmitry Chunyuk, Victor Kaliakin, and Abdulla Omarov

Finite Element Analysis of the Load-Settlement Behavior of Large-Scale Shallow Foundations on Fine-Grained Soil Utilizing Plaxis 3D 249
 Asmaa G. Salih, Ahmad S. A. Rashid, and Nihad B. Salih

Energy Piles, Applications and Research Aspects: An Investigation on the Behavior of a Single Energy Pile in Dry Condition 261
 Fardin Jafarzadeh and Sina Afzalsoltani

Wetting and Drying Cycles Influences on Geotechnical Properties of Lime-Stabilized Clayey Soil 278
 Tavga Aram Abdalla and Nihad Bahaaldeen Salih

Inversion Analysis of Slope Engineering Parameters Using Back Propagation Neural Network Based on Strength Reduction Coefficients 290
 Arif Raouf and Kunyong Zhang

Agricultural Nano Fertilizers: Macronutrient Types and Applications Review 306
 Mohammad R. Alrbaihat

Investigation of Shear Strength Parameters for Gypseous Soils Using a Modified Apparatus of Triaxial Test 317
 Mustafa M. Abdalhusein, Ali Akhtarpour, Rusul Almahmodi, and Mohammed Sh. Mahmood

Analytical Solution to the Consolidation Problem of PVD Improved Soil with Nonlinear Variation of Vacuum Pressure 331
 Fatema S. Noori and Ala N. Aljorany

Structural Problems of a Multi-storey Building During Construction Due to the Absence of a Specialized Geotechnical Role—A Field Case Study 340
 Taha Y. Al-Kaabi, Mohammed Y. Fattah, and Ahmed S. A. Al-Gharbawi

Assessment of Bearing Capacity and Settlement Characteristics of Compacted Clay Soil Reinforced by Sand Dune and Sodium Silicate Columns 352
 Evan E. Al-Khalidi, Mahmood D. Ahmed, Ammar A. Sheikha, and Ali A. J. Alshamoosi

Finite Element Based Pseudo-Static Stability Analysis of Soil Slope Under Combined Effects of Horizontal and Vertical Seismic Accelerations 365
 Tanmoy Das and Deepankar Choudhury

Elastic Modulus Determination Based on Pressuremeter Tests and Standard Penetration Tests	377
Ali Tabatabaei, M. R. Kamali, and Saba Abedi Anaraki	
Slope Stability and Seepage Analysis of Dikes Strengthened with Sheet Pile Wall	384
Aneed Husam Sameer, István Kádár, and Zsombor Illés	
The Behavior of Reinforced Reactive Powder Concrete Two-Way Slabs Under Drop-Weight Impact Loads	397
Sajjad H. Majeed, Eyad K. Sayhood, and Nisreen S. Mohammed	
Damage Assessment of Tympanic Membrane in Sheep Subjected to Blast	411
Assal Hussein	
Estimation of Deep S-Wave Velocity Profile Using Seismic Records Case of Lima, Peru	421
Jorge Soto and Jorge E. Alva	
A Life Cycle Assessment Comparison of External Cavity Walls Using Different Types of Concrete Block	433
D. Todd, Joseph Amoako-Attah, and Khalid Hashim	
Integration of 3D Concrete Printing in the Construction Industry: A Short Review	445
Ravekumar Chandrasekar, Michaela Gkantou, Georgios Nikitas, Khalid Hashim, Hampannaver Rajanna Pradeep, and Arun Ahuja	
Impact of Vehicle Speed and Loading Time on Permanent Deformations of Asphalt Pavement	453
Zainab Ahmed Alkaissi and Qais Sahib Banyhussan	
Study of Pedestrian Crossing Behavior at A Number of Unmarked Crossings in Kuala Lumpur, Malaysia	463
Zainab Hacham and Hussain Hamid	
Non-destructive Tests of Reactive Powder Concrete Using Sustainable Materials as a Partial Replacement of Fine Aggregate	476
Mena A. Gawad and Nada M. Fawzi	
Author Index	489



Calculating the Real Need for Fire Brigade Stations in Al-Samawah City

Waleed A. Rzajj¹(✉), Basim H. K. Al-Obaidi¹, and Mohammed R. Abbas²

¹ Civil Engineering Department, University of Baghdad, Baghdad, Iraq
waleed.ahmed.re@gmail.com,
dr.basimal-obaidy@coeng.uobaghdad.edu.iq

² Directorate of Civil Defense, Samawah, Al-Muthanna Governorate, Iraq

Abstract. The location of fire brigade stations and equipment has a significant impact on the efficacy and efficiency of fire brigade department services. The challenge addressed by this study was that the fire brigade department required a consistent and repeatable technique to assess the response capabilities and safeguarding levels offered as the city of Samawah/Iraq grew and changed. Evaluating the locations of the current fire brigade stations in the city of Samawah is the aspect addressed by the research to determine the accuracy and validity of the locations of these stations by the competent authorities and their suitability to the area of the city's neighborhoods and its residents. The Iraqi Ministry of Housing, Construction, Municipalities and Public Works has set standards for fire brigade stations in the year 2018. These standards were used in this research because they are the standards adopted in Iraq. The first criterion represents the population size criterion. This criterion specified that each fire brigade station must provide a service for (48000 people), and the second criterion represented the distance traveled, which defined its field of service by (2 km) for each fire brigade station, as for the third criterion represented by the response time, which was set at (10 min) for the local standard and this criterion is considered large compared to the global standard of (4 min). The result using geographic information system (GIS) showed that needs four additional fire brigade stations to be added to the already existing four stations so that the total number of fire brigade stations in the city becomes eight stations, and this number of stations will provide service to all residents of the city and reduce the risk of fires on the city.

Keywords: Fire brigade station · Evaluating · Response time · Location · Distribution · Population size

1 Introduction

The location of fire brigade stations has grown increasingly essential in order to serve the largest number of residents [1]. The proper placement of fire brigade stations is a key aspect in providing effective and cost-effective fire protection. In the past, fire brigade stations were built on or near major thoroughfares and in regions where existing stations were too far away to respond. The locations of the sites were chosen based on personal

preferences. Even though cities may appear to be the same on a map, determining deployment requires a deeper investigation [2].

