European Scholar Journal (ESJ)
Available Online at: https://www.scholarzest.com
Vol. 3 No.4, April 2022
ISSN: 2660-5562

DESIGN OF RF-BASED SMART WASTE MANAGEMENT SYSTEM

Taha Darwassh Hanawy Hussein
Internet Manager, kirkuk, Iraq.
Taha_hussein@uokirkuk.edu.iq

Article history:
Received: 30th January 2022
Accepted: 1st March 2022
Published: 19th April 2022

Abstract:
The advancements in technology rapidly grow, considering the smart city systems as an essential part of our life. In these systems, the residents send observations, requirements, and recommendations. The main goals of the systems. Firstly, accessing sustainable development. Secondly, better rationalization of resource consumption. Thirdly, intelligent governance is led by participating in decision-making. Lastly, improving the quality of urban areas' life. Nevertheless, an infrastructure based on individuals' knowledge-sharing is crucial in smart cities (such as modern technology). This paper proposes a design RF-based smart waste system. The paper is divided into two parts. In the beginning, it reviews and analyzes the establishment requirements of a smart city structure. Design the proposal using an RF communication system and remote-control techniques (such as sensors. The system aimed at reducing the employees of traditional waste management and thus the expenditure (i.e., cost) of cleaning cities. Additionally, during the cleaning process, the wasting time can be reduced. To goals are demonstrated using computer experiments and analyzed using SSPS software.

Keywords: Smart city, infrastructure, global positioning, sensors, decision-making.

1.INTRODUCTION

IoT is a network connected with physical devices, sensors, and everyday objects interacting with them and the environment [15]. With its general understanding, the Smart city is a large and complex structure for its services aims to achieve citizen welfare. It improves people's lives where everything is connected with technologies [1][16]. In unsmart cities, there are many issues related to waste management, such as waste disposal, traffic jams and carbon dioxide [2]. The main goal of this work is to mitigate these problems without needing to resort to traditional waste disposal techniques. It is well known that traditional waste management systems suffer from several problems, such as irregular and delays in the cleaning. countries have foreseen this increase. Therefore, the population density increase is one of the challenges that cities face [12].

As mentioned earlier, this work proposes a new waste management system-based RF technology. The following parts are the main components of the system.

1. An Arduino card (Uno or mega).
2. Sensors HC-12 and HC-SR04 are distributed in the city.
3. Use RF technology in sending and receiving data among the sensors.

2. GENERAL INFORMATION

The following are the critical factors of the tendency to build cities: Smart Governance, Smart Management, Smart economy, Smart life, and Smart environment. The system comprises an electronic development board. It consists of an open-source electronic circuit with Arduino (a microcontroller) [3]. As illustrated in Table 1, several characteristics made the Arduino better than other microcontrollers.

1. An open-source which makes its development easy and fast
2. The libraries for most of the accessories are available.
3. Obtainable accessories.
4. Handle flexibility.
5. Easy to handle
6. Low cost.
7. Ability to link it to a high-level programming language, such as VB.NET, Java, and MATLAB [4].

Table 1. Types and characteristics of Arduino microcontroller

Characteristic	Types of Arduino

	Due	Mega	Uno
Microcontroller	AT91SAM3X8E	ATmega2560	ATmega328P
Dimensions of the painting	101.52mm/53.3mm	101.52 mm / 53.3mm	68.6 mm / 53.4mm
Weight	36 g	37 g	25 g
Memory Size	512 KB	256 KB	32 KB
Processor Speed	84MHz	16 MHz	16 MHz
Input Analogue ports	12	16	6
I/O digital ports	54	54	14
Port recommended	6-16 v	7-12v	7-12v
Boundary port voltage	6-16 v	6-20 v	6-20 v
Operating voltage	3.3 v	5 v	5v