Therefore, fire brigade stations services are one of the security services that must be available in every city and distributed over all its residential neighborhoods in a manner commensurate with the continuous increase in the size of its population and with the area of that city and the future expansion of each of them, and this, in turn, depends on several things, the most important of which are the speed of arrival of fire brigade station vehicles to the places of accidents, which is one of the important indicators of the efficiency of this service, which comes from the efficient geographical distribution of fire brigade stations within cities, and thus this provides security and safety for residents inside and outside the city [3]. Where Iraqi cities suffer from a weakness in the spatial distribution of fire brigade stations in general, as there are areas that are not covered by emergency response services, not taking into account planning standards in the spatial distribution of fire brigade stations, and the difficulty of accurately determining the locations of fires in the city and the shortest distance and time to reach. Among the characteristics of fire brigade station efficiency is the speed of reaching the location of the accident in the shortest possible time, the skill of rescuers or fire brigade station men in dealing with accidents, what are the procedures followed to deal with the accident, and what are the modern techniques using civil defense men to reduce time and speed in rescue [4].

To evaluate the locations and performance of fire brigade stations, many studies have been conducted around the world. These studies included tests of these stations with different levels of performance, in terms of the speed of response to extinguish the fire, the speed of access to the site of the accident, and other criteria. Mufeed [5] presented a study to evaluate the locations of fire brigade stations in the city of Baghdad, and the results showed that the lack of response speed in some cases is not due to the inaccurate distribution of these stations, but rather there is a lack of consideration for the distribution of road network centers, traffic, closed roads and intersections in the streets to facilitate the arrival of firefighters and shorten the time. Whereas Jerald [6] presented a procedure for evaluating the locations of fire brigade stations in West Covina and concluded that a standard operating procedure should be adopted for the regular evaluation of the station's location and the effectiveness of deployment. It is also recommended to purchase software that uses advanced GIS features to improve the delivery of firefighting services. Also, Maher [1] presented a study to evaluate the fire brigade station locations in the city of Samawa based on the standards of the Ministry of Construction and Housing for the year 1983 and found that these standards are old and do not fit the housing growth in the city.

The research aims to evaluate the distribution of fire brigade stations and to indicate the accuracy of the selection of these places by the competent authorities, through the use of local and international standards in addition to geographic information systems (GIS) in order to ensure a fair distribution of this service to all neighborhoods of the city and to ensure the life and property of its residents through a service efficiency offered by these stations. The local standards of the Iraqi Ministry of Housing, Construction, Municipalities and Public Works for the year 2018, which were approved in the Republic of Iraq, as well as the use of geographic information systems (GIS), were used in the

analysis and identification of serviced and unserved areas by fire stations in the city of Samawah.

2 Material and Methods

2.1 Case Study Description

The study case that was adopted in this research is the city of Samawah, an Iraqi city located in southern Iraq on the banks of the Euphrates River. It is the center of Al-Muthanna Governorate, 280 km southeast of Baghdad, and its area is (941 km²). Figure 1 shows the location of the city.



Fig. 1. The location of the city of Samawah on the map of Iraq [7].

2.2 Data Collection and Analysis

Data was collected about fire brigade stations in terms of their locations and the neighborhoods they serve. This information was taken from the Directorate of Civil Defense in the city of Samawah. Also, information was collected about the number of residents of the neighborhoods served by the fire brigade stations, and this information was taken from the Directorate of Statistics of the city of Samawah. As for the local standards adopted in locating fire brigade stations, they were taken from the Department of Construction and Housing in the city of Samawah. Figure 2 shows the locations of the fire brigade station in the city of Samawah.

Table 1. Details of fire brigade stations in the city of Samawah [8, 9].

Fire brigade station location	Serviced area (km ²)	Residents of serviced neighborhoods
AL-Soub AL-Saghir	15.10	76781
Thawrat AL-Ashrin	13.55	36404
AL-Samawah	5.21	37628
AL-Jumhori	7.67	83164
Total	41.53	233977

3 Fire Brigade Station Concepts and Considerations

Fire brigade is the process of putting out a fire with the use of specialist equipment and techniques. Fire science ideas and procedures are used to save people trapped in fires and prevent material and human losses [10]. The location of fire brigade stations has a substantial impact on the efficacy and efficiency of the fire department's services [11]. Evaluation of fire brigade station locations is done by using many criteria and considerations, including (population size, distance traveled, and response time). The Iraqi Ministry of Construction, Housing, Municipalities, and Public Works has set parameters for these standards, and according to the instructions of the housing standards for the year 2018, which are shown in Table 2.

Table 2. Size of approved criteria [12].

Criteria name	Criteria measurement
Population size	(38400–57600) capita
The traveled distance	2000 m
Response time	10 min

4 Results and Discussion

4.1 Serviced Area and Population

It is noticed that there is a random and illogical distribution of fire brigade stations, and this is appears in Figs. 3 and 4, where there are stations responsible for protecting the population and neighborhoods of the spaces and numbers of citizens, the service provided by other fire brigdae stations is weak, and this certainly affects the ability of these stations to provide a full service to the areas for which these stations are responsible. This indicates that the city needs additional fire stations to assist other fire stations in providing full services to the city's residents and protecting their properties.

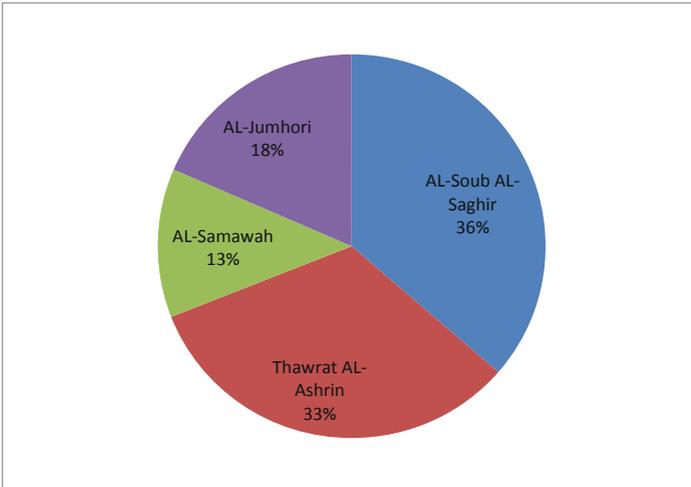


Fig. 3. Percentage of the area served by each fire brigade station.