There are several types from (Aurdino) that may be use in this study that are, Aurdino Uno: that has many feature which are , microcontroller: ATmega328P Operating voltage of the electrical system 5 v, Port voltage (boundary): 6-20 v Port voltage (recommended): 7-12v, Digital ports (input / output): 14
Analog ports (input): 6, Processor Speed: 16 MHz, Memory Size: 32 KB (KB0.5 used used for boot), Dimensions: 68.6 mm / 53.4mm and the Weight: 25 g .[5], Arduino Mega : that has many feature
which are, Microcontroller: ATmega2560 Operating voltage of the electrical system: 5 v, Port voltage (boundary): 6-20 v Port voltage (recommended): 7-12 v , Digital ports (input / output): 54 Analogue ports (input): 16, Processor Speed: 16 MHz , Memory Size: 256 KB (KB8 used to boot) , Dimensions: 101.52 mm / 53.3mm , Weight: 37 g[6]. Aurdino Due: that has many feature which are, Microcontroller: AT91SAM3X8E Operating voltage of the electrical system: 3.3 v Port voltage (boundary): 6-16 v Port voltage (recommended): 7-12v , Digital ports (input / output): 54 Analogue ports (input): 12 , Processor Speed: 84MHz , Memory Size: 512 KB (fully available for user applications) , Dimensions of the painting: 101.52mm / 53.3mm Weight: 36 g[7].
Arduino library is used for the ultrasonic distance sensor (HC-SR04). Every time, the sensor confirms whether the container is full or empty.
Its characteristics provide (2-400 cm) non-contact measurement function with an accuracy range reaching 3 mm. The module comprises an ultrasonic control circuit, sender, and receiver. The systems concept are:

1. The high-level signal is created using an IO trigger for ten us (at least)
2. Eight signals (in 40 kHz) are transmitted by the model to determine there is a pulse signal back.
3. Through high level, in case the signal is backed, high output IO time duration is the time from transmitting ultrasonic to getting back. Test distance is at a high-level time velocity of sound ((340 m/s)/2) [13].

To transmit and get information among the system's endpoints, we selected the radio frequency (HC-12 Wireless Transceiver Modules) (i.e., waste trucks, information office, and waste containers). Electromagnetic waves technology is one of the most significant discoveries throughout history. The technology is used in the wireless serial port communication modules and is based on a SI4463 RF chip and a built-in microcontroller. It accepts (3.2-5.5 V) and can be used with (3.3 V) and 5V UART voltage devices (3.3V safe) [14]. The AT commands are used to configure it. Depending on transmission speed, receiver sensitivity ranges between (-117 to -100 dBm), and the maximum output power is 20 dBm (100mW).
The transmission of various types of information anywhere is facilitated by electromagnetic waves [8].
The communications systems' construction is enabled by the waves where the transmitters and receivers can be moved or fixed. Using these waves, various devices and equipment can be remotely controlled at offices and houses. Therefore, waves are crucial in designing a smart city.
Here the electromagnetic spectrum is explained. It contains the following main bands.

1. The spectrum (0 - 300 GHz) is used entirely in radio communication systems.
2. The spectrum of rays utilized is (300 GHz - three million GHz).

Partly in optical communication systems, it consists of X-ray spectra, ultraviolet, and night vision systems [9]. It is hard to use due to difficulties in generation and danger to organisms. Nevertheless, it is used in some industrial and medical applications, such as using x-rays to test materials and image living objects. Different types of antennas and propagation are used because of large variations in the characteristics of radio-electromagnetic waves in terms of generation methods.
Most waves implemented in life are illustrated in Figure 1. Where the abbreviations are as follows: Extremely Low Frequency (ELF), Super Low Frequency (SLF), Ultra Low Frequency (ULF), Very Low Frequency (VLF), Low Frequency (LF), Medium Frequency (MF), High Frequency (HF), Very High Frequency (VHF), Ultra-High Frequency (UHF), Super High Frequency (SHF), and Extremely High Frequency (EHF).

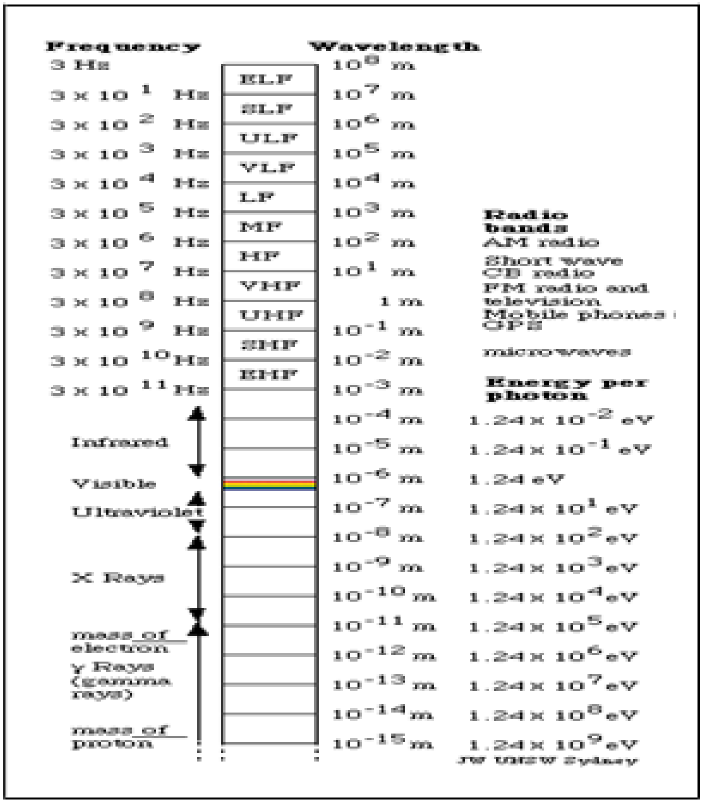


Figure 1. Spectrum bands [10]

The waves are reflected and returned back to the same medium if impediments obstruct them. They are not affected negatively, or part of their energy is absorbed. Without losing much of their capacity, the radio waves are often transmitted over long distances. Since WiFi does not have this feature, it is needed for a wave capable of transmitting and receiving information in all system parts. However, the designers of radio communication systems face the problem of assigning frequencies for growing and large numbers of systems (e.g., air navigation systems, military, and civil communications systems, radar systems, satellite systems, wireless and cellular telephones, and radio and television broadcasting systems).

In the electromagnetic spectrum, the limitation in the available frequencies is the main reason for this issue. The atmosphere of the earth is a medium where wireless systems transmit all frequencies. Also, to prevent interferences among the systems, the same frequency cannot be utilized in the same place. Except for high frequencies, most radio spectrum bands are used by communication systems. Also, due to their short wavelength, the high frequencies have prevented them from being heavily weather-affected. Nevertheless, there are applications that utilize these frequencies because of increased demand for frequency availability and satellite communication use.

National telecommunication regulators (such as International Telecommunication Union (ITU)) allocated frequencies to users to tackle this issue. Therefore, the available frequencies have been assigned by the ITU. The allocation provided permission to reuse the same frequency to avoid interference among the systems. It is done by the following: polarization methods, encoding, using different modulations techniques, taking advantage of geographic distance and limited broadcasting capacity [11].

1. System model

Sensors are responsible for providing notifications about the fullness of waste in containers. Therefore the modeling of the proposed system is as follows. Firstly, the sensor (HC-12 Wireless Transceiver Modules) transmits and receives signals between the following: 1) between vehicles and base estuation and 2) the base estuation and container. Secondly, Sensor (Arduino library for HC-SR04) acknowledges whether the container is full or empty. Data is collected from the sensor (i.e., Arduino library for HC-SR04) and gives the receiver and transmitter information for transmission to the base center. The data consists of the number of containers that equals the number of the total sensors. To ensure that the container is full or empty, information on the sensor can be updated continuously. In case the container is empty, these signals are not be sent. On contract, sensors transmit indication signals in case the container is full. Radio waves are sent to the information center with a sensor (HC-12 Wireless Transceiver Modules) . Since that device can send and receive simultaneously, the device utilized in transmitting information from the container is the same device used in receiving the data by the center. The Arduino receives the data, which is then sent to the central computer to convert the signals to data. It is essential to mention that the data includes the container fill and number. Next, a notice is distributed to all cities and the cars where each vehicle consists of a container number. According to the containers signals (based mainly on the sensor (Arduino library for HC-SR04), the data is updated continuously. Then, to private vehicles that collect wastes, the center sends information about full containers. An Arduino with a screen is available in each vehicle. As shown in Figure 2, to receive information from the information center, the screen displays the data and container number