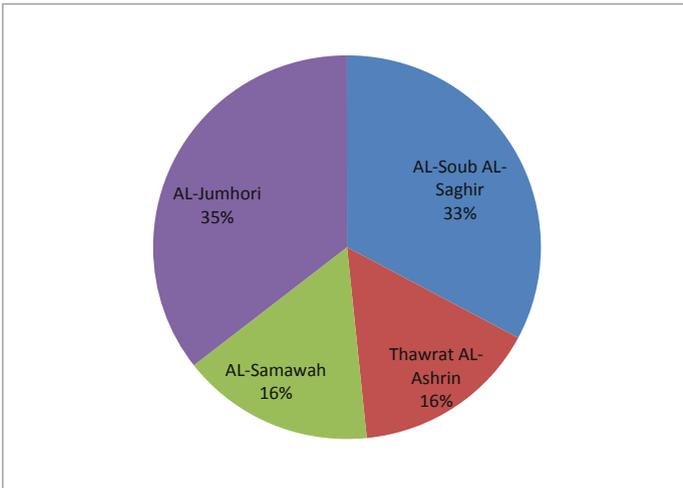


Fig. 4. Percentage of population served by each fire brigade station.

4.2 Assessment of Annual Fire

The population expansion in the city of Samawah and random construction in informal neighborhoods, led to an increase in the number of fires in the city. In the past five years, an increase in the number of fires has been observed from year to year. In 2017, the number of fires reached 1491, to nearly double this number in 2021, and this indicates the large population increase during this period and the expansion of residential neighborhoods, as well as the weakness of preventive measures against fires, knowing that the main cause of fires is the use of electrical appliances, Therefore, residents must be made aware of the danger of fires. Figure 5 shows the annual growth of the number of fires in Samawah over the years (2017–2021).

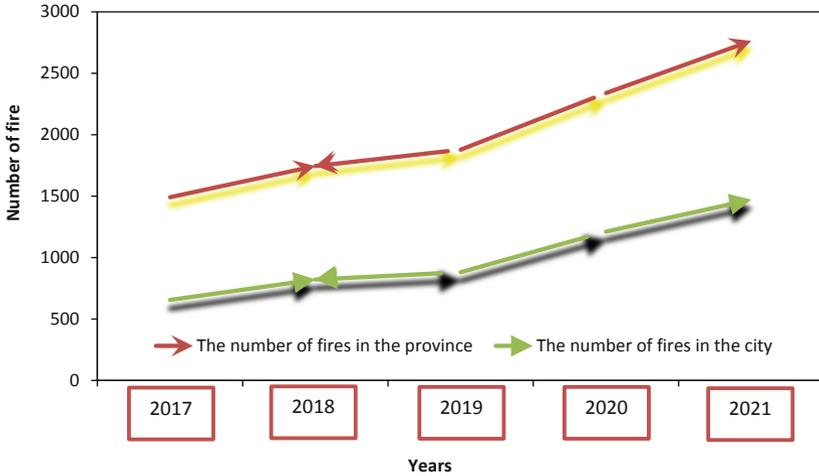


Fig. 5. The increase in the number of fires annually.

4.3 Classification of Fire

The Directorate of Civil Defense in Al-Muthanna Governorate classifies fires into three categories (government sector fires, private sector fires, mixed sector fires). Table 3 shows the rate of fires that occurred during the past five years in each sector.

Table 3. Fire rate in sectors for the past five years.

Classification of fire	Fire rate for the period from (2017–2021)
Government sector	286
Residential sector	1758
Mixed sector	0

The data in the above table showed that there is a big difference between the number of fires in the governmental and residential sectors in Al-Muthanna Governorate, and this indicated that the most crowded areas have the largest number of fires and this is observed in residential areas. As for the mixed sector, the number of fires is equal to zero because the number of mixed buildings between the residential and government sectors in the governorate is almost non-existent. In the city of Samawah (70%) of these fires occur because it is the center of the governorate and the most densely populated and built.

4.4 Evaluation of the Efficiency of the Fire brigade Stations Distribution

4.4.1 Population Size Criterion

The Directorate of Statistics in the city of Samawa estimated the population of the city of Samawa to reach 233977 people for the year 2020. Since the urban and rural housing standards in Iraq for the year 2018 indicate that each fire brigade station must provide a service for (38400–57600) capita (average = 48000 capita), this indicates a shortage in the number of fire brigade stations in the city according to this standard. There are four fire brigade station available in the city, meaning that there is a need to open two additional fire brigade stations according to this standard.

4.4.2 Distance Traveled Criterion

The Ministry of Housing standards for 2018 indicates that the coverage distance of civil defense centers is 2 km. By applying the criterion of the distance traveled within the study area and based on the area of residential neighborhoods represented by the