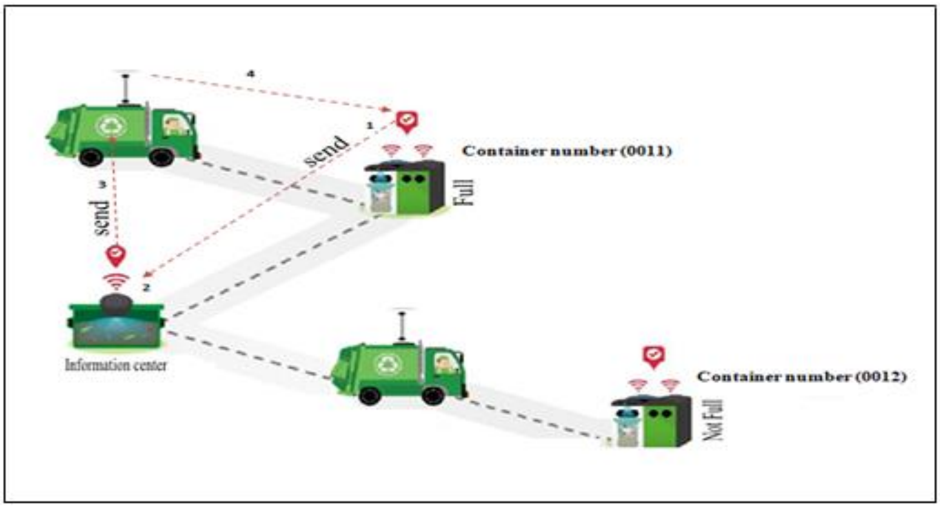


Figure 2. The data collection procedure in the system

When the cycle bin is complete, This mechanism only sends a signal which helps to avoid the database becoming full early. Additionally, a proactive mechanism is another mechanism is adopted in this work. The system depends on the mechanism's work to transmit and receive signals. Because speedily full of the system database, the mechanism is not heavily used. The flowchart of the proposed system is illustrated in Figure 3.

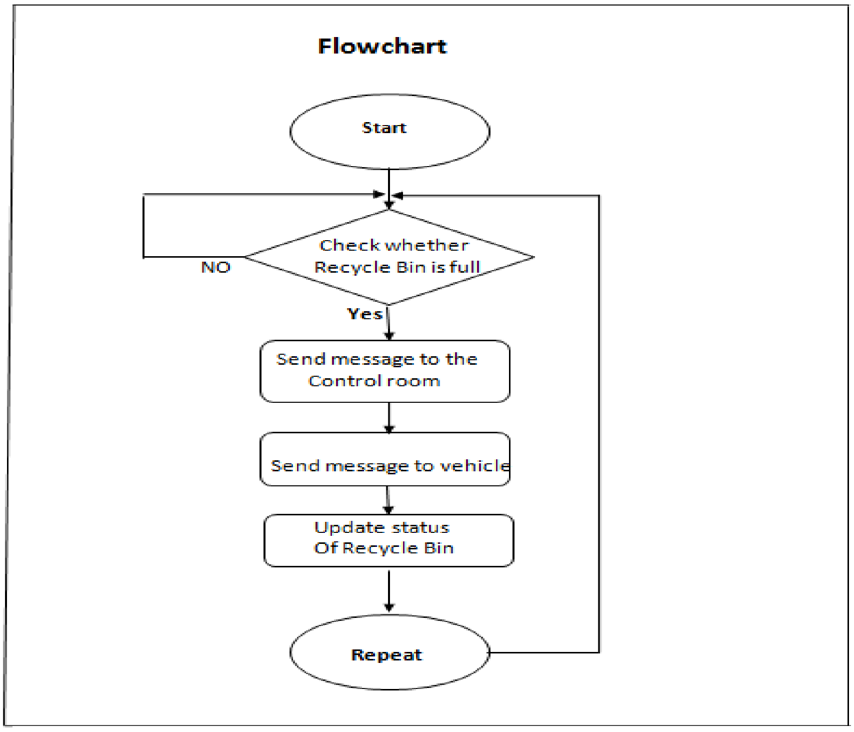


Figure 3. System's flowchart

2. Performance Evaluation

In Kirkuk city, Iraq, we conducted the tests on 70 citizens in different residents' quarters. To evaluate the system, a questionnaire form was spread to the people who relied on 14 areas[17] (see Table 2):

1. Reducing pollution.
2. The decrease in cost.
3. Processing speed.
4. Transparency.
5. Cost and effort of the system.
6. Technical integrity.
7. Satisfaction.
8. Technical integrity.

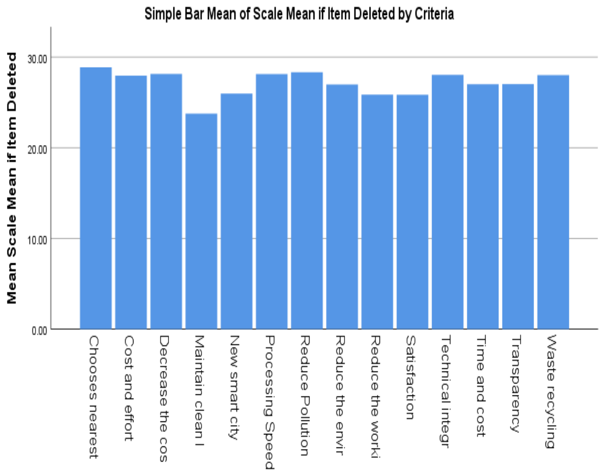
9. New smart city.
10. Time and cost.
11. Wasting recycling.
12. Maintain the clean line.
13. Reduce the working people.
14. Reduce the environment and health.
15. Chooses the nearest cycle bin.

To calculate and interpret the results, we used Statistical Package for the Social Sciences (SPSS).