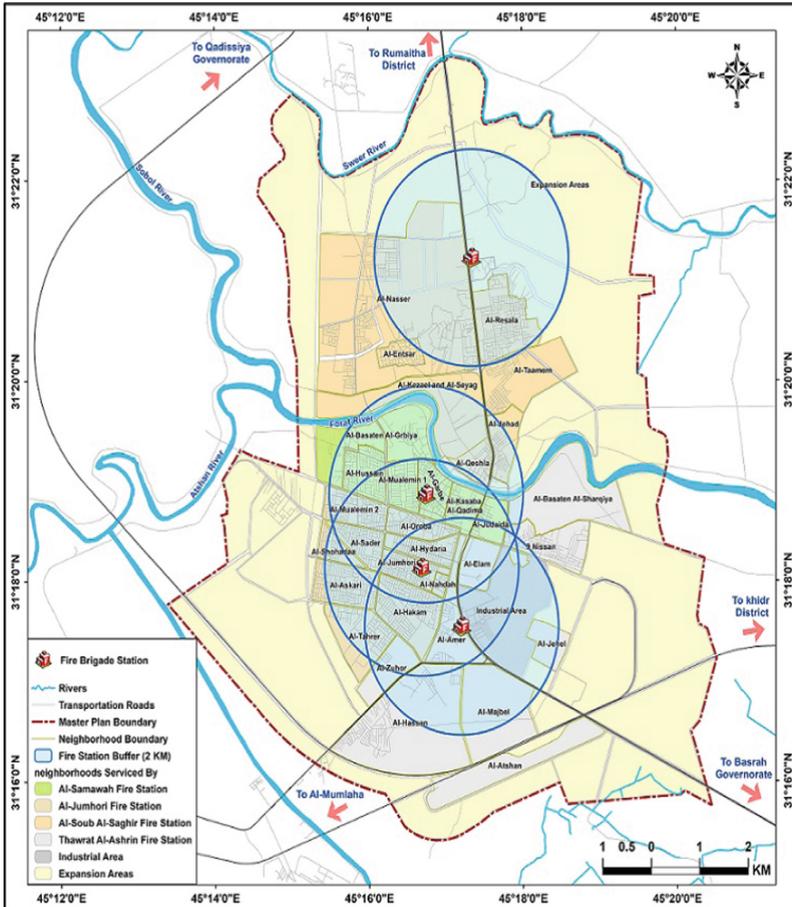


Fig. 6. Coverage of existing fire brigade stations for city areas.

GIS program, the proportion of areas served and not served by fire brigade stations in the city of Samawah. Figure 6 shows the parts of the city that are not covered by fire brigade stations services, which constitute large areas of the city, and this makes many of the city's residents and their properties exposed to risks due to the lack of fire stations covering their areas.

This means that the city needs to open additional fire brigade stations to reduce the shortfall in coverage of all areas of the city and achieve the standard traveled distance of 2 km, as shown in Fig. 7.

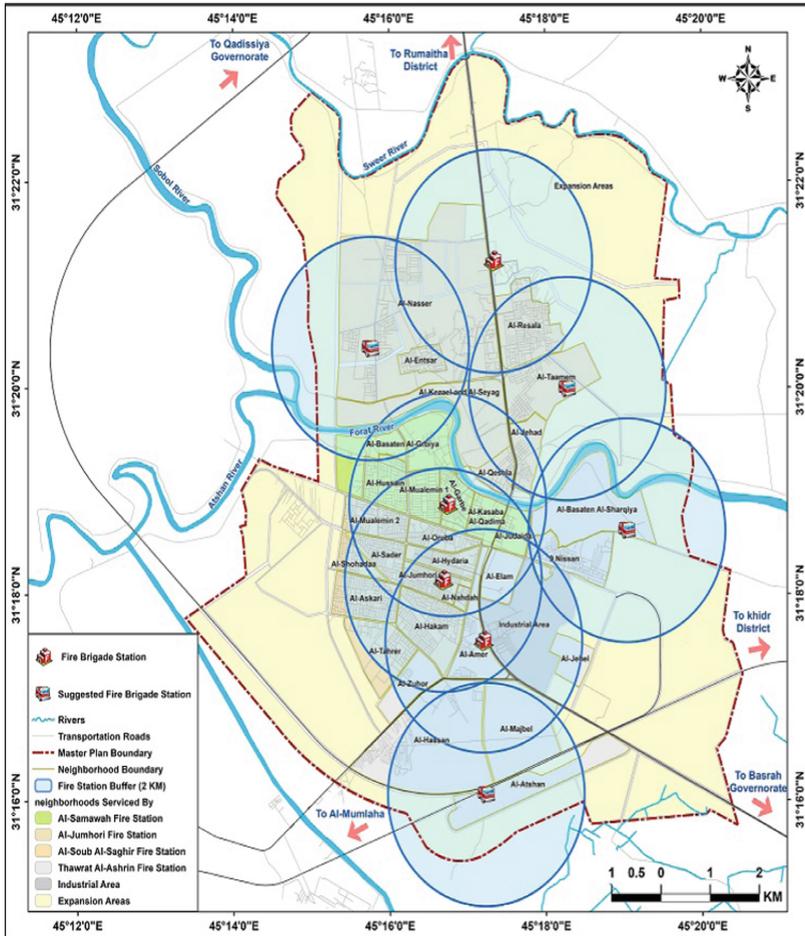


Fig. 7. Additional fire brigade station locations.

4.4.3 Response Time Standard

Time is the critical element when reporting any emergency. For example, a fire can expand and double its size significantly in a short time. Time is the most important

factor in saving building occupants and reducing human and material losses [13]. The Iraqi local standard, according to the Ministry of Housing, set the response time at 10 min, which is a very long time if it is compared with the international standard, which is 4 min, so reducing the time required requires finding an ideal distribution for fire brigade stations and this depends on good planning for that service, which in turn is reflected on providing good service as quickly as possible and for the largest number of residents. To achieve this ideal service, the number of fire brigade stations must be increased and distributed in an ideal manner, taking into account the area of the city. The response time of 4 min was adopted for research purposes because it represents a global and realistic standard in practice and is approved in many countries [1]. Table 4 shows the response rate of fire brigade stations in the city of Samawah for the past five years.

Table 4. Response time to fire brigade stations in the past five years.

Year	Response time (minutes)						
	<3 min	(4–5) min.	(6–10) min.	(11–15) min.	(16–30) min.	(31–59) min.	>60 min.
2017	460	137	48	6	2	2	0
2018	540	213	51	12	4	1	0
2019	569	230	59	16	6	1	0
2020	798	296	85	21	11	0	0
2021	1091	421	113	31	17	2	0
Ave.	692	260	72	18	8	2	0
%	65	24	7	1.7	0.79	0.018	0

It is clear from the above that the fire brigade stations in the study area have applied the international standard in response time, which was estimated at four minutes, 65% of the total during the study period. As for the national standard, which estimated the response time at ten minutes, the rate of arrival of fire brigade teams during this period was It reached 7% of the total number of fires in urban centers in the city during the study period, and there are percentages of the arrival of fire brigade teams outside the local and international classification, so these percentages are not appropriate for rescue operations from fire accidents that are quick to destroy everything within minutes. Suggesting fire brigade stations through which an appropriate and standard response time is achieved to reduce the proportion of human and material losses as much as possible.

5 Conclusions

From this study the following was concluded:

- There is an illogical distribution of fire brigade stations in terms of the area served, as there are fire brigade stations that serve areas twice the area served by other stations.