Table 2. Performance Evaluation

item	Criteria	Cronbach's Alpha if Item Deleted	Corrected Item-Total Correlation	Scale Variance if Item Deleted	Scale Mean if Item Deleted
1.	Cost and effort of system	0.646	0.345	14.630	26.9565
2.	Transparency	0.636	0.393	13.852	26.9710
3.	Technical integrity	0.622	0.557	13.895	27.0435
4.	Satisfaction	0.639	0.409	14.460	26.8406
5.	New smart city	0.627	0.480	13.852	26.9710
6.	Time and cost	0.682	0.127	14.813	26.7391
7.	Waste recycling	0.623	0.509	13.715	26.9275
8.	Maintain clean lines	0.772	-0.371	18.475	24.7681
9.	Reduce the working people	0.650	0.301	14.169	26.9130
10.	Reduce the environment and Health	0.618	0.523	13.426	26.9855
11.	Chooses nearest cycle bin	0.619	0.522	13.485	27.0145
12.	Processing Speed	0.633	0.425	13.986	27.1159
13.	Decrease the cost	0.650	0.304	14.425	27.0435
14.	Reduce Pollution	0.662	0.208	15.073	27.3188

The Total Results of the system evaluation are illustrated in Figures (4, 5).



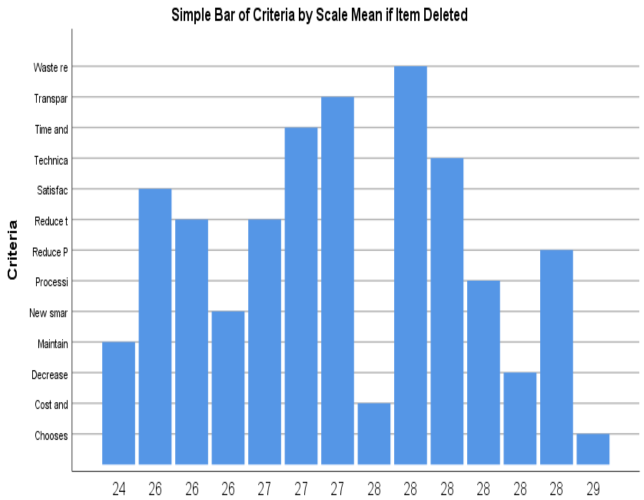
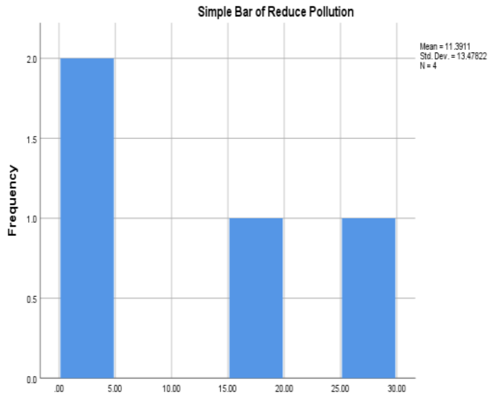


Figure 4: Reduced Pollution

Figure 5: Reduced Pollution

As shown in Figure 6, the system contributed to decreasing the pollution rate. Additionally, from Figure 7, the system reduced the cost of cleaning.



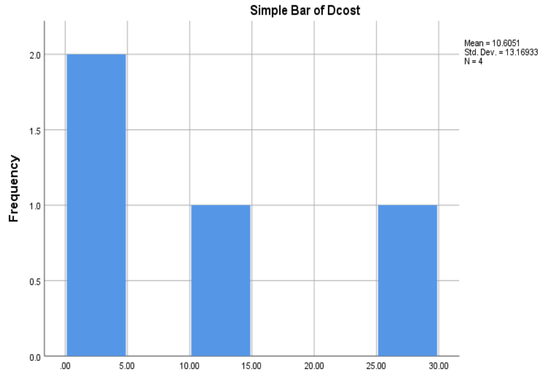
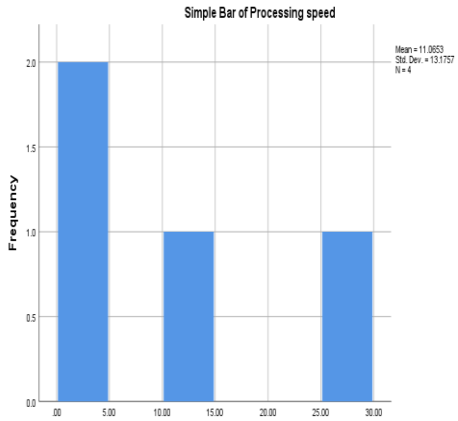


Figure 6: Pollution Reduction

Figure 7: Cost reduction

Also, as seen in Figure 8, the system increased the processing speed. Furthermore, the system improved the rate of vehicles finding the nearest recycle bins. Moreover, as illustrated in Figure 9, the system decreased diseases rates in the environment. Additionally, as presented in Figure 10, the number of employees decreased who work in the city cleaning system according to our system (see Figure 11).