- There is a significant increase in the number of annual fires and these fires are gradually increasing with the years as a result of the population increase in the city.
- Evaluate the locations of fire brigade stations, according to:
 - a. Population size criterion: By applying this criterion, it was found that the study area needs additional fire brigade stations.
 - b. Distance traveled criterion: Through the application of this criterion, it was observed that there is a large deficit in all fire brigade stations in delivering their services to residential neighborhoods in the city, where the percentage of the deficit reached approximately (40%) of the total area of the city.
 - c. Response time criterion: There is a delay in the response time for a number of fires, and this is unacceptable because the fire spreads very quickly and causes a heavy loss of life and property.
- According to the above criteria, the study area needs eight fire brigade stations, meaning that it needs to add four fire brigade stations to the actual existing stations, which are four fire brigade stations. This additional number of stations will serve the expansion areas around the study area.

Acknowledgment. The author would like to extend his thanks to the Civil Defense Directorate in AL-Muthanna Governorate, the Department of Statistics in the city of Samawah for allowing him to obtain data and information and to communicate with them. The author would like to thank the staff from the Sanitary Engineering Laboratory and the Civil Engineering Department-College of Engineering, the University of Baghdad for their invaluable support in completing this work.

References

1. Maher, N.A.: Evaluation of the services civil defense centers. J. College Basic Educ. Educ. Hum. Sci. (27), 489 (2016)
2. Granito, J.A.: Evaluation and planning of public fire protection. In: Cote, A.E., Linville, J.L. (eds.) Fire Protection Handbook, 16th edn., pp. 15–90–15–101. National Fire Protection Association, Quincy (1986)
3. Muna, A.D., Abd-aljalel, D.A.: Evaluation of the efficiency of the distribution of civil defense centers in the urban centers of Wasit Governorate. J. Fac. Educ. (37), 467–492 (2019)
4. Osama, J.M., Sadiq, T.S.: Studying the efficiency of the spatial distribution of civil defense centers using geographic information systems GIS. J. Fac. Arts, 1113–1127 (2019). Special number for conferences
5. Shok, M.E.: Optimal sapial distribution of fire stations using geographic information systems Baghhdad case study. IOP Conf. Ser. Mater. Sci. Eng. **737**, 012225 (2020)
6. Johanson, J.L.: A Procedure for Evaluuation of Fire Station Locations and Deployment (Executive Development). An applied research project submitted to the National Fire Academy as part of the Executive Fire Officer Program (1999)
7. Encyclopaedia Britannica: Al-Samawah, capital of Al-Muthanna governorate, Iraq (2011). <https://www.britannica.com/place/Al-Samawah>
8. Directorate of Civil Defense in Muthanna Governorate (2021)

9. Directorate of Statistics in the city of Samawah (2021)
10. Bashir, M.: Spatial analysis of the distribution of civil defense centers in Muscat Governorate using geographical information systems, Kuwait Geographical Society, Issue No. 356ESRI, G. 2007. GIS for Fire Station Locations and Response Protocols. White Paper, Redlands, CA (2010)
11. Gay, W., Siegel, A.: Fire station location analysis: a comprehensive planning approach. MIS Rep. **19**, 1–8 (1987)
12. Ministry of construction, Housing, Municipalities and Public Works. Urban Housing Standards (2018)
13. Ayad, A.F., Mohammed, S.R.: Spatial analysis of fire brigade stations in the city of Baghdad using information systems Geography. J. College Educ. (3), 134 (2012)



Drinking Water Assessment Using Statistical Analyses of AL-Muthana Water Treatment Plant

Mohammed Abed Naser^{1,2}(✉) and Khalid Adel Abdulrazzaq¹

¹ Civil Engineering Department, University of Baghdad, Baghdad, Iraq
mohammadnasier0@gmail.com, aleoubaidy@coeng.uobaghdad.edu.iq

² Directorate of Education Al-Muthana, Ministry of Education, Baghdad, Iraq

Abstract. Water is essential for survival, and controlling water quality is one of the most basic requirements for protecting this natural wealth from pollution and extinction. Statistical analysis technique was used with the SPSS v26 software to evaluate the quality of raw water period from (2016–2020), and 14 water parameters were assessed (Ka, Na, TSS, TDS, Mg, Ca, SO₄, Alk, TH, pH, Turbid, Temp, Cl, and Ec). Five principal components have eigenvalues value greater than unity and explain (76.159%) of the total variance of original data set. The first component was (28.678%) of the total variance with high loading on (TH, Ca, Mg, Cl and Ka), the second component was (16.141%) with positive loading on (TSS, Turb, and Temperature), the third component was (14.826%) with positive loading on (TDS and Ec), the fourth component was (8.929%) with positive loading in (Alk and SO₄), and the last one has (7.59%) from total variance which high positive loading in (pH). The Multiple Linear Regression (MLR) results in a strong relationship between water conductivity and total suspended solid with other water parameters which the coefficient of determination (R^2) values were 0.963 and 0.92. The ANN model was created to forecast river turbidity based on influent TSS, Mg, TDS, and Ca. The sum of squared errors and relative errors being (0.231, 0.101) and (0.009, 0.027) respectively, respectively, the error rate in predicting the model is low, indicating that the model is successful in predicting the turbidity of the river's raw water.

Keywords: Drinking water · Assessment · Statistical analyses

1 Introduction

Water is one of the most important basic sources of life. Water pollution has a significant impact on human health, so keeping clean water free of pollution is a high priority for a disease-free life [1]. Detecting variations in the quality of drinking water through the use of statistical analysis techniques, which improve the reliability of the system in laboratories, allowing the administration to make the appropriate decision, and these techniques provide foresight into future changes and challenges confronting the authorities in charge of managing and regulating water [2]. Monitoring water quality over time and using statistical analysis is one of the most common and effective methods for evaluating time changes and environmental problems that occur in raw water sources

based on chemical and physical parameters and biological indicators, and it contributes significantly to assisting researchers in changing the state of pollution [3]. According to [4], the temporal data of raw water quality is a fundamental method for discovering hypotheses that were not present when measurements were taken and were not expected, and it is of a standard value that reveals important patterns that allow us to identify trends and rare events that appear, and thus discover undesirable characteristics in the quality of drinking water. One of the most important components of machine learning and artificial intelligence is artificial neural networks. It is inspired by the structure of the human brain and operates as if it were made up of interconnected nodes where simple manipulations can be performed [5].

Artificial Neural Networks (ANNs), also known as neural networks, are cutting-edge computational systems and methods for deep learning, knowledge presentation, and finally applying acquired knowledge to maximize complicated system output responses [6]. Also, the principal component analysis (PCA) is another statistic technique used in water quality sample testing to summarize and abbreviate data, converting a large number of implicitly, albeit partially, correlated variables into a much smaller set of imaginary independent variables, which are usually called principal components. It is calculated primarily from the original variables in ratios and amounts that increase or decrease depending on the role and influence of the original variables [7]. This study aims to use statistical analysis tools to assess drinking water quality in Al-Muthanna Water Treatment Plant and find mathematical models that allow us to predict basic water quality parameters.

2 Materials and Methods

The following points can summarize the statistical analysis and modeling prediction of source water using SPSS v26:

- Multiple linear regression (stepwise regression model) was used for raw water quality parameters to find a mathematical relationship that predicts the value of (Ec and Turb) with other water parameters.
- Principal component analysis (PCA): is a technique for identifying a smaller number of uncorrelated variables known as principal components from a larger set of data. This technique is commonly used to highlight differences and capture strong patterns in data sets. It is one of the most widely used methods for analyzing water quality data and reducing variables without affecting the system [8].
- The ANN model was created to forecast river turbidity based on influent TSS, Mg, TDS, and Ca turbidity. Water turbidity is one of the most important parameters indicating the quality of drinking water because it is an integrated parameter that is closely related to the rest of the water quality parameters and can be used to infer the quality of drinking water [9].

3 Results and Discussion

3.1 Principal Component Analysis (PCA)

The data were standardized, and the Kaiser-Meyer-Olkin (KMO) and Bartlett sphericity tests were computed. The KMO test resulted in 0.62, and the Bartlett sphericity test resulted in less than 0.001. The value of (Kaiser-Meyer-Olkin (KMO) test and Bartlett sphericity test) equals (0.66), which is an acceptable value because the minimum value is (0.5), indicating that the measurement is good and the significant degree of the measurement has been reached (0). Eigenvalues accounts and scree plot in Table 1 listed that only five principal components have eigenvalues greater than unity and explain (76.159%) of the total variance in the data set. The first component accounted for about (28.678%) of the total variance with high loading on (TH, Ca, Mg, Cl, and Ka). Polyvalent mineral ions cause water hardness. Water hardness is formed primarily by calcium and magnesium. An increase in hardness has a negative impact on human health and the industries that use water [10]. The second component accounted for about (16.141%) of the total variance and has a height positive loading for (TSS, Turb, and Temperature). The increase in suspended matter and turbidity has a negative impact on drinking water quality and the efficiency of drinking water treatment plants [11].

The third component accounted for about (14.826%) of the total variance and has a height positive loading for (TDS and Ec). TDS and Ec are water quality parameters that indicate salinity. These two parameters are correlated and are usually expressed using the following simple equation: $k Ec = TDS$ [12]. The fourth component accounted for about (8.929%) of the total variance and has a height positive loading in (Alk and SO_4), and the last one has (7.59%) from total variance which high positive loading in (pH). Increased pH and Alk values indicate that the water contains alkaline salts like (NaOH) and $(CaOH)_2$ [13].

Table 1. Total variance explained.

Comp.	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total
1	4.014	28.672	28.672	4.014	28.672	28.672	3.383
2	2.260	16.141	44.813	2.260	16.141	44.813	3.246
3	2.076	14.826	59.640	2.076	14.826	59.640	2.304
4	1.250	8.929	68.569	1.250	8.929	68.569	1.721
5	1.063	7.590	76.159	1.063	7.590	76.159	1.268

3.2 Multiple Regression Results (MLR)

Multiple linear regression is an advanced statistical method that ensures the accuracy of inference in order to improve research results through the optimal use of data in finding causal relationships between the phenomena of the subject of study. The multi-linear regression analysis was used to determine the relationship between the dependent and independent water quality parameters. The dependent variables (TSS and Ec) were selected, and the most independent influence parameter of water quality was chosen using a stepwise regression mod. The Multiple Regression Results listed in Table 2 and Fig. 1 a strong relationship between water conductivity and other water parameters, with a coefficient of determination (R^2) value (0.963), indicating a positive relationship with a high degree of predictability. The test also indicated that electrical conductivity is a function of (TDS) which can be represented in Eq. (1) that can be used to predict current and future values

$$Ec = 55.917 + 1.595 \text{ TDS} \tag{1}$$

Table 2. Model summary of Ec prediction.