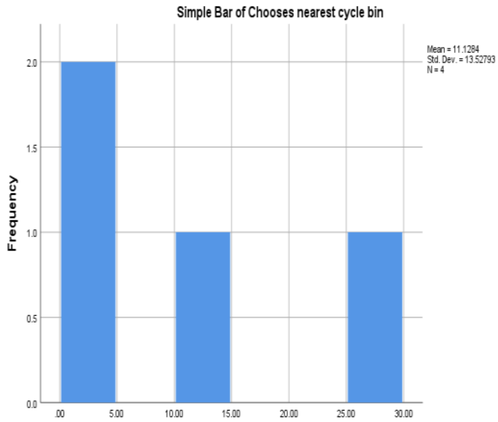
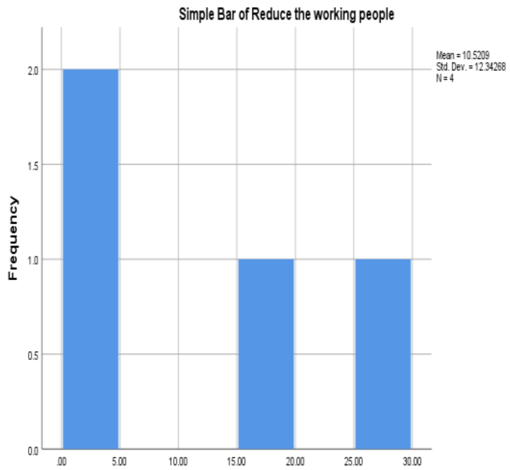


Figure 8: The speed of processing

Figure 9: Selecting the nearest bin



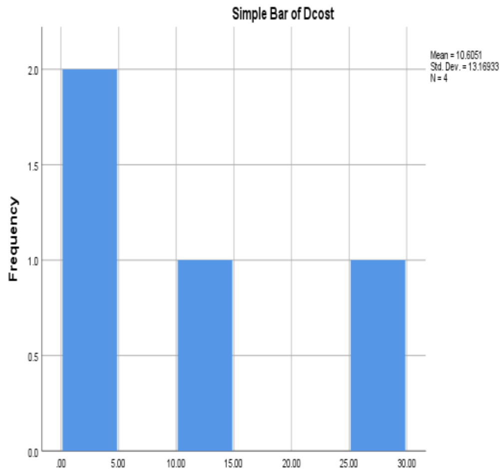


Figure 10:Reducing in Health and environment

Figure 11:Reducing in employees

Figures 12 and 13 demonstrate that clean lines maintenance and waste recycling are increased, respectively. Also, the system demonstrated that establishing a new smart city decreases the time and cost (see Figures 14 and 15). The satisfaction criteria, technical integrity, and transparency are improved (see Figures 16, 17, and 18). Finally, the effort and cost of the system decreased as well (see Figure 19).