Model	R	R ²	Adjusted R ²	Std. error of the estimate
1	.981 ^a	.963	.953	10.4614

^aDependent variable Ec

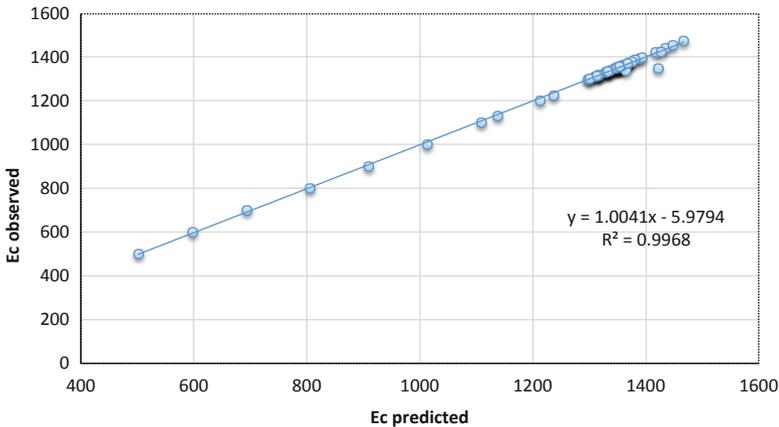


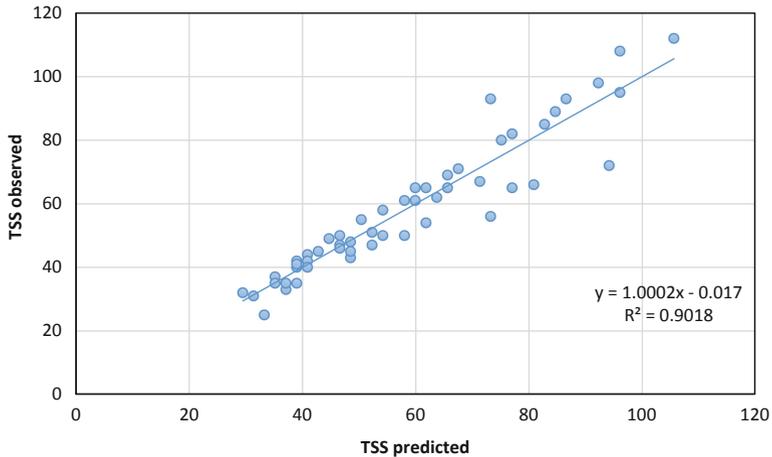
Fig. 1. Comparison of Ec ($\mu\text{S}/\text{cm}$) between observed and predicted values.

Table 3 and Fig. 2 listed that high relegation factor between (TSS) and other water quality parameters with (R^2) value (0.92), and indicated that total suspended solid is a function of (Turbidity), which can be produced by the Eq. (2).

$$\text{TSS} = 0.93 + 1.903 \text{ Turb} \tag{2}$$

Table 3. Model summary of TSS prediction.

Model	R	R ²	Adjusted R ²	Std. Error of the estimate
1	.959 ^a	.920	.897	6.5505

**Fig. 2.** Comparison of TSS (mg/L) between observed and predicted values.

Both above equations have been tested in the field and have proven to be reliable equations capable of producing very high results.

3.3 Artificial Neural Network (ANN)

The neural network application is an important tool for predicting water quality in drinking water treatment plants in order to reduce analysis and operating costs, evaluate performance, and control operating conditions more broadly [14]. The ANN model was created to forecast river turbidity based on influent TSS, Mg, TDS, and Ca. The model required 61 input data points divided into 47 for training and 14 for testing. Standardization is the data scaling method, and the number of hidden layers is one. Table 4 listed the amount of error was small in both training and testing, with the sum of squared errors and relative errors being (0.231 and 0.101) and (0.009 and 0.027) respectively, which the error rate in predicting the model is low, indicating that the model is successful in predicting the turbidity of the river's raw water. Table 5 explains the nature of the strength of the relationship between the independent and dependent factors in the input, hidden, and output layers, illustrated in Fig. 3. It shows that the gray line indicates positive values, and the blue line indicates negative values. The thickness of the line depends on the element's influence in the prediction process, regardless of whether the value is positive or negative.

Table 4. ANN model summary.

Training	Sum of squares error	0.213
	Relative error	0.009
	Stopping rule used	1 consecutive step(s) with no decrease in error
	Training time	0:00:00.00
Testing	Sum of squares error	0.101
	Relative error	0.027
Dependent Variable: Turbidity		
a. Error computations are based on the testing sample		

Table 5. Hidden layer parameters parameter estimates.

Predictor		Predicted			
		Hidden layer 1			Output layer
		H (1:1)	H (1:2)	H (1:3)	Turbidity
Input layer	(Bias)	.118	.098	-.246	
	TSS	-.405	-.541	.420	
	Ca	-.026	-.122	-.337	
	TDS	.025	-.470	-.142	
	Mg	.169	-.307	.305	
Hidden layer 1	(Bias)				.332
	H (1:1)				-1.624
	H (1:2)				-.355
	H (1:3)				.611

Figure 4 compares the prediction of turbidity concentrations based on different turbidity input parameters observed in this study. The expected trend follows the observed trend for all input data, and there is a significant convergence between the expected and actual values, with a small disparity.

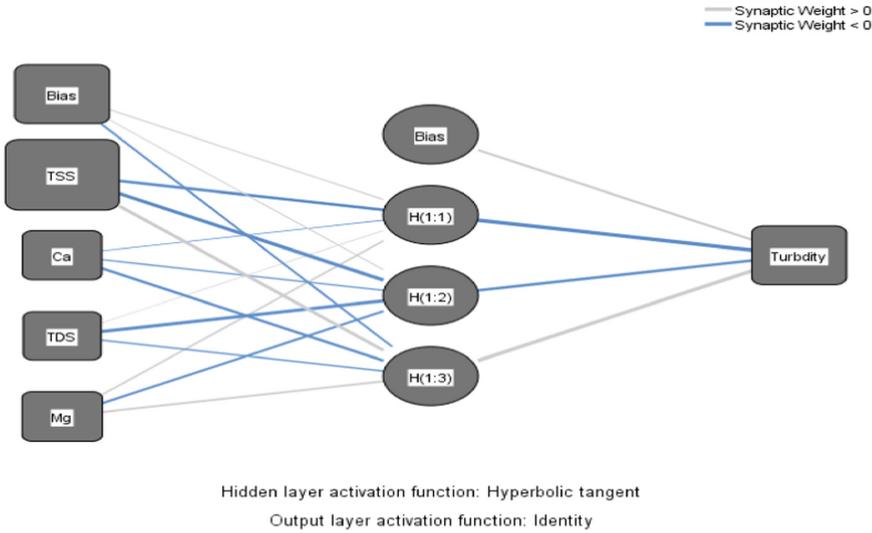


Fig. 3. Artificial neural network.

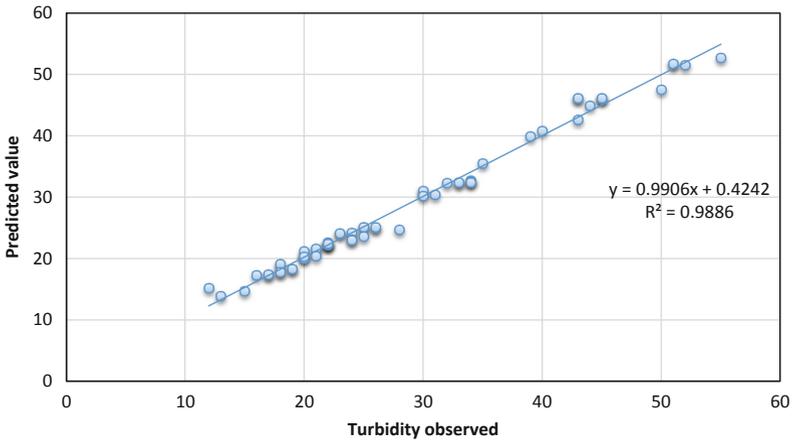


Fig. 4. Actual turbidity (NTU) versus predicted turbidity.

4 Conclusions

The following were the conclusions reached through the use of statistical analysis techniques: -

- Only five principal components have eigenvalues value greater than unity and explain (76.159%) of the total variance in the data set.

- The Multiple Linear Regression (MLR) results in a strong relationship between water conductivity and total suspended solid with other water parameters which the coefficient of determination (R^2) values were (0.963) and (0.92) sequentially, indicating a positive relationship with a high degree of predictability.
- The ANN modeling results show that the model performed at 99.06% prediction accuracy

References

1. Juntunen, P., Liukkonen, M., Pelo, M., Lehtola, M.J., Hiltunen, Y.: Modelling of water quality: an application to a water treatment process. *Appl. Comput. Intell. Soft Comput.* **2012** (2012)
2. Nnorom, I.C., Ewuzie, U., Eze, S.O.: Multivariate statistical approach and water quality assessment of natural springs and other drinking water sources in Southeastern Nigeria. *Heliyon* **5**(1), e01123 (2019)
3. Sun, X., et al.: Analyses on the temporal and spatial characteristics of water quality in a seagoing river using multivariate statistical techniques: a case study in the Duliujian River, China. *Int. J. Environ. Res. Public Health* **16**(6), 1020 (2019)
4. Burt, T.P., Howden, N.J.K., Worrall, F.: On the importance of very long-term water quality records. *Wiley Interdiscip. Rev. Water* **1**(1), 41–48 (2014)
5. Kujawa, S., Niedbała, G.: Artificial neural networks in agriculture. *Agriculture* **11**(6), 497 (2021)
6. Chen, M., Challita, U., Saad, W., Yin, C., Debbah, M.: Artificial neural networks-based machine learning for wireless networks: a tutorial. *IEEE Commun. Surv. Tutor.* **21**(4), 3039–3071 (2019)
7. Teixeira de Souza, A., Carneiro, L.A.T., da Silva Junior, O.P., de Carvalho, S.L., Américo-Pinheiro, J.H.P.: Assessment of water quality using principal component analysis: a case study of the Marrecas stream basin in Brazil. *Environ. Technol.* **42**(27), 4286–4295 (2021)
8. Zavareh, M., Maggioni, V., Sokolov, V.: Investigating water quality data using principal component analysis and granger causality. *Water* **13**(3), 343 (2021)
9. Iglesias, C., et al.: Turbidity prediction in a river basin by using artificial neural networks: a case study in northern Spain. *Water Resour. Manage* **28**(2), 319–331 (2014)
10. Akram, S., Rehman, F.: Hardness in drinking-water, its sources, its effects on humans and its household treatment. *J. Chem. Appl.* **4**(1), 1–4 (2018)
11. Serajuddin, M., Chowdhury, A.I., Haque, M.M., Haque, M.E.: Using turbidity to determine total suspended solids in an urban stream: a case study. In: *Proceedings of the 2nd International Conference on Water and Environmental Engineering*, Dhaka, pp. 19–22 (2019)
12. Rusydi, A.F.: Correlation between conductivity and total dissolved solid in various type of water: a review. In: *IOP Conference Series: Earth and Environmental Science*, vol. 118, no. 1, p. 012019. IOP Publishing, February 2018
13. Putro, P.G.L., Hadiyanto, H.: Water quality parameters of tofu wastewater: a review. In: *IOP Conference Series: Materials Science and Engineering*, vol. 1156, no. 1, p. 012018. IOP Publishing, June 2021
14. Nasr, M.S., Moustafa, M.A., Seif, H.A., El Kobrosy, G.: Application of Artificial Neural Network (ANN) for the prediction of EL-AGAMY wastewater treatment plant performance-EGYPT. *Alex. Eng. J.* **51**(1), 37–43 (2012)



Simulation Design and Performance of a Residential Complex Using Liquefied Petroleum Gas Network

Amna A. Farouq^(✉) and Basim H. K. Al-Obaidi

Civil Engineering Department, University of Baghdad, Baghdad, Iraq
{Amna.farouq2001M, dr.basimal-obaidy}@coeng.uobaghdad.edu.iq

Abstract. The population has been trying to use clean energy instead of combustion. The choice was to use liquefied petroleum gas (LPG) for domestic use, especially for cooking due to its advantages as a light gas, a lower cost, and clean energy. Residential complexes are supplied with liquefied petroleum gas for each housing unit, transported by pipes from LPG tanks to the equipment. This research aims to simulate the design and performance design of the LPG system in the building that is applied to a residential complex in Baghdad taken as a study case with eight buildings. The building has 11 floors, and each floor has four apartments. The design in this study has been done in two parts, part one is the design of an LPG system for one building, and the second part is the design of an LPG system for a complex containing eight buildings. The results were obtained by using mathematical equations and using the Pipe Flow expert v7.30 program to design and analyze with explaining steps in the program to design.

Keywords: LPG · Simulation · Design · Performance · Pipe flow software · Residential complex

1 Introduction

Many people who live globally lacked access to clean cooking, a modest rise over 2012. Although South and Southwest Asia had the most significant number of these people, Sub-Saharan Africa had a tremendous shortage. Because the population grows by 25 million per year, while access to clean cooking increases by just 4 million, access is proportional to population. Getting to Goal seven of the Sustainable Development Goals to ensure cheap and dependable access [1]. Because of its clean-burning properties and practical advantages over solid fuels and kerosene, liquefied petroleum gas (LPG), which primarily consists of propane and butane, is particularly well suited to residential cooking and heating needs. It is more convenient, safer, and cleaner in particular. It's also lightweight and has a high calorific value, both volume, and mass. As a result, switching from solid fuels and kerosene to LPG can have significant health, developmental, and environmental benefits [3].

Liquid Petroleum Gases (LPG) classify as light gases like propane and butane. Among its characteristics, it is considered a gas at normal temperature and pressure