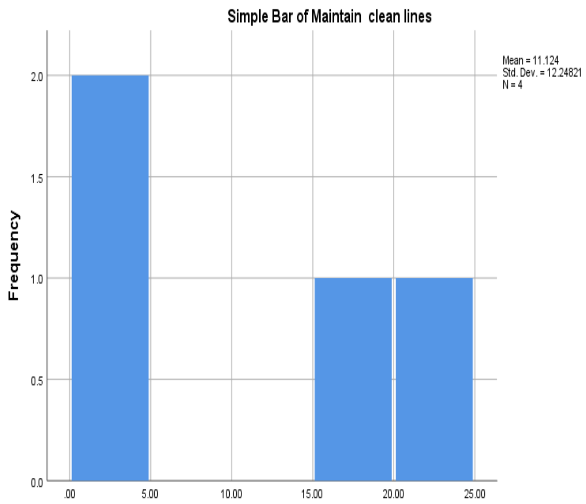


Figure 12: Clean lines maintained

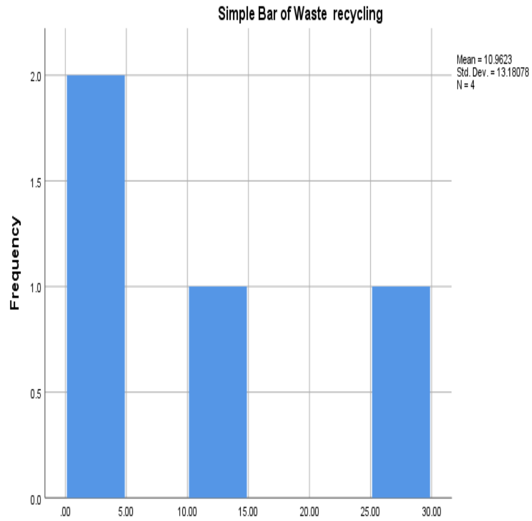


Figure 13: Recycling of wastes

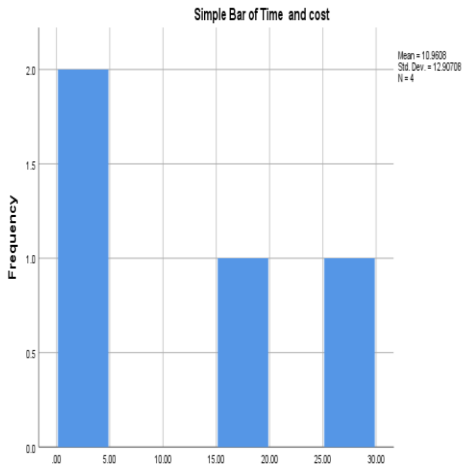


Figure 14: Sample of cost and Time

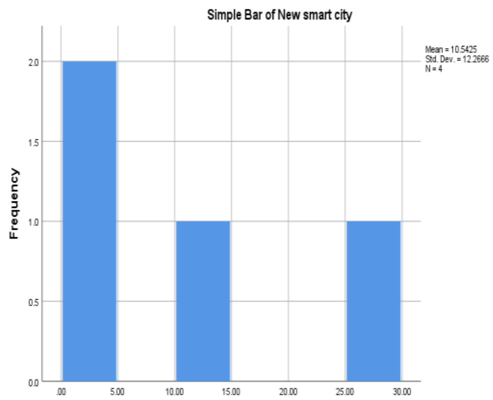


Figure 15: New smart city

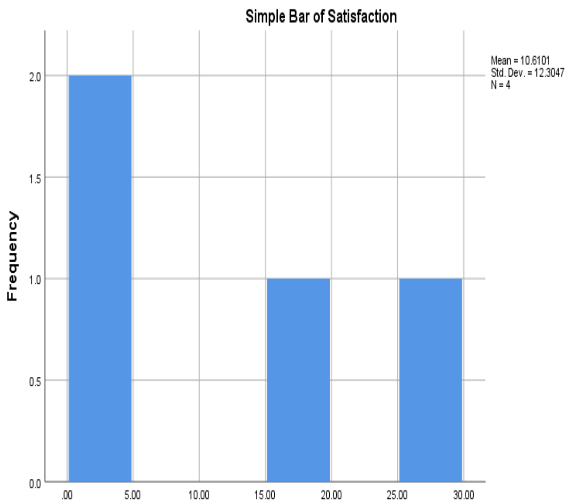


Figure 16:Satisfaction

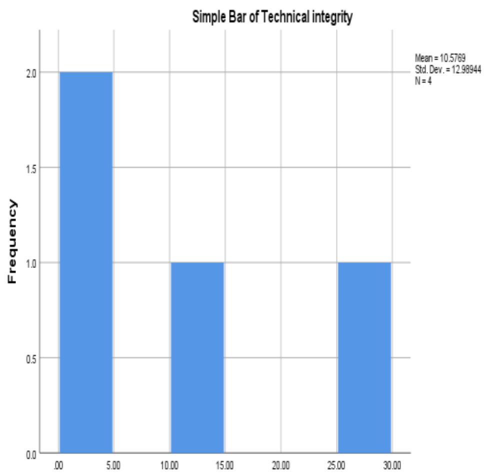


Figure 17:Technical integrity

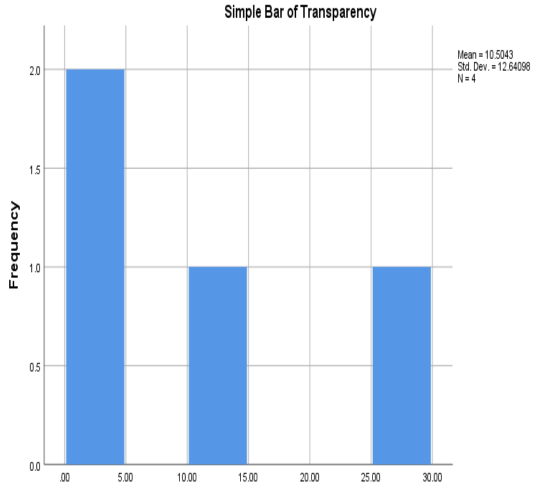


Figure 18: Transparency

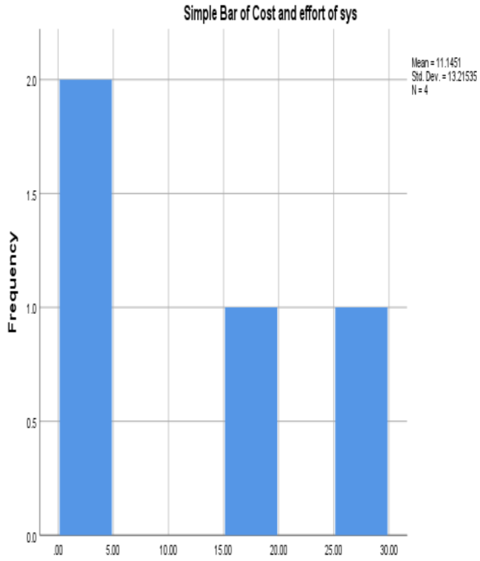


Figure 19: The effort and cost

3. CONCLUSIONS

Using RF technology, this paper proposed a waste management system that contributed to improving different features of traditional systems:

1. Maintain cleanliness of the environment.
2. Reduce the number of waste management employees.
3. Choosing the nearest point may decrease the consumed time to clean the area.
4. Flexibility in accessing the full container.
5. Reducing the overall cost of the system.
6. Reducing cleaning-up time
7. Speed up the clearing system of residential areas.
8. The study contributes to reducing pollution in modern cities.

The authors' future work will calculate an optimum solution for the research objectives. Optimization of soft computing algorithms in the considered

REFERENCES

1. J. Sun, J. Yan1 and K. Z. K. Zhang, "Blockchain-based sharing services: What blockchain technology can contribute to smart cities," 2016.
2. O. Benedikt, «The Valuable Citizens of Smart Cities: The Case of Songdo City,» 2016.
3. Leo Louis, "Working Principle of Arduino and using it as a Tool for Study and Research", India, International Journal of Control, Automation, Communication and Systems (IJCACS), Vol.1, No.2, April 2016.
4. ARDUINO.CC, "Arduino – Introduction", 2015 [Online].
5. available:http://arduino.cc/en/Guide/Introduction. [Accessed: 25- sep - 2018].
6. Galadima, A.A., "Arduino as a learning tool," in Electronics, Computer and Computation (ICECCO), 2014 11th International Conference on, vol1.
7. ArduPilot Mega, 'ArduPilot Mega', 2015. [Online]. Available: http://www.ardupilot.co.uk/. [Accessed: 23- sep-2018].
8. Arduino Official Website: www.arduino.cc/en/Main/ArduinoBoardDue, 19/10/2018 , 14:05.
9. Federal Communications Commission. (1997). Millimeter-wave propagation: Spectrum, management implications (FCC Bulletin No. 70). Washington, DC.November 25, 2003.
10. Federal Communications Commission. (2000, April). Revision of part 15 regarding ultra-wideband transmission (FCC 02-48), ET Docket 98-153, first report and order. Retrieved October 15, 2004, from http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-02- 48A1.pdf.
11. Mark, J., & Zhuang W. (2003). Wireless communications and networking. Upper Saddle River, NJ: Prentice-Hall.
12. William H. Mecking, JoraMinasian, Problem of radiofrequency allocation, September 1995.
13. https://www.albankaldawli.org/ar/topic/urbandevelopment/overview.
14. https://cdn.sparkfun.com/datasheets/Sensors/Proximity/HCSR04.pdf.
15. https://www.elecrow.com/download/HC-12.pdf.

16. U.Deniz Ulusar,∗ , G. Celik, M.Sc. a , Fadi Al-Turjman, Ph.D. "Cognitive RF-based localization for mission-critical applications in smart cities: An overview" , Computers & Electrical Engineering, Volume 87, October 2020.
17. K . Chimmanee, S. Jantavongso * ," Practical mobile network planning and optimization for Thai smart cities: Towards more inclusive globalization", Research in Globalization 3 (2021).
18. K.H.,Jihad , B.A.,Qader., , H.K. Omer, "An electronic irrigation system using IoT and neural networks", Periodicals of Engineering and Natural Sciences, 2021, 9(4), pp. 1083–1